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Effects of Different Rates of Herbicide on Growth and Yield of Sorrel (*Hibiscus sabdarifa L.*) in Maiduguri, Borno State, Nigeria

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Abstract: *An experiment was conducted to determine the effects of different rates of herbicide on growth and yield of sorrel (Hibicus sabdarifa L.) in Maiduguri. The study was carried out at the Integrated Teaching and Research farm Ramat polytechnic, Maiduguri in wet season of 2023. The experiment consist of four treatment, T1 weedy check, T2 (100ml), T3 (200ml) and T4 (300ml) arranged in Randomized Complete Block Design (RCBD) replicated three times. Data on growth parameter were collected and they include plant height, number of leaves and leave area at 2, 4, 6 and 8 weeks after planting (WAS), while data on yield parameters include days to first flowering, days to 50% flowering and calyx weight (kg/ha). The results of the study shows that treatment 3 (200ml) gave the tallest plants, most number of leaves per plant, the largest leave area per plant at all the sampling period and heaviest weight calyx weight kg/ha . Treatment 1 (weedy check) and treatment 4 (300ml) recorded the shortest days to first flowering, 50% of the plant to attain flowering and least number of calyx per plant of sorrel in Maiduguri. From the results of the present study, treatment 3 (200ml) which produced the highest yield is the best herbicide rate for cultivation of sorrel in Maiduguri.*

Keywords: *Rates of Herbicides, Maiduguri Borno state, Growth and Yield, Sorrel*

INTRODUCTION

Sorrel (*Hibiscus sabdariffa* L.) production is conducted in countries with tropical and subtropical regions. This species is primarily cultivated because of the consumption of its calyx (sepals); they are commercially important in the food industry for the production of juices, jams, salads, pigments, and beverages (Borrás-Linares *et al.,* 2015). On a dry basis, roselle as a food species contains proteins, fats, carbohydrates, raw fiber, and ashes (Adanlawo y Ajibade, 2006), as well as vitamins, organic acids, and phytosterols (Ismail *et al.,* 2008), which are useful for the health of consumers (Da-Costa-Rocha *et al.,* 2014). Sorrel is also an important source of minerals, with K, Ca, and Mg as well as trace elements (Fe, Mn, Zn, and Cu) that the play role in health by functioning as antioxidants or as components of antioxidant enzymes (Evans and Halliwell, 2001). In addition to its nutritional value, the sorrel calyx contains components that confer pharmacological, nutraceutical, and cosmetological properties. Within this group are the polyphenols

including delphinidin and cyanidin (Borrás-Linares *et al.,* 2015; Jabeur *et al.,* 2017), that show antioxidant activity in the human body (Wang *et al.,* 2011). Sorrel (*Hibiscus sabdariffa* L.) belongs to the family Malvaceae, locally called "karkade", is an important annual crop grown successfully in tropical and sub-tropical climates. The commercially important part of the plant is the fleshy calyx (sepals) surrounding the fruit (capsules). The whole plant can be used as beverage, or the dried calyces can be soaked in water to prepare a colorful cold drink, or may be boiled in water and taken as a hot drink. It also has some medicinal properties. The seeds contain 17.8–21% non-edible oil and 20% protein, and are sometimes used for animal feed. Sorrel is a flexible plant with a number of uses. It is intercropped with crop staples such as sorghum and sesame, or planted along field margins. It requires little care. Its leaves, seeds, capsules and stems are used in traditional medicines. In rural areas women are usually responsible for growing roselle. They add value to the crop by developing products for market Mclean, Wilson and Menzel reported that Hibiscus sabdariffa is a tetraploid (2n = 4x = 72), whose chromosomes are related to the diploid (2n = 2x = 36) Hibiscus cannabinus. The two botanical types of Sorrel are Hibiscus sabdariffa var. sabdariffa, grown for its fleshy, shiny-red calyx, and Hibiscus sabdariffa var. altissima grown for its phloem fiber. Despite its potential economic importance, karkadi has received little attention and there is a lack of information regarding its genetics, breeding and production, particularly under rain-fed conditions. China and Thailand are the largest producers and control much of the world supply. The world's best sorrel comes from Sudan and Nigeria. Mexico, Egypt, Senegal, Tanzania, Mali and Jamaica are also important suppliers but production is mostly used domestically. In the Indian subcontinent (especially in the Ganges Delta region), sorrel is cultivated for vegetable fibres. Sorrell is called meśta (or meshta, the ś indicating an sh sound) in the region. Most of its fibres are locally consumed. However, the fibre (as well as cuttings or butts) from the sorrel plant has great demand in natural fibre using industries. Sorrel will grow best in a fertile, loamy soil that is moisture retentive and drains well. The plant also does best in soil rich in organic matter. If the soil is too clayey or doesn't drain well it will need to be amended with compost and some sand. The Sorrel (*Hibiscus sabdariffa*) is being extensively used in folk medicine owing to its rich phytochemical profile including polyphenols, especially anthocyanin's, organic acids, and polysaccharides, thereby offering greater prospects in therapeutic and medicinal uses. The Sorrel infusions or decoctions present significant therapeutic options against various degenerative ailments such as hyperlipidemia, hypertension, diabetics, cancer, hepatoprotection, nephroprotection, and many others. The previous work supports the scientific hypothesis that Sorrel plant enriched with bioactive constituents plays an imperative role in the management of degenerative and chronic diseases that are associated with oxidative stress. However, well-designed animal and human studies are underway to precisely quantify the therapeutic potential of purified phytochemical preparations. Sorrel (leave) is an important source of trace and major minerals especially iorn (Fe), Manganese (Mn), Zink (Zn) and Coper (Cu) which acts as antioxidants. Also sorrel (calyx) contains components that confer pharmacological nutritional and cosmetologically properties, however, the full potential of the crop is not expensively explored in this environment. Maiduguri is a semi-arid environment associated with limited amount of rainfall spanning for few months, necessitating the need for farmers to make most of this limited resource. Weed is a major hindrance to crops in this environment and herbicides application is the cheapest and easiest method of weed control. Sorrel leaves are consumed therefore, herbicides application most come with strict precaution to avoid poisoning from indiscriminate use and application. This research is aimed at establishing the minimal rate of herbicide for the optimum yield of sorrel in this environment. Most of the sorrel farmer within the study area are semi-skilled lacking the technical knowledge associated with herbicide application or stick strickly to the laid down procedures accompanying tested in environments different from theirs. This experiment sought to find the most minimal herbicide dose for sorrel production in Maiduguri.

MATERIALS AND METHOD

Experimental site

The experiment was conducted at the Integrated Teaching and Research Farm of Agricultural Technology at Ramat Polytechnic Maiduguri determines the effects of different rates of herbicide on growth and yield of Sorrel (*Hibiscus sabdariffa L.*) in Maiduguri (11.83845^{O}N and 13.13357^{O}E). It lies in the semi-arid zone characterized by the short raining season 3 – 4 month (June – September) with an annual rained varying from 300mm – 600mm (Kinsolver, 2004) ambient temperature of 34 – 40^{0}C and above in the month from April and May. The relative humidity range from 30 – 50% with it drops to 10% and minimum of 90% in August.

Materials

The materials that was used for this experiment include sorrel seeds, field or garden plot for cultivation, water source, Knapsack sprayer, weed control tools (if needed), measuring tape, ranging pole, rope, hoe, rake, pencils, exercise book and sunparaquat selective herbicides.

