https://doi.org/10.48047/AFJBS.6.14.2024. 487-501

African Journal of Biological Sciences

USING AN AUXIN-LIKE HERBICIDE TO ERADICATE MESQUITE (*PROSOPIS JULIFLORA* SWARZ) DC

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Article History
Volume 6, Issue 13, 2024
Received: 18June 2024
Accepted: 02July 2024
doi:*10.48047/AFJBS.6.14.2024.* 487-501

Abstract: A study was conducted to assess the impact of 2,4-D herbicide on mesquite trees in the field, it aimed to evaluate the possibility of using the herbicide to eradicate this invasive tree. Different rates of 2,4-D (0, 6, 12, 18, 24 grams a.i.) were dissolved in either diesel or water and applied during two consecutive seasons - winter and rainfall. It was observed that during the rainy season, the large tree treated with all rates of 2,4-D dissolved in diesel resulted in 100% mortality. During both seasons (rainy and winter), applying of 24 grams a.i. dissolved in diesel resulted in 100% mortality percentage for three tree sizes compared to the control group that used diesel only, which achieved (46.67%, 46.67% and 50.0%) and (33.33%, 33.33%, and 0.00%) for small, medium, and large sizes during the rainy and winter season, respectively. According to the study, the mortality percentage of mesquite trees varied based on the application rate of 24 grams a.i. dissolved in water (16.67%, 13.33%, 33.33%) and (0.0%, 8.33%, 8.33%) during rainy and winter seasons for small, medium, and large, respectively

Keywords: 2,4-dichloro phenoxy acetic acid, *Prosopis juliflora*, mortality, diesel, and water

1- Introduction

The *Prosopis* genus, belonging to the Leguminosae (Fabaceae) family, and the Mimosoideae, sub-family, consists of about 44 species, with four being widely distributed globally: *P. juliflora, P. pallida, P. glandulosa, and P. relutina* (Pasiecznik *et al.* 2004). These species have become invasive weeds in several countries including Ethiopia, Kenya, Sudan, Eritrea, Iraq, Pakistan, India, Australia, South Africa, the Caribbean, the Atlantic Islands, Bolivia, Brazil, the Dominican Republic, El Salvador, Nicaragua, the United States of America (USA), and Uruguay (Pasiecznik *et al.* 2004). Mesquite has rapidly spread and multiplied making it one of the most dominant invasive trees in the world (Becker *et al.* 2016)

Prosopis juliflora is a multi-stemmed evergreen tree or shrub, that usually grows to heights of 3-12 m, but can reach up to 20 m in favorable conditions (Dave and Bhandari, 2013). This plant has sharp thorns that can cause gangrene, and its leaves can contaminate water sources, making it bitter (Walter and Armstrong, 2014). The pollens released by *P. juliflora* can lead to allergic asthma, and skin allergy (Dousti *et al.* 2016). According to Muturi *et al.* (2017), mesquite can inhibit the seed germination of other species in its vicinity and hinder the growth of plants around it (Noor *et al.* 1995). This is due to the plant releasing compounds that can be toxic to other plants (Thoyabet *et al.* 2009). It has been discovered that the leaves contain high concentrations of alkaloids (Damasceno *et al.* 2017). According to McGinnies (1973) mesquite has numerous buds covering the surface of the stem base above the juncture of the root and stem. The buds sprout whenever the stem above the soil surface is injured or destroyed.

The use of mechanization to control mesquite is applied in various ways. Choosing of the most effective mechanical method for controlling mesquite depends on several factors, such as the species characteristic, stem size, topography and soil type. Bulldozing is an adapted method for up-rooting stands of large mesquite trees, and it is most effective during the summer. However, this method has the disadvantage of being slow (Ansley *et al.* 2006).

The chemical control of mature mesquite trees can be carried out using the cut-stump and basal bark technique were used to control mature mesquite trees. In the cut stump technique, the stump should be cut horizontally to 30 cm above the soil surface, the herbicide should be applied immediately within 15 seconds of cutting. This method is effective year-round (Suliman, 2007). The basal bark treatment is the most widely used method for individual trees, involving the spraying of herbicide around the entire stem up to 30 cm from the soil surface. Its effectiveness varies depending on species and location, but it is generally effective during the growing season March to November (Geesing *et. al*.2004). There have been numerous studies conducted on the effectiveness of auxin-like herbicides in controlling mesquite. Research shows that a combination of auxin-like herbicide and diesel oil is highly effective in controlling mesquite with a 100% mortality rate observed in mesquite trees treated with triclopyr at a concentration of 4grams a.i. per tree mixed with diesel Abdelaziz, 2009), Additionally, mesquite trees treated with triclopyr at concentrations of 18-20% showed 100% mortality. (Abdelaziz *et al.* 2014). Furthermore, according to Shanwad *et al.* (2015), spraying mesquite trees with a combination of 2,4-dichlorophenoxy acetic acid (2,4-D) and glyphosate, increased the mortality percentage.

