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Effectiveness of Selected Cultural, Biological and Chemical Methods Singly or in Integration as Management Options against Kongwa Weed (*Astripomoea hyoscyamoides* Vatke Verdc.)

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Abstract

Kongwa weed (*Astripomoea hyoscyamoides* Vatke Verdc.) cause's damage on pasture productivity. This study was carried-out to evaluate the effectiveness of cultural, biological and chemical methods singly or in integration as management options. The experiment was conducted at two sites 2.2 km apart within Kongwa District Dodoma region. Site A located at 06.06225S, 36.34204E and 992 masl, characterized with low weed population, and site B located at 06.07862S, 36.32756E and 962 masl, characterized with high weed population, both with sandy loam texture. A randomized complete block designs with four replicates were used at both sites. Site A contained five treatments while site B had 12 treatments as weed management techniques applied in paddocks occupied with buffel grass (*Cenchrus ciliaris*) and star grass (*Cynodon dactylon*), respectively. Results showed that, at site A treatment M. azedarach significantly affected the number of Kongwa weed survivor (5) and number of weed leaves (7), similar effect observed on pasture yield of (8.9 ton ha^{-1}) in the same treatments at $p<0.001$. However results on site B showed that, number of weed leaves (14), height (37.55 cm) and girth (3 mm) were significantly affected at $p<0.001$ by 2,4-D treatment, while cutting+ *Melia azedarach* treatment was significantly affected weed survivor 10 at $p<0.001$ compared to other applied treatments. Further hand pulling+*Melia azedratch* and cutting+2, 4-D) had significant influence on pasture yield of 14.02 ton ha^{-1} at $p<0.001$ compared to other treatments. Integrated weed management (cutting+*Melia azedarach*, hand pulling+*Melia azedarach* and cutting+2, 4-D were more effective than single treatment when applied in high weed infestation. It is recommended that, integrated weed management could be applied in high weed infestation, whereas herbicides or plant extracts could be applied singly in low weeds infested rangelands.

Keywords: Kongwa weed; Allelopathy; Noxious; Invasive

Introduction

According to Rao and Nagamani weed management is a science based on decision making process that directs the use of ecology, weed biology and environment information and all available technologies to control weeds by the most economical and ecologically viable methods [1]. But it is encountered with a daunting set of challenges such as weed resistance to herbicides, environmental damage caused by control practices, greater weed impacts due to changes in climate and land use and accelerated rates of weed dispersal through global trade [2]. However, managing invasive weeds species in rangelands has several challenges including remoteness (massive roadless areas) that limit access for weed control, and lands of low economic value that make chemical and mechanical control impractical [3]. These challenges support the use of various weed control methods such as cultural and biological methods applied in integration.

Manipulating the pasture ecosystem, focusing on plant competition and allelopathy could facilitate sustainable management of broadleaf weeds in perennial pasture [4]. Using singly weeds control method alone would be unsuccessful with weeds challenges. Rather, their user will need to be integrated with a range of other weed management strategies and the practical use of herbicides [5]. These studies indicate that broadleaf weeds like Kongwa weed in perennial pasture are amenable to mitigation using available weed control methods. Kongwa weed (*Astripomoea hyoscyamoides* Vatke Verdc.) is among obstacles to rangeland productivity through their ability of competing for resources and causing negative impact on forage quality [6]. Kongwa weeds have been reported to cause pasture losses up to 100% if not managed [6,7]. Since Kongwa weed was reported in the central zone of Tanzania, the weed has moved beyond the open areas and continued to invade a wide range of agro-ecosystems [6]. The weeds reported to reduce both crop yield and the amount of forage available to livestock on both public and private grazing lands [8]. Although Kongwa weed covers more than 70% of the Kongwa Ranch and had a notable negative impact on pasture production, to date there is only one consistent research result reported in the area [6]. Farmers have experienced heavily infested grazing and crop land when the weeds reach unmanageable levels, resulting in food insecurity and increased loss of household income.