Method: The field or garden plot was prepared by removing existing weeds and tilling the soil to ensure proper seedbed preparation. Sorel seeds or seedlings were sown or transplanted at a specified spacing according to standard sorrel cultivation practices. Once the sorrel plants reached the appropriate growth stage, different rates of herbicide treatments were applied according to the experimental design. Application rates were accurately measured and applied uniformly. The growth parameters of the sorrel plants were monitored and recorded, including plant height, leaf area, branching, and overall health. These measurements were taken at regular intervals throughout the growth cycle. The effectiveness of weed control was assessed by visually monitoring weed growth and documenting any visible weed suppression or re-growth. The sorrel plants were harvested at the appropriate maturity stage according to market preferences or specific research objectives. Samples of harvested sorrel were collected for quality analysis, including nutritional composition, flavor, and other relevant parameters. The data collected was analyzed to determine the effect of different herbicide rates on growth and yield of sorrel.

Experimental Design

The experimental design consists of (4) treatments replicated three (3) times each. The treatment are; 0.00 herbicide rates, 100ml, 200ml and 300ml laid out in Randomized Complete Block Design (RCBD), there was a total of 12 plots each measuring is 4x4 (16m^2). The gross plot size is 266m^2 (14x19). Each plot was separated using 1m as working alley. The net plot consist of the central rows in each plot, thus the net plot size is 12.5m^2, and data was collected within the net plots only.

RESULTS

Effects of Different Rates of Herbicide on Plant Height (cm) of Sorrel at 2, 4, 6 and 8 (WAS) in Maiduguri

Table one shows the effects of different rates of herbicide on plant height of sorrel at 2, 4, 6 and 8 (WAS) in Maiduguri. There is significant difference among the treatment at all the sampling period. Treatment 3 recorded the tallest plant while T_1 gave the shortest plant. Treatment 3 is the best rate of herbicides on plant height of sorrel in Maiduguri.

Table 1: Effects of Different Rates of Herbicide on Plant Height (cm) of Sorrel at 2, 4, 6 and 8 (WAS) in Maiduguri

Treatments	Weeks After Sowing (WAS)			
	2	**4**	**6**	**8**
T1	5.667[c]	7.667[d]	11.333[c]	15.000[c]
T2	8.000[b]	11.000[c]	16.000[b]	21.667[b]
T3	11.333[a]	16.667[a]	20.667[a]	26.000[a]
T4	9.000[b]	12.667[b]	16.333[b]	21.333[b]
	0.805	0.471	1.045	1.122
SE	11.60	4.81	7.96	6.54

Means in the same column followed by the same letter are not significantly different according to LSD at 5% level of probability.

T1 Weedy check
T2 100ml/L
T3 200ml/L
T4 300ml/L

Effects of Different Rates of Herbicide on Number of Leaves at 2, 4, 6 and 8 (WAS) in Maiduguri

Table two shows the effects of different rates of herbicide on number of leaves of sorrel at 2, 4, 6 and 8 (WAS) in Maiduguri. There was no significant difference on number of leaves per plant at 2 (WAS), but there were significant differences at 4, 6 and 8 (WAS). Treatment 3 recorded the most number of leaves/plant of sorrel in Maiduguri. Treatment 1 and 4 gave the least number of leaves/plant. Treatment 3 is the best rate for number of leaves/plant of sorrel in Maiduguri.

Table 2: Effect of Different Rates of Herbicide on Number of Leaves at 2, 4, 6 and 8 (WAS) in Maiduguri

Treatments	Weeks After Sowing (WAS)			
	2	**4**	**6**	**8**
T1	5.667[a]	7.333[b]	17.667[c]	17.667[c]
T2	6.000[a]	8.667[b]	20.667[b]	20.667[b]
T3	6.667[a]	13.000[a]	27.333[a]	27.333[a]
T4	5.000a	7.000[b]	19.000[c]	19.000[c]
	20.00	9.97	8.31	3.78
SE	0.953	0.733	0.653	0.653

Means in the same column followed by the same letter are not significantly different according to LSD at 5% level of probability.