2,4-D was one of the first herbicides with auxin-like properties to be used. This compound is structurally similar to the natural auxin Indol-3-acetic acid (IAA) (Gervais, 2008). There are two types of 2,4-D formulations: amine salts (2,4-D reacts with an amine) and esters (2,4-D reacts with alcohol). (Peterson *et al.* 2016). According to Kumar and Singh (2010), the effectiveness of 2,4-D herbicide depends on several factors such as the application rate, plant stage, and environmental variables. Therefore, this study was conducted to evaluate the effectiveness of using 2,4-D to induce mesquite tree mortality and prevention the re-sprouts from ground buds.

2- Materials and Methods

2-1: Site of experiment and plant materials

Two experiments were conducted in Khartoum, Sudan during the winter and rainy seasons of 2019-2020. The study area was approximately forty hectares and was divided into three sections (replicates). In each section, thirty mesquite trees were chosen and classified into three size categories: based on the canopy diameter, (1-2 meter), (3-5 meter), and (more than 5 meter) for small, medium, and large, respectively, each size category contained ten trees.

2- 1 Chemical solutions and their application method:

The chemical used in this study was 2,4-D herbicide at different rates (Table 1), any 2,4-D rate dissolved in one liter of diesel or water. The basal bark treated method was used to spray the stem of mesquite tree around the entire basis of the stem about thirty cm (Gessing *et al.* 2004). The amount of the mixture differs according to the number of stems; the herbicide mixture was applied only once using a knapsack sprayer with a cone nozzle.

Table 1: The rates of 2,4-D, solvent types and experimental unit

2,4-D Rate (gram a. i.)	Solvent Types
0	Diesel only (Control)
6	Liter Diesel
12	Liter Diesel
18	Liter Diesel
24	Liter Diesel
0	Water only (Control)
6	Liter Water
12	Liter Water
18	Liter Water
24	Liter Water

2-2 Experimental design:

The study was conducted using a Factorial design with the three factors (1) 2,4-D rates, (2) solvent types, and (3) tree sizes. The treatments were arranged with three replicates to evaluate the impact of three factors, along with all interactions between them.

2-3 Data Collection and Analysis:

After one year of application, the following characteristics were observed to assess the effect of 2,4-D on mesquite mortality percentage, which included the trees that should not have produced any re-sprouts from ground buds and the stems that met certain criteria, such as being 100 % defoliated and having no living tissue. The mortality percentage was calculated used the formula:

$$\text{Mortality percentage} = (\text{No. of dead stems} \div \text{No. of total stems}) \times 100.$$

The statistic software (Statistix 10) was used to analyze the data, Analysis of variance tables were computed, and the means were separated by the least significant difference test (LSD) at 0.05 level of significance.

3- Results

3-1: Effect of the three factors 2,4-D rates solvent types and tree sizes on mortality percentage

The results in (Table 2) show significant differences in the mortality percentage with an increase of the 2,4-D rate compared to the control, during both seasons the rates of 18 and 24 grams a.i. gave a high mortality percentage, in the winter season 48.33% and 52.22%, while in the rainy season 50% and 62.22%, respectively. (Table 2).

The mortality percentage for diesel and water during the winter season was 74.26% and 1.675, while the mortality percentage for diesel and water during the rainy season was 88.44% and 4.22%, respectively (Table 3). However, there were no significant differences between the mortality percentages of the three tree sizes during both seasons (Table 4)

Table 2: Effect of 2,4-D rates on mortality percentage

2,4-D rates (grams a.i.)	Mortality percentage	
	Winter season	Rainy season
0	14.72 c	23.61 c
6	33.33 b	47.78 b
12	33.89 b	47.78 b
18	48.33 a	50.0 b
24	52.22 a	62.22 a
SE±	6.81	2.70

Figures followed by the same letter in a column are not significantly different according to the least significant differences (LSD)

Table 3: Effect of solvent types on mortality percentage

Solvent types	Mortality percentage	
	Winter season	Rainy season
Diesel	74.26a	88.44a
Water	1.67b	4.22b
SE±	4.31	1.71

Figures followed by the same letter in a column are not significantly different according to the least significant differences (LSD)

Table 4: Effect of tree sizes on mortality percentage

Tree sizes	Mortality percentage	
	Winter season	Rainy season
Small	37.24 a	44.33 a
Medium	39.0 a	44.67 a
Large	36.84 a	50.0 a
SE±	5.27	2.09

Figures followed by the same letter in a column are not significantly different according to the least significant differences (LSD)