Recently, stocking density in Kongwa ranch declined by 10% annually due to insufficient animal feed resulting from pasture displacement caused by the weeds infestation [9,10]. The study was conducted to evaluate the effectiveness of selected cultural, biological and chemical methods singly or in integration as management options against Kongwa weed.

Materials and Methods

Description of the study sites

The study was conducted at two sites in Kongwa district of Dodoma region with different weeds population and growth stage. Site A located at 06.06225S, 36.34204E and 992 m above the sea levels, the field is occupied with low weed population in vegetative growth stage while site B located at 06.07862S, 36.32756E and 962 m above the sea levels, the field occupied with high weeds population during flowering stage **(Figure 1)**. The study area is semi-arid zone, with an average annual rainfall of 500 mm-800 mm, which falls between December and April. Rainfall is unimodal, unpredictable, and poorly distributed with high variation within and between seasons [6]. The mean temperature is 26.5°C, but sometimes gradually changes up to 11°C. The cool weather occurs between January and June when temperature ranges between 20-33°C and the highest temperature recorded is 31°C while the lowest temperature is 18°C [11]. The dominant soil types are classified as Chromic Luvisols with a sandy loam texture [12].

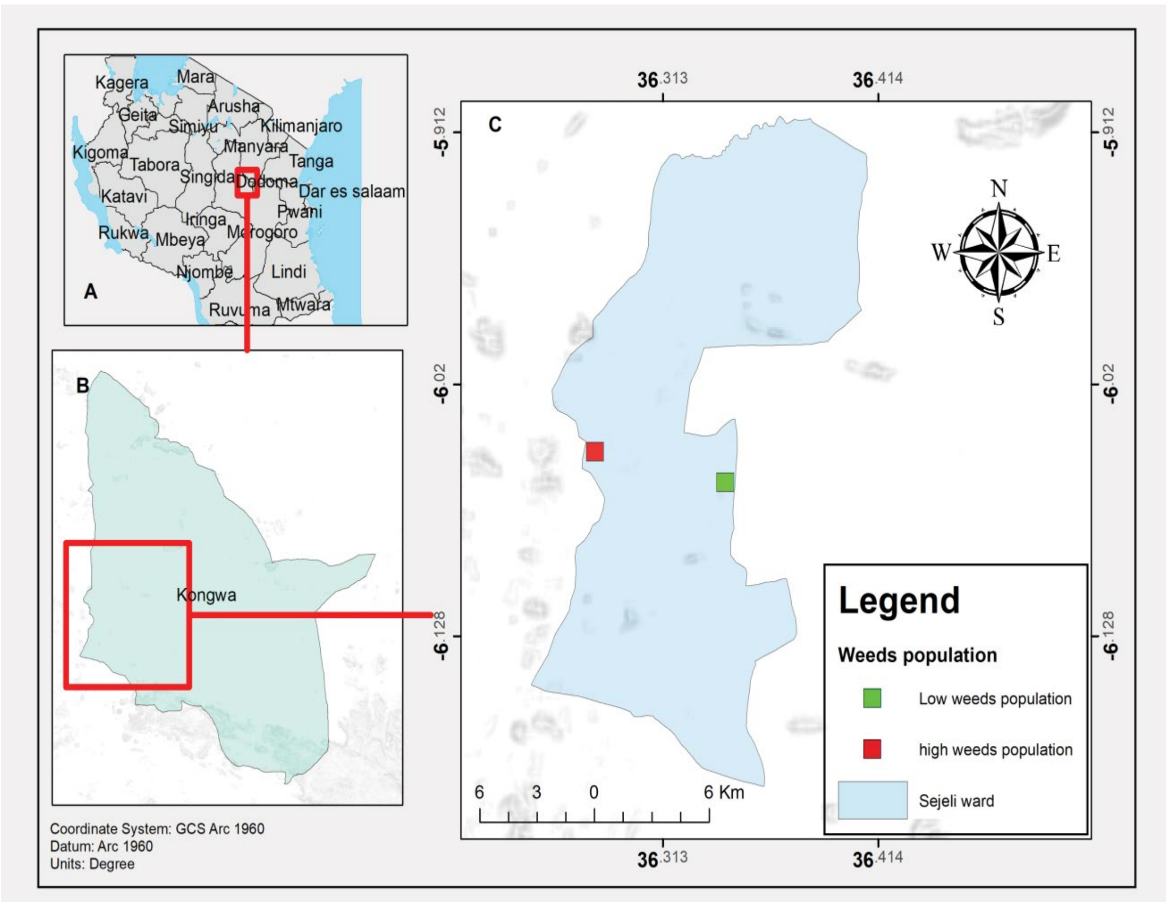

Figure 1 A represent Tanzania, B represent Kongwa District and C represent experimental site.

Table 1: Materials used as weed management practices evaluated in site A.

S/No.	Treatments	Descriptions
1	**Melia azedarach**	Aqueous plant extract from **Melia azedarach** applied at a rate of 10 gL^{-1} sprayed once using a knapsack sprayer in natural established pasture.
2	**Ricinus communis**	Aqueous plant extract from castor **Ricinus communis** applied at a rate of 10 g L^{-1} sprayed once using a knapsack sprayer in natural established pasture.
3	2,4-D	Application of 2, 4-Dichlorophenoxyacetic acid (2, 4-D) at application rate of 2 L ha^{-1} in 150 litres of water (267 ml 20 L^{-1} of water) sprayed once using a knapsack sprayer in natural established pasture.
4	Hand- pulling	Pulling done once, only Kongwa weed were uprooted in the plot

Table 2: Materials used as weed management practices evaluated in site B.

S/No.	Treatments	Descriptions
For treatment description step number 1 to 4 were as already described for site A **Table 1** of this study.		
5	Hand-pulling+ *M. azedarach*	Pulling done once, only Kongwa weed were uprooted in the plot flowed by application of *M. azedarach* applied at a rate of 10 g L^{-1} sprayed once using knapsack sprayer in natural established pasture.