T1 Weedy check
T2 100ml/L
T3 200ml/L
T4 300ml/L

Effects of Different Rates of Herbicide on Leaves Area at 2, 4, 6 and 8 (WAS) Sorrel in Maiduguri

Table three shows the effects of different rates of herbicide on leaves area of sorrel per plant at 4, 2, 6 and 8 (WAS) there is significant difference among the treatment at all the sampling periods. Treatment three recorded the largest leave area/plant, while Treatment 1 and 4 gave the smallest leave area/plant of sorrel in Maiduguri. Treatment 3 which gave the largest leave area/plant of sorrel in Maiduguri is the best herbicide rate for leave area/plant of sorrel in Maiduguri.

Table 3: Effects of Different Rates of Herbicide on Leaves Area at 2, 4, 6 and 8 (WAS) in Maiduguri

Treatments	Weeks after sowing (WAS)			
	2	4	6	8
T1	7.333[b]	11.573[b]	13.663[b]	16.300[b]
T2	8.917[ab]	13.660[ab]	15.953[ab]	21.723[ab]
T3	11.777[a]	16.663[a]	22.550[a]	29.220[a]
T4	6.617[b]	10.343[b]	16.157[ab]	14.613[b]
CV	16.53	18.49	20.01	21.94
SE	1.169	1.972	2.791	3.667

Means in the same column followed by the same letter are not significantly different according to LSD at 5% level of probability.

T1 Weedy check
T2 100ml/L
T3 200ml/L
T4 300ml/L

Effects of Different Rates of Herbicide on Days to First Flowering and 50% flowering of Sorrel

Table four shows the effects of different rates of herbicides on days to first and 50% flowering of sorrel in Maiduguri. There is significant difference among the treatments at all the sampling periods. Treatment 1 and 4 recorded the shortest days to first flowering and 50% of the plant to attain flowering, while treatment 3 took longest days to first flowering and 50% of the plant to attain flowering. Treatment one are the optimum rate of herbicide for first flowering and days to 50% of the plant to attain flowering of sorrel in Maiduguri.

Table 4: Effects of Different Rates of Herbicide on Days to First Flowering and 50% flowering of Sorrel

Treatments	Days to First Flowering	Days to 50% Flowering
T1	20.000[c]	30.333[c]
T2	25.333[b]	34.000[b]
T3	29.000[a]	37.667[a]
T4	26.667[b]	33.000[b]
	3.91	4.88
SE	0.805	1.694

Means in the same column followed by the same letter are not significantly different according to LSD at 5% level of probability.

T1 Weedy check
T2 100ml/L
T3 200ml/L
T4 300ml/L

Effects of Different Rates of Herbicide on Calyx weight (kg/ha) of Sorrel in Maiduguri

Table five shows the effects of different rates of herbicides on calyx of sorrel in Maiduguri. There were significant differences among the treatments. Treatment 3 recorded the heaviest calyx weight of sorrel in Maiduguri, while treatment one and four gave the least weight of calyx of sorrel. Treatment 3 is the best rate for optimum calyx production of sorrel in Maiduguri.

Table 4.5: Effects of Different Rates of Herbicide on Calyx weight (kg/ha) of Sorrel

Treatments	Calyx (kg/ha)
T1	7.333[c]
T2	10.100[b]
T3	14.833[a]
T4	8.667[bc]
CV	13.40
SE	1.119

Means in the same column followed by the same letter are not significantly different according to LSD at 5% level of probability.

T1 Weedy check
T2 100ml/L
T3 200ml/L
T4 300ml/L

Conclusion

From the results of present study, it can be concluded that 200ml of herbicide (T3) tallest plants, gave highest number of leaves/plant, largest leaf area/plant, longest days to first flowering and 50% of plant to attain flowering and highest calyx weight (kg/ha), while treatment 1 (0.00ml) herbicide rate recorded the shortest plant and least number of leaves per plant. Also, treatment 1 and 4 gave smallest leaf area and least calyx weight (kg/ha) of sorrel in Maiduguri.

Recommendations

From the result of the present study, it is recommended that 200ml (T3) which give highest yield is the best for production of sorrel (*Hibicus sabdarifa L*) in Maiduguri.

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