3-2: Effects of the interaction of 2,4-D rates and solvent types on mortality percentage

Using diesel solvent increased the performance of 2,4-D, which increased the mortality percentage. All 2,4-D rates dissolved in diesel caused significantly higher mortality than the corresponding rates dissolved in water The four rated of 2,4-D herbicide in a tank mixture with diesel solvent achieved a significant increase in the mortality percentage of trees of three different sizes compared to the control (diesel only), which gave 29.44% during the winter season, while in the rainy season, the diesel only had mortality rates of 47.22%. (Table 5)

Table 5: Effect of the interaction of 2,4-D rates and solvent types on mortality percentage

2,4-D rates (gram a. i.)	Solvent types			
	Diesel		Water	
	Winter	Rainy	Winter	Rainy
0	29.44c	47.22b	0.00d	0.00d
6	66.67b	95.56a	0.00d	0.00d
12	67.78b	95.56a	0.00d	0.00d
18	96.67a	100a	0.00d	0.00d
24	98.89a	100a	5.56 d	24.44c
SE±	9.63	3.81	9.63	3.81

Figures followed by the same letter in a column are not significantly different according to the least significant differences (LSD)

3-3: Effect of the interaction of tree sizes and solvent types on mortality percentage

During both seasons, the interaction of tree sizes and diesel solvent caused a significant increase in mortality percentage compared to the water solvent. In the rainy season, the interaction of small, medium, and large sizes with diesel solvent resulted in mortality percentage of 85.33%, 86.67%, and 93.33%, respectively. Similarly, in the winter season, the same interaction resulted in increased mortality percentage of the three tree sizes, which gave 76.46%, 76.33%, and 72.0%, for small, medium and large trees, respectively. (Table 6).

Table 6: Effect of the interaction of tree sizes and solvent types on mortality percentage

Tree sizes	Solvent types			
	Diesel		Water	
	Winter	Rainy	Winter	Rainy
Small	74.46a	85.33a	0.00b	3.33b
Medium	76.33a	86.67a	1.67b	2.67b
Large	72.00a	93.33a	1.67b	6.67b
SE±	7.46	2.95	7.46	2.95

Figures followed by the same letter in a column are not significantly different according to the least significant differences (LSD)

3-4: Effect of the interaction of 2,4-D rates and tree sizes on mortality Percentage

The results presented in (Table 7) indicated that the mortality percentage of the three tree sizes increased as the 2,4-D rate increased. Among the different rates tested, the highest rate of 2,4-D (24 grams a.i.) resulted in the highest mortality percentage. During the winter season, this rate caused 48.17%, 54.17%, and 57.17%, while during the rainy season the same rate caused 58.34%, 56.57%, and 66.67% mortality for small, medium, and large sizes, respectively.

Table 7: Effect of the interaction of 2,4-D rates and tree sizes on mortality Percentage

2,4-D rates (gram a. i.)	Winter			Rainy		
	Small	Medium	Large	Small	Medium	Large
0	16.67cd	16.67cd	0.00d	23.34d	23.34 d	25.0d
6	38.17abc	27.5 bc	33.34abc	46.67c	46.67 c	50.0bc
12	38.17abc	46.67ab	46.67ab	46.67c	46.67 c	50.0bc
18	45.0ab	50.0 ab	50.0ab	46.67c	50.0 bc	50.0bc
24	48.17ab	54.17 a	57.17a	58.34b	56.57 b	66.67a
SE±	11.79			4.67		

Figures followed by the same letter in a column are not significantly different according to the least significant differences (LSD)

3-5: Effect of the interaction of 2,4-D rates, solvent types and tree sizes on mortality percentage

Results in (Table 8) show that, during both seasons, the three different sizes of trees treated with varying rates of 2,4-D dissolved in diesel significantly increased the mortality percentage compared to the same rates of 2,4-D dissolved in the water. The high rate of 2,4-D dissolved in diesel (24 grams a.i.) resulted in 100% mortality of small, medium and large sizes (Photo 1), (Photo 2), and (Photo 3) compared to the control group (diesel only), which showed a lower mortality percentage (Photo 4). In the rainy seasons, the rate of 24 grams a.i. of 2,4-D dissolved in water significantly increased the mortality percentage of the different tree sizes, which gave 16.67%, 13.33%, and 33.33% for small, medium, and large trees, respectively (Photo 5). when compared to the control group (water only) (Photo 6).