6	Hand-pulling+ *R. communis*	Pulling done once, only Kongwa weed were uprooted in the plot flowed by application of *R. communis* applied at a rate of 10 g L^{-1} sprayed once using knapsack sprayer in natural established pasture.
7	Cutting+ *M. azedarach*	Cutting done once by using machete only Kongwa weed were slashed, flowed by application of *M. azedarach* applied at rate of 10 g L^{-1} sprayed once using knapsack sprayer in natural established pasture.
8	Cutting+ *R. communis*	Cutting done once by using machete only Kongwa weed were slashed, flowed by application of *R. communis* applied at rate of 10 g l^{-1} sprayed once using knapsack sprayer in natural established pasture.
9	Cutting+2,4-D	Cutting done once by using machete only Kongwa weed were slashed flowed by application of 2, 4-Dichlorophenoxyacetic acid (2, 4-D) at application rate of 2 L ha^{-1} in 150 litres of sprayed once using knapsack sprayer in natural established pasture.
10	Hand-pulling+2,4-D	Pulling done once, only Kongwa weed was uprooted in the plot flowed by application of 2, 4-Dichlorophenoxyacetic acid (2, 4-D) at application rate of 2 l ha^{-1} in 150 litres of water sprayed once in natural established pasture.
11	Cutting	Cutting done once by using machete only Kongwa weed were slashed
12	Control	No weed management practices applied.

Description of experimental material

Here we are giving the description of experimental material in site A and site B. In **Table 1** we are giving the details of materials used as weed management practices evaluated in site A and in **Table 2** materials used as weed management practices evaluated in site B.

Preparation of plant extract as bio-herbicides

Standard procedures of Nekonam et al. for preparation of aqueous plant extracts *R. communis* and *M. azedarach* were followed [13]. The aerial plant parts (mixture of old and young leaves) samples of *R. communis* and *M. azedarach* were collected from Kongwa District. The samples were air dried and ground to get fine powder. Extracts were prepared for each plant species using the fine powder at concentrations of 10 g L^{-1}, 100 g of the powder was added into 1000 ml of distilled water to prepare aqueous extract with, 10 g L^{-1}concentration. Then the mixture was left at ambient condition for 24 hrs, then filtered through filter paper and used as a source of bio-herbicides. The supernatant solution of each plant extract after filtration was applied in a field as bio-herbicides. However, 2, 4-Dichlorophenoxyacetic acid (2, 4-D) at application rate of 2 L ha^{-1} in 150 litres of water (267 ml 20 L^{-1} of water) was purchased from the nearby Agro dealers at Kongwa.

Experimental design

The experiment at site A was laid out in Randomized Complete Block Design (RCBD) with five treatments replicated four times. Each replication contained five treatments: *M. azedarach*, *R. communis*, 2, 4-D, Hand pulling and Control as weed management practices. Treatments were applied in a selected paddock occupied with *Cenchrus ciliaris*, the paddock were covered with low Kongwa weed infestation during vegetative stage. The dimension of each plot was 5 m × 5 m and the distance between the plots was 1m. The distance between one replication and another was 1 m. All treatments were applied to existing natural vegetation in grassland. The experiment was carried from 13, January to 13 March 2020.

The study at site B was laid out in a Randomized Complete Block Design (RCBD) with 12 treatments replicated four times. Each replication contained 12 treatments. *M. azedarach*, hand pulling+*M. azedarach*, cutting+*M. azedarach, R. communis,* cutting+*R. communis*, 2,4-D, hand pulling+2,4-D, cutting+2,4-D, cutting, hand pulling and control treatments was applied in a selected paddock occupied with *Cynodon dactylon* highly infested with Kongwa weed during flowering stage. The dimension of each plot, distance between plots, distance between replication and treatments allocation were as described in site A. The experiment was carried out from 17, February to 17 April 2020.

Data collection

After treatments application, Kongwa weed and pasture species (*Cenchrus ciliaris* in site A and *Cynodon dactylon* in site B) were sampled from two quadrants of 1 m × 1 m at seven days intervals (7, 14, 21 and 28 days after treatment application) in each plot using zigzag method. The number of survived weed, number of weed leaves, number of pasture leaves and pasture tillers were counted and recorded. Weed plants and pasture height was measured from the ground to the top of a growing tip by stretching its leaves upwards using a measuring tape. Weed plants and pasture girth was measured using a vernier caliper, measurements were taken from the center of the stem (a point between the rhizosphere and the canopy).

Sixty (60) days after treatment's application, pasture and weed were harvested using a sickle, therefore pasture species were separated from Kongwa weed and other plant species, then sun dried for three days to biomass. Hays were prepared in bundles for per harvested plot; Kongwa weed and other plant species were also prepared in different bundles. Using portable electronic weighing scale, the weight of pasture species, Kongwa weed and weight of other weeds were determined and recorded. Finally, the recorded weights were converted into kilogram per hectare (ha).

Statistical analysis

The collected data were subjected to analysis of variance (ANOVA) at ($p \leq 0.05$) using GenStat 16th Edition statistical package. Treatment means were separated using Turkey's, significant test at 5% level.

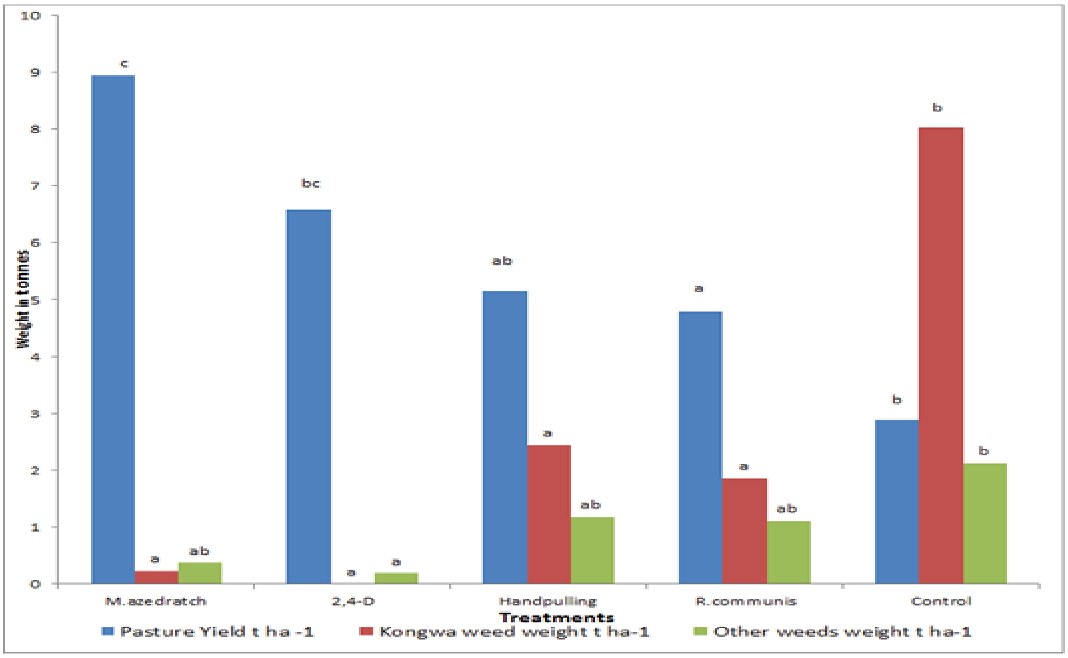

Figure 2 Treatments effect on weed weight and pasture yield at site A.

Table 3: Treatment effects on weed and pasture performance at site A.

Treatments	No. of Survived weeds	No. of leaves weed^{-1}	Weed height (cm)	Weed girth (mm)	Pasture height (cm)	Pasture girth (mm)	No of leaves plant^{-1}	No. of tillers
M. azedratch	4.53a*	6.65a	26.35a	1.73a	115.7	2.51	17.88	21.13
2,4-D	4.80a	8.05a	24.88a	1.57a	112.6	2.65	16.8	19.08
R. communis	6.80a	9.50a	43.38a	2.53ab	108.7	2.6	17.18	19.1
H. pulling	8.45a	17.62a	51.00a	2.81ab	110.4	2.63	16.58	18.5
Control	27.30b	38.42b	84.10b	4.98b	112.5	2.31	16.8	21.25
Mean	10.4	16	45.9	2.7	112	2.5	17	19.8
SD	1.71	2.94	12.48	0.38	7.5	0.26	2.64	2.32
CV%	16.4	18.4	27.2	13.9	6.7	10.2	15.5	11.7
p-value	0.001	0.001	0.001	0.01	0.74	0.38	0.96	0.34

*Means in the same column, followed by the same letter(s) do not differ significantly ($p \leq 0.05$) according to Tukey's honestly test; CV: Coefficient of Variation; SD: Standard Deviation

Results

Treatments effect on weed and pasture performance at site A

Weed management practices had a very highly significant effect on the number of Kongwa weed survived, number of weed leaves and weed height at p<0.001. *M. azedarach* treatment resulted in the lowest number of weeds surviving 5 m^{-2}, number of weed leaves 7 per plant, while control resulted in the highest value. Further weed girth was significantly influenced by the weed management practices applied at p<0.01 as indicated in **Table 3**.

Treatments effect on pasture yield and weed weight at site A

Figure 2 shows treatments effect on weed weight and pasture yield at site A. Kongwa weed weight (0.2-ton ha^{-1}), were very significantly affected at p<0.001 when treatment *M. azedarach* was applied likewise pasture yield of 8.9-ton ha^{-1} was very significantly influenced at p<0.001 in the same treatment. While other weeds weigh (0.4-ton ha^{-1}) were significantly affected at p=0.03 by 2, 4-D treatment. However untreated plots (control) had highest Kongwa weed weight (8.0-ton ha^{-1}), other weeds weight (2.1-ton ha^{-1}) and lowest pasture yield (2.9-ton ha^{-1}) than the other applied treatments.

Relationship between weed survival and pasture performance at site A

The regression analysis showed that the number of leaves per plant were significantly positive collated to pasture girth with R=0.44 at p<0.05 as expected number of survived weeds had a significant negative collation (R=-0.64) at p<0.01 to pasture yield (*Cenchrus ciliaris*). The remaining variables were not significantly collated at p<0.05 as indicated in **Table 4**.

Table 4: Relationship between weed survival and pasture performance at site A.

	Pasture height (cm)	Pasture girth (mm)	No. of leaves plant^{-1}	No. of tillers plant^{-1}	Pasture yield ton ha^{-1}	No. of Survived weeds
Pasture height (cm)	1					
Pasture girth (mm)	0.08	1				
No. of leaves plant-1	-0.13	0.44*	1			
No. of tillers	-0.21	-0.27	0.26	1		
Yield plot-1	0.05	-0.04	-0.05	0.23	1	
No. of Survived weed	0.05	-0.33	0.14	0.34	-0.64**	1
n=20, df =n^{-2}, *Significant liner correlation p=0.05 and **Significant liner correlation p=0.01						

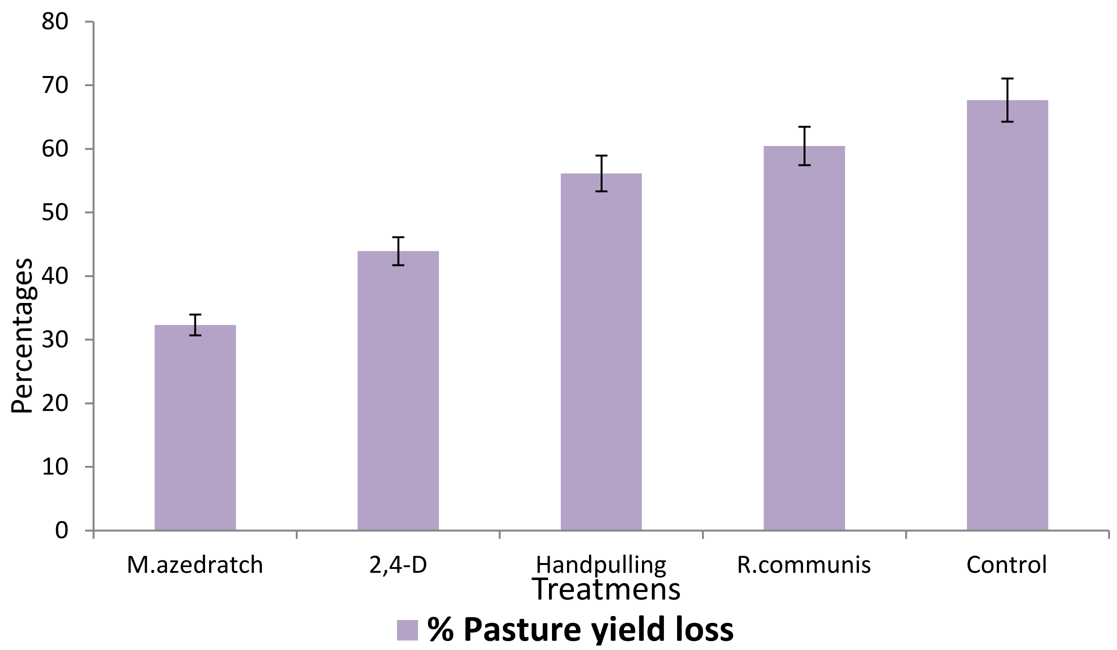

Figure 3 Percentage pasture yield loss at A.

Percentage pasture yield loss due to Kongwa weed in site A

Results on yield loss coursed by Kongwa weed infection on pasture yield are shown in **Figure 3**. Yield losses ranged from 32 for *M. azedarach* treatment to 68% for the control treatments at site with low weed infestation.

Treatments effect on Kongwa weed and pasture performance at site B

Table 5 shows treatments' effect on Kongwa weed and pasture performance at site B. The results on number of weed leaves (14), weed height (37.55 cm) and weed girth (3 mm) were significant affected at p<0.001 by 2,4-D treatment, while Cutting+ *M. azedratch* treatment was significantly effect at p<0.001 on the number of survived weed 10 compared to other applied treatments. However, treatments hand pulling+*M. azedarach* and cutting+2, 4-D) had significant influence at p<0.001 on pasture yield of 14.02-ton ha^{-1} compared to other applied treatment.

Influence of treatments on pasture yield and weed weight in site B

Figure 4 shows the influence of treatments on pasture yield and weed weight in site B. Pasture yield of 14.02-ton ha^{-1} was significantly influenced at p<0.001 by treatments hand pulling+ *M. azedarach* and cutting+2, 4-D than other applied treatments. Kongwa weed weight was significantly affected at p<0.001 under hand pulling+2, 4-D followed by cutting+2, 4-D (0.14-ton ha^{-1}) and 2, 4-D only (0. ton ha^{-1}). Further other weed weight were significant affected at p<0.001 by 2,4-D (0.12 ton ha^{-1}) followed by hand pulling+2,4-D (0.43 ton ha^{-1}) and hand pulling+*M. azedarach* (0.5 ton ha^{-1}), as expected the control treatment had the highest Kongwa weed weight (22.73 ton ha^{-1}), other weeds weight (1.09 ton ha^{-1}) and lowest pasture yield (1. ton ha^{-1}).

Relationship between weed survival and pasture performance at site B

Table 6 shows the relationship between weed survivals and pasture performance at site B. The regression analysis showed

Table 5: Treatments effect on weed and pasture performance at site B.

Treatments	No. of Survived weeds	No. of leaves weed^{-1}	Weed height (cm)	Weed girth (mm)	Pasture height (cm)	Pasture girth (mm)	No. of leaves plant^{-1}	No. of tillers^{-1}
Hand pulling+ *M. azedarach*	13.40ab	18.55abc	62.17abc	4.67a-d	81.61	1.65	12.97	11.9
Cutting+*M. azedarach*	9.92a	16.90ab	51.11abc	4.07abc	71.11	1.64	12.84	13.78
Cutting	22. 40c	25.97bcd	70.10bc	5.99bcd	72.76	1.75	13.04	13.5
Cutting+*R. communis*	16.32abc	25.82bcd	75.37c	6.65d	78.4	1.73	14.14	12.43
Hand pulling+2,4-D	12.00ab	16.35ab	42.86a	3.75ab	69.89	1.77	14.09	13.58
2,4-D	11.90ab	13.77a	37.55a	3.00a	69.76	1.77	13.62	13.35
Cutting+2,4-D	10.25a	16.25ab	46.79ab	4.04abc	71.56	1.72	13.24	14.18
M. azedarach	11.45ab	15.57a	47.60ab	3.98abc	80.76	1.79	13.77	14.3
Hand pulling	16.60abc	23.55a-d	74.32c	6.35cd	73.54	1.74	12.7	13.43
R. communis	21.87c	30.60d	75.95c	7.02d	68.39	1.66	14.04	14.25
Hand pulling+*R. communis*	18.20bc	28.02cd	69.75bc	6.22cd	72.31	1.73	13.97	14.45
Control	56.08d	86.45e	150.52d	10.76e	74.41	1.7	14.09	13.6
Mean	18.37	26.49	67	5.54	73.7	1.716	13.54	13.56
SD	2.76	4.11	10.12	0.98	7.59	0.12	1.15	1.33
CV%	15	15.5	15.1	17.6	10.3	7	8.5	9.8
p-value	0.001	0.001	0.001	0.001	0.26	0.76	0.55	0.27

*Means in the same column, followed by the same letter(s) do not differ significantly (p ≤ 0.05) according to Tukey's honestly test., CV: Coefficient of Variation; SE ±: Standard Deviation

Table 6: Relationship between weed survivals and pasture performance at site B.

	Pasture height	Pasture girth	No. of leaves plant^{-1}	No. of tillers	Yield plot^{-1}	No. of Survived weeds
Pasture height	1					
Pasture girