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CULTIVAR AND WEED CONTROL STRATEGY INFLUENCING THE PRODUCTIVITY OF ROSELLE (*HIBISCUS SABDARIFFA* L.) IN A SEMI-ARID ENVIRONMENT OF NIGERIA

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Abstract: Field trial was conducted during the 2019/2020 cropping seasons to determine the effect of cultivar and weed control strategies on the productivity of roselle in a semi-arid environment. The trials comprised of two cultivars (deep red and white) and seven weed control strategies (pendimethalin at 2.0, butachlor 2.0, butachlor 1.5 + pendimethalin 1.5 kg a.i. ha^{-1}, butachlor 1.5 kg a.i. ha^{-1} + SHW at 6 WAS, pendimethalin 1.5 kg a.i. ha^{-1} + SHW at 6 WAS, hoe weeded twice at 3 and 6 WAS, and weedy check) which were factorially combined and replicated thrice in a Randomized complete block design. The application of pendimethalin at 2.0 kg a.i. ha^{-1}, as well as the deep red roselle cultivar, resulted in significant (P<0.01) increase in the number of days to 50% emergence, crop injury scores, and lowest stand count. The weedy check, on the other hand, recorded the lowest crop vigor score, plant height, number of leaves plant^{-1}, leaf area, and leaf area index. Similarly, weedy check had the lowest fresh fruit weight, fresh capsule weight, dried capsule weight, seed weight, seed yield, and 1000 seed weight when compared to the other weed control strategies. Weed cover and weed density were similar in weedy check compared to the other weed control strategies, but treatment efficiency index was significantly (P<0.01) higher with application of two hoe weeding's at 3 WAS and 6 WAS, butachlor 1.5 kg a.i. ha^{-1} + SHW at 6 WAS and pendimethalin 1.5 kg a.i. ha^{-1} + SHW at 6 WAS. Deep roselle cultivar outperformed white roselle in terms of growth and yield characters. Therefore, the cultivation of deep red roselle with butachlor and pendimethalin at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS can be adopted in place of hoe weeding for season long weed control in the study area.

Keywords: cultivar, productivity, roselle, yield, weed control strategy.

Introduction

The semi-arid ecology is an integral part of a dryland area found worldwide with an aridity index of 0.20-0.50 and with about 34% of its land under cultivation [SAFRIEL & al. 2005]. Dryland ecosystems are considered to be under threat [ADEEL & al. 2005; SAFRIEL & al. 2005] due to loss of biodiversity, increasing soil degradation, poverty, drought, and encroachment of invasive species which impede crop and livestock production [REYNOLDS & al. 2007; COTULA & al. 2006; 2009]. This can be mitigated by encouraging farmers to enhance their crop production ventures, especially those with household and industrial applications, since they have the potential to improve their socioeconomic standing. Crop production, on the other hand, faces a number of obstacles posed by biotic and abiotic stress, including determining which agronomic approaches are best for a given crop in a given ecosystem. Biotic variables are the most important component in ensuring a crop's predicted yield. Weed infestation becomes more significant among biotic variables depending on the weed

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flora and duration of weed competition [THAKUR *&* al. 2016]. Semi-arid dryland soil contains approximately 100-300 million buried weed seeds per hectare, of which only a percentage germinate and emerge each year, resulting in crop-weed competition for limited environmental resources [CHIKOYE *&* al. 2004]. Roselle (*Hibiscus sabdariffa* L.), of Malvaceae family, crop native to Central and West Africa. It is, however, mostly grown in tropical and subtropical places around the world for its tasty calyces [AMIN & al. 2008; PURSEGLOVE, 1991]. Apart from the nutritional and physiological benefits that the crop provides, it also provides a considerable source of revenue for subsistence rural farmers in Africa's drylands [NYARKO *&* al. 2006; ATTA *&* al. 2010]. The Roselle seeds until now do not have any commercial applications though they are a valuable food resource on account of their protein, calorie and substantial amount of fiber and valuable micro-nutrient [AKANBI *&* al. 2009; NORHAYATI & al. 2019]. The seeds contain an edible fixed oil (17-20%) similar with cotton seed oil properties [OTTAI *&* al. 2004; OTTAI & ABD-EL-KHAIR, 2004; HUSSEIN *&* al. 2010; HASSAN & al. 2014]. Roselle is more prone to weed infestation, especially at the beginning of its life cycle, because of its slow initial growth behavior, which reduces canopy cover. An effective weed management practices is necessary for higher crop production and better economic returns of any crop production venture. As a result, weed control in the crop has become increasingly important. The need to evaluate the effectiveness of some weed control strategies and choices of cultivars becomes imperative towards ensuring sustainable roselle production in the semi-arid dryland areas.

Materials and methods

Experimental site

The experiment was carried out during the 2019/2020 seasons at the Research and Training Farm of the Centre for Dry Land Agriculture, Bayero University Kano (12°43' N Latitude; 8°31'0.9" E Longitude; altitude of 481 m above sea level). The maximum temperature fluctuated between 29.7 °C and 40.2 °C, while the minimum temperature ranged between 20.7 °C and 26.5 °C, with a total amount of rainfall of 989.8 mm falling from June to October. The soil at the experimental site was sandy loam with a pH of 6.37, low organic carbon (0.49 g/kg), low available N (0.04 percent), low available P (31.7 mg/kg), and medium available K (0.19 cmol/kg).

Treatments and experimental design

The experiment included seven (7) weed control treatments and two roselle cultivars (white and deep red roselle) factorially combined and laid out in a randomize complete block design (RCBD) and replicated three (3) times.

Land preparation and sowing

Prior to marking out individual plots, the experimental field was harrowed twice. The gross and net plot was 3 x 4 m and 4.5 m^2 respectively, with 0.5 m and 1.0 m between subplots and replicates. Cultivars were sourced from the National Horticultural Research Institute (NIHORT) Kano Station, Bagauda, and 5 seeds of each cultivar were sowed per hole before being pruned to two plants per stand-1 at 2 WAS (weeks after sowing).

Treatment and fertilizer application

The herbicides were administered pre-emergence two days after sowing with a knapsack sprayer equipped with a blue deflector polyjet nozzle and set at 2.1 kg m^{-2} pressure to provide a spray volume of 250 L ha^{-1}. To avoid wind drift, the spraying was done first thing in the morning. Herbicides were used in accordance with the treatment plan. Hoe weeding was performed at 3 and 6 WAS for hoe weeded treatments, respectively, and at 6 WAS for the treatments assigned to additional hoe weeding. Weedy check plots were left unweeded for comparison during the experiment period. The optimal fertilizer rate was applied at 2 WAS at the rate of 300 kg ha^{-1} of N, P_2O_5, and K_2O in the form of NPK 20-10-10.

Data collection and Data analysis

Data were collected on growth and yield characters of roselle, as well as on weed attributes. The data acquired in the field was subjected to analysis of variance (ANOVA) using GENSTAT (17^{th} edition). Significant means were separated using the Student Newman-Keuls Test (SNK) at a 5% level of probability.

Results and discussion

Effect of weed control strategy and cultivar on growth characters

Weed control strategy was only significant on days to 50% emergence; weed control strategy and cultivar were both significant on crop injury scores, days to 50% flowering and stand count at harvest, but the interaction was only significant on crop injury score (Table 1). When compared to other weed control strategy that resulted in a lower number of days to 50% emergence; application of pendimethalin at 2.0 kg a.i. ha^{-1} considerably ($P \leq 0.05$) increased the number of days to 50% emergence, but was par with butachlor 2.0 kg a.i. ha^{-1} and butachlor 1.5 + pendimethalin 1.5 kg a.i. ha^{-1}. Pendimethalin at 2.0 kg a.i. ha^{-1} produced the greatest crop injury scores, however it was comparable to other strategies' that caused less crop injury (Table 1). Similarly, pendimethalin 2.0 kg a.i. ha^{-1}, pendimethalin 1.5 + butachlor 1.5 kg a.i. ha^{-1}, and pendimethalin 1.5 kg a.i. ha^{-1} + SHW at 6 WAS resulted in a lower stand count as compared to other weed control strategies that led in a greater stand count. Weedy check significantly ($P \leq 0.05$) in increasing the number of days to 50% flowering though at par with application of pendimethalin at 2.0 kg a.i. ha^{-1}. The remaining weed control strategies, on the other hand, resulted in decreased number of days to 50% flowering (Table 1). In comparison to the white roselle cultivar, the deep red roselle cultivar produced the highest crop injury scores and longest days to 50% flowering. Stand count was significantly ($P \leq 0.01$) higher with white cultivar. Significant interaction was observed on crop injury scores (Table 2). The application of pendimethalin 2.0 kg a.i. ha^{-1} to deep red roselle resulted in the greatest injury score, closely followed by the same treatment applied to white roselle, while other treatments resulted with lower injury values throughout the cultivars. The increase in number of days to 50% emergence, crop injury scores, as well as low stand count obtained in pendimethalin applied at 2.0 kg a.i. ha^{-1} and other pendimethalin combinations might be due to the phytotoxic effect of the herbicide on the cultivars. IMOLOAME & al. (2011) in sesame; DANTATA & SHITTU (2014) in sorghum and SHITTU & al. (2021) in roselle, all observed phytotoxic effects of pendimethalin on small-seeded crops, as evidenced by reduced stand counts and high crop injury scores. This confirms the herbicide's ability to include mitotic poisons that impair cell division in susceptible crops and weed seeds. However, depending on their genetic make-up, some sensitive crop genotypes may be able to metabolize it. Weed control strategy was highly significant ($P \leq 0.01$) on crop vigor, whereas cultivars and their interaction did not differ significantly.

Table 1. Effect of weed control strategy and cultivar on days to 50% emergence, crop injury score, days to 50% flowering, stand count at harvest of roselle during 2019/2020 (pooled data)

Treatment	Days to 50% emergence	Crop injury scores	Days to 50% flowering	Stand count at harvest
Weed control strategy (W)				
Weedy check	4.17	-	88.17^{a}	18.50^{a}
Hoe weeded at 3 and 6 WAS	4.33	-	83.33^{b}	21.67^{a}
Pendimethalin at 2.0 kg a.i. ha^{-1}	5.00	5.50^{a}	85.33^{ab}	11.33^{b}
Butachlor at 2.0 kg a.i. ha^{-1}	4.67	2.88^{b}	83.67^{b}	21.67^{a}
Butachlor at 1.5 + Pendimethalin 1.5 kg a.i. ha^{-1}	4.67	2.17^{c}	85.50^{b}	12.83^{b}
Butachlor at 1.5 kg a.i. ha^{-1}+ SHW at 6 WAS	4.17	2.17^{c}	84.33b	22.33^{a}
Pendimethalin at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS	4.00	3.00^{b}	85.67^{b}	12.00^{b}
Level of probability	0.253	0.039	0.002	<0.001
SE(±)	0.303	0.134	0.731	1.139
Cultivar (C)				
White roselle	4.24	2.80^{b}	76.38^{b}	18.81^{a}
Deep red roselle	4.62	3.07^{a}	93.90^{a}	15.57^{b}
Level of probability	0.108	<.001	<0.001	<0.001
SE (±)	0.162	0.030	0.391	0.609
Interaction				
W x C	0.957	0.030	0.558	0.357

Means followed by the same superscripts in a column are not significantly different at 5% according to Student-Newman-Keuls test (SNK). WAS = weeks after sowing, SHW = supplementary hoe weeding, SE = Standard Error.

Table 2. Interaction between weed control strategy and cultivar on crop injury score of roselle during 2019/2020 (pooled data)

Cultivar	Weed control strategy						
	T1	T2	T3	T4	T5	T6	T7
White roselle	-	-	4.00^{b}	2.67^{cd}	2.00^{cd}	2.33^{cd}	3.00^{c}
Deep red roselle	-	-	5.00^{a}	3.00^{c}	2.33^{cd}	2.00^{d}	3.00^{c}
SE(±)	0.189						

Means followed by the same superscripts in a column are not significantly different at 5% according to Student-Newman-Keuls test (SNK). T1 = Weedy check; T2 = Hoe weeded at 3 and 6 WAS; T3 = Pendimethalin at 2.0 kg a.i. ha^{-1}; T4 = Butachlor at 2.0 kg a.i. ha^{-1}; T5 = Butachlor 1.5 + Pendimethalin 1.5 kg a.i. ha^{-1}; T6 = Butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS; T7 = Pendimethalin at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS; SE = Standard Error.

Plant height, number of leaves, leaf area, and leaf area index were also significant as a result of the weed control strategy and cultivar (Table 3). The application of Butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS was highly significantly ($P \leq 0.01$) and produced the most robust plant, followed by hoe weeding twice at 3 and 6 WAS and butachlor at 2.0 kg a.i. ha^{-1}. Other treatments, such as weedy checked, resulted in less vigorous plants. Application of butachlor at 2.0 kg a.i. ha^{-1}, butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS, and hoe weeded twice at 3 and 6 WAS increased plant height substantially more than other treatments that resulted in decreased plant height (Table 3). Hoe weeded twice at 3 and 6 WAS was highly significant ($P \leq 0.01$) and resulted in more number of leaves, followed by butachlor 2.0 and butachlor 1.5 kg a.i. ha^{-1} + SHW at 6 WAS, compared to other treatments that resulted in a significantly lower number of leaves, with weedy check recording the lowest number of leaves $plant^{-1}$ (Table 3). Application of butachlor at 2.0 kg a.i. ha^{-1} was highly significant (P≤0.01) and produced the widest leaves which were closely followed by hoe weeded twice at 3 WAS and 6 WAS, butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS in comparison with other treatments that resulted in wider leaves, while weedy check recorded the narrowest leaf (Table 3). Hoe weeded twice at 3 and 6 WAS, and butachlor at 2.0 kg a.i. ha^{-1} was highly significant (P≤0.01) and increased LAI, though at par with butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS and pendimethalin at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS, compared with weedy check that significantly resulted in the decrease LAI (Table 3). The white roselle cultivar produced significantly taller plants than the Deep red, which produced shorter plants. At 12 WAS, the deep red roselle cultivar considerably (P≤0.05) produced a greater number of leaves $plant^{-1}$, leaf area, and leaf area index, whereas the white roselle produced the lower values, respectively (Table 3). The increase in plant aspect caused by butachlor application at 2.0 kg a.i. ha^{-1} and butachlor application at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS might be attributed to more effective weed management with less phytotoxic effect as compared to pendimethalin rates. RAJU & MITRA (2020) observed that the use of Pretilachlor 50 EC (900 ml ha^{-1}) + one-hand weeding resulted in the best growth parameters and fibre output of roselle. Similarly, SHITTU *&* al. (2021) also reported the efficacy of butachlor at 2.0 kg a.i. ha^{-1} and butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS on calyx yield of roselle in Nigeria's Sudan savanna region.

Table 3. Effect of weed control strategy and cultivar on crop vigor scores, plant height, number of leaves, leaf area and leaf area index of roselle during 2019/2020 (pooled data)

Treatment	Crop vigor at 12 WAS	Plant height (cm) at 12 WAS	Number of leaves at 12 WAS	Leaf area (cm^2) at 12 WAS	Leaf area index at 12 WAS
Weed control strategy (W)					
Weedy check	3.83^{d}	56.98^{b}	59.67^{e}	137.8^{d}	1.57^{c}
Hoe weeded at 3 and 6 WAS	7.33^{b}	83.86^{a}	115.48^{a}	217.8^{a}	2.91^{a}
Pendimethalin at 2.0 kg a.i. ha^{-1}	4.83^{c}	58.70^{b}	69.63^{d}	160.5^{cd}	2.16^{b}
Butachlor at 2.0 kg a.i. ha^{-1}	7.17^{b}	90.79^{a}	104.43^{b}	221.9^{a}	2.81^{a}
Butachlor at 1.5 + Pendimethalin 1.5 kg a.i. ha^{-1}	5.00^{c}	60.56^{b}	75.87^{cd}	167.8^{cd}	2.16^{b}
Butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS	8.50^{a}	84.17^{a}	106.96^{b}	200.1^{ab}	2.66^{ab}
Pendimethalin at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS	5.50^{c}	65.19^{b}	79.62^{c}	183.0^{bc}	2.44^{ab}
Level of probability	<0.001	<0.001	<0.001	<0.001	<0.001
SE(±)	0.328	2.369	2.152	9.02	0.151
Cultivar (C)					
White roselle	6.10	76.54^{a}	85.60^{b}	132.6^{b}	1.77^{b}
Deep red roselle	5.95	66.39^{b}	89.16^{a}	235.6^{a}	2.99^{a}
Level of probability	0.570	<0.001	0.038	<0.001	<0.001
SE(±)	0.175	1.266	1.150	4.82	0.081
Interaction					
W x C	0.166	0.833	1.010	0.49	0.952

Means followed by the superscripts in a column are not significantly different at 5% according to Student-Newman-Keuls test (SNK). WAS = weeks after sowing; SHW = supplementary hoe weeding; SE = Standard Error.

Effect of cultivar and weed control strategies on yield and yield related characters

Table 4 presents the effect of cultivar and weed control strategy on number of fruits plant^{-1}, fresh fruit weight, fresh capsule weight, dry capsule weight, seed weight, seed yield and 1000 seed weight of roselle. Weed control strategy was highly significant ($P \leq 0.01$) with all the yield characters, cultivar was significant ($P < 0.05$) except with fresh capsule weight and 1000 seed weight while interaction was not significant ($P > 0.05$) across the yield and yield related characters (Table 4). The application of butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS was highly significant ($P \leq 0.01$) and produced the height number of fruits plant^{-1} compared with the remaining weed control strategy. However, it was at par with two hoe weeding's at 3 and 6 WAS and butachlor at 2.0 kg a.i. ha^{-1} compared with the rest of the treatment that produced lower number of fruits plant. Fresh fruit weight was highly significant ($P \leq 0.01$) with the application of hoe weeding twice at 3 and 6 WAS, though at par with other weed control strategy that resulted in higher values compared to weedy check that significantly produced the lowest fresh fruit weight (Table 4). Fresh and dry capsule weight were significantly ($P \leq 0.01$) highest with the application of hoe weeding twice at 3 and 6 WAS, butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS and pendimethalin at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS compared with other weed control strategies that produced lower while weedy check substantially produced the lowest fresh and dry capsule weight of roselle (Table 4). Seed weight and seed yield was significantly highest with hoe weed d twice at 3 and 6 WAS though statistically comparable with the remaining weed control strategy with the exception of weedy check which significantly produced the lowest seed weight and seed yield (kg ha^{-1}) of roselle (Table 4). All weed control strategy except weedy check significantly produced higher 1000 seed weight of roselle. Similarly, the deep roselle cultivar outweighed the white roselle by significantly ($P \leq 0.01$) producing the highest number of fruits plant^{-1}, fresh fruit weight, dry capsule weight, seed weight and seed yield ha^{-1}, respectively (Table 4). The increased yield and yield related characters in these treatments might be due to effective control of weeds during the critical period as evidenced by low weed cover scores, weed density and high treatment efficiency index, which favored the increased crop growth and ultimately on yield components and yield of the crop. This corroborates with the findings of AMARA JYOTHI *&* al. (2018) who reported high yield and yield components of roselle due to application of Butachlor 50% EC at 1.5 kg a.i. ha^{-1} at 45-48 hours of sowing + one hand weeding. This is also supported by the findings of SHITTU *&* al. (2021) who confirms the increased in calyx yield of roselle due to application of butachlor at 1.5 kg a.i. ha^{-1}. In another development by SHITTU (2023), the productivity of Tomatoes was greatly enhanced due to effective weed management owing to the application of butachlor at 1.5 and 2.0 kg a.i. ha^{-1} + SHW at 6 WAS.

Table 4. Effect of weed control strategy and cultivar on number of fruits, fresh fruit weight, fresh capsule weight, dry capsule weight, seed weight, seed yield and 1000 seed weight of roselle during 2019/2020 (pooled data)

Treatment	Number of fruits $plant^{-1}$	Fresh fruit weight (g)	Fresh capsule weight (g)	Dry capsule weight (g)	Seed weight (g)	Seed yield (Kg ha^{-1})	1000 seed weight (g)
Weed control strategy (W)							
Weedy check	7.00^{c}	62.9^{e}	29.20^{c}	11.06^{c}	7.32^{d}	822^{d}	23.67^{b}
Hoe weeded at 3 and 6 WAS	18.50^{ab}	165.9^{a}	75.17^{a}	25.06^{a}	17.08^{a}	2305^{a}	35.67^{a}
Pendimethalin at 2.0 kg a.i. ha^{-1}	8.33^{c}	70.5^{b-d}	42.69^{b}	15.64^{b}	10.21^{bc}	1196^{cd}	34.33^{a}
Butachlor at 2.0 kg a.i. ha^{-1}	13.67^{bc}	129.8^{abc}	45.64^{b}	16.08^{b}	12.20^{abc}	1753^{abc}	32.67^{a}
Butachlor 1.5 + Pendimethalin 1.5 kg a.i. ha^{-1}	9.67^{c}	76.4^{b-d}	40.45^{b}	14.55^{b}	10.63^{bc}	1368^{bcd}	31.33^{a}
Butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS	22.17^{a}	131.7^{ab}	73.80^{a}	24.01^{a}	15.28^{ab}	2033^{ab}	37.00^{a}
Pendimethalin at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS	10.17^{c}	83.2^{bd}	70.07^{a}	21.47^{a}	15.25^{ab}	1902^{ab}	32.50^{a}
Level of probability	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SE (±)	1.737	15.21	3.39	1.397	1.394	173.1	1.581
Cultivar (C)							
White roselle	11.40^{b}	92.51^{b}	54.50	16.64^{b}	11.71^{b}	1513^{b}	32.62
Deep red roselle	14.43^{a}	113.31^{a}	53.21	19.89^{a}	13.42^{a}	1738^{a}	32.29
Level of probability	0.019	0.032	0.620	0.005	0.017	0.098	0.783
SE (±)	0.928	8.13	1.81	0.747	0.745	92.5	0.845
Interaction							
W x C	0.572	0.108	0.156	0.349	0.878	0.856	0.747

Means followed by the same superscripts in a column are not significantly different at 5% according to Student-Newman-Keuls test (SNK). WAS = Weeks after sowing, SHW = Supplementary hoe weeding; SE = Standard Error.

Effect of cultivar and weed control strategies on weed parameters

Table 5 presents the effect of cultivar and weed control strategy on weed cover scores, weed density and herbicide efficiency index of roselle. Weed cover cores was highly significant ($P \leq 0.01$) and highest in weedy check compared with other weed control strategy that resulted in lower weed cover scores. Similarly, weed density was highest in weedy check compared with the remaining weed control strategy. However, the application of hoe weeded twice at 3 and 6 WAS, pendimethalin at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS and butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS significantly ($P \leq 0.01$) produced the lowest weed cover scores in roselle (Table 5). Treatment efficiency index was highly significantly ($P \leq 0.01$) and highest in hoe weeded twice at 3 and 6 WAS compared with the remaining weed control strategy. However, it was closely followed by the application of butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS and pendimethalin at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS which had higher treatment efficient index compared with the rest of the weed control strategy that resulted in lower TEI (Table 5). Uninterrupted weedy conditions resulted in high weed cover scores and weed density being obtained in weedy check plots. However, application of herbicide either alone or supplemented with hoe weeding at 6 WAS resulted in lower weed cover scores, weed density, as well as an enhanced treatment efficiency index as compared with the weedy check. Similar findings were reported by various scholars on reduced weed cover score and weed density as well as increased weed control efficiency in roselle due to pre-emergence herbicide application [AMARA JYOTHI *&* al. 2018; RAJU & MITRA, 2020; SHITTU *&* al. 2021; SHITTU & BASSEY, 2023; SHITTU, 2023].

Table 5. Effect of weed control strategy and cultivar on weed cover scores, weed density and treatment efficiency index of roselle during 2019/2020 (pooled data)

Treatment	Weed cover scores	Weed density (n m^{-2})	Treatment efficiency index (TEI)
Weed control strategy (W)			
Weedy check	4.45^{a}	185.50^{a}	-
Hoe weeded at 3 and 6 WAS	1.20^{d}	15.00^{d}	34.45^{a}
Pendimethalin at 2.0 kg a.i. ha^{-1}	2.90^{bc}	66.33^{c}	8.59^{d}
Butachlor at 2.0 kg a.i. ha^{-1}	3.05^{b}	132.50^{b}	9.28^{d}
Butachlor 1.5 + Pendimethalin 1.5 kg a.i. ha^{-1}	2.53^{bc}	89.33^{c}	9.58^{d}
Butachlor at 1.5 kg a.i. ha^{-1}+ SHW at 6 WAS	2.00^{bcd}	24.00^{d}	15.29^{b}
Pendimethalin at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS	1.67^{cd}	23.00^{d}	12.55^{c}
Level of probability	<.001	<.001	<0.001
SE (±)	0.334	11.03	0.445
Cultivar (C)			
White roselle	2.70	82.5	14.30^{b}
Deep red roselle	2.39	70.5	15.60^{a}
Level of probability	0.238	0.162	0.002
SE (±)	0.178	5.89	0.257
Interaction			
W x C	0.976	0.514	0.344

Means followed by the same superscripts in a column are not significantly different at 5% according to Student-Newman-Keuls test (SNK). WAS = weeks after sowing, SHW = supplementary hoe weeding; SE = Standard Error; Weed cover score by visual observation on a scale of 1-5; 1 = less weed cover and 5 = highly infested weed cover.

Conclusion and Recommendation

In arid places, the communities are highly unique. Others rely on natural resources less, while others rely on them more. Environmental variability, combined with rising population levels and increased competition for crop growth resources between crop and weed biotypes, emphasizes the need for an effective weed control strategy that can promote viable roselle growth and seed yield as an alternative to hoe weeding, which is a common farmer practice for combating weeds, thereby increasing farmers' income and investment options in roselle production. Based on the findings from this trial, it can be concluded that application of butachlor at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS and pendimethalin at 1.5 kg a.i. ha^{-1} + SHW at 6 WAS be recommended as alternative to two hoe weeding’s, which is the farmer's practice in the dry land ecology of Nigeria, as it increases fresh fruit weight, fresh and dry capsule weight, and seed yield, which was also traced to the deep red cultivar, and effectively results in the lowest weed cover scores and weed density as well as enhances the treatment efficiency index. Hence, farmers in this area can be encourage to adopt this strategy of combating weed menace in roselle farm.

Conflict of interest

The authors declare no conflict of interest.

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