Table 8: The effect of the interaction of 2,4-D rates, solvent types, and tree sizes on mortality percentage

2,4-D rates (gram a. i.)	Solvent types	Winter season			Rainy season		
		Small	Medium	Large	Small	Medium	Large
0	Diesel	33.33de	33.33de	0.00 f	46.67 b	46.67 b	50.0 b
6	Diesel	76.33abc	55 cd	66.67bc	93.33 a	93.33 a	100 a
12	Diesel	76.33abc	93.33ab	93.33ab	93.33a	93.33 a	100 a
18	Diesel	96.33 ab	100 a	100 a	93.33a	100 a	100 a
24	Diesel	100 a	100 a	100 a	100 a	100 a	100 a
0	Water	0.0 f	0.0 f	0.0 f	0.0d	0.0d	0.0d
6	Water	0.0 f	0.0 f	0.0 f	0.0d	0.0d	0.0d
12	Water	0.0 f	0.0 f	0.0 f	0.0d	0.0d	0.0d
18	Water	0.0 f	0.0 f	0.0 f	0.0d	0.0d	0.0d
24	Water	0.0 f	8.33ef	8.33ef	16.67c	13.33cd	33.33b
SE±		14.95			6.88		

Figures followed by the same letter in a column are not significantly different according to the least significant differences (LSD)

1  2 

3  4 

5  6 

Photos :(1) Large tree treated with 2.4-D at rate 24 grams a.i. dissolved in diesel (2) Medium tree treated with 2.4-D at rate 24 grams a.i. dissolved in diesel (3) Small tree treated with 2.4-D at rate 24 grams a.i. dissolved in diesel (4) Large tree treated with diesel only (5) Large tree treated 24 grams a.i. dissolved in water (6) Control

4- Discussion

The mortality percentage was calculated one year after the application, to ensure adequate time for varying weather conditions throughout the year. The mortality percentage of mesquite trees is significantly higher when 2,4-D was combined with diesel solvent compared to water solvent. This indicates that mesquite trees respond differently to different solvents. The effect of auxin-like herbicides is based on tissue sensitivity and specificity, low concentrations of 2,4-D encourage the growth of the target plant, while high concentrations of the herbicide can lead to abnormal plant growth (Grossmann, 2010). 2,4-D acts like the natural plant hormone indole -3-acetic acid IAA and triggers the activation of auxin-responsive genes (Korasick *et al.* 2015). Synthetic auxin 2,4-D can disrupt the balance of natural auxin IAA balance either inhibiting its transport or reducing the auxin complex needed to regulate plant growth (Cobb and Reade, 2010). 2,4-D persists in the plant for extended periods, while the natural auxin (IAA) undergoes degradation, this disruption of the balance between natural auxin and other hormones affects their interaction (Song, 2014). These types of herbicides are selective toward broad-leaf weeds. They move through the xylem and the phloem to areas of new growth, causing disruption of transport tissue. They also act on multiple sites to disrupt hormone balance and protein synthesis, leading to various abnormalities in plant growth. The symptoms of injury are most noticeable on newly developing leaves. (Grossmann, 2010).

2,4-D activates the synthesis of amino cyclopropane- 1-carboxylic acid, which leads to ethylene biosynthesis and triggers H_2O_2, which causes oxidative stress (Eduardo *et al.* 2017). H_2O_2 at a low rate acts as a signaling molecule, regulating genes involved in stress response and development (Mittler *et al.* 2011). H_2O_2 is the second messenger in abscisic acid (ABA) synthesis (Vanderauwera *et al.* 2011). Exceeds of ABA promotes oxidative damage leading to DNA, lipids, protein, and DNA destruction in stressed cells (Sandalio *et al.* 2012). In addition, the synthesis of ABA stimuli to stoma closure limits CO2 assimilation, which is followed by a reduction in photosynthesis and respiration (Grossmann, 2010)

The presence of alkanes and polycyclic aromatic hydrocarbons (PAHs) in diesel can be harmful to plants (Adam and Duncan, 1999). Alkio *et al.* (2005) reported that PAHs reduced stem and root growth, increased hydrogen peroxide, and finally cellular death of *Arabidopsis.* Additionally, toxic hydrocarbons can inhibit the activities of amylase and starch phosphorylates (Achuba, 2006).

According to a study conducted by (Peterson *et. al.* 2016), the effectiveness of 2,4-D varied based on the season in which it was used. Used of 2,4-D during the rainy season resulted in a better mortality rate than its use during the winter season. This may be due to the higher temperature and humidity levels, which promote the uptake and translocation of 2,4-D, additionally, sensitive species tend to translocate more of the herbicide than tolerant species.

5- Conclusion

1/ This study has demonstrated the possibility of controlling the invasive mesquite tree under field conditions.

2/ During the two seasons under investigation, all three tree sizes treated with the two rates of 2,4-D (18 or 24 grams a.i.) dissolved in diesel exhibited 100% mortality until one year of application, based on these results, the study recommended that 2,4-D herbicide at these rates. dissolved in diesel can be used for mesquite tree control.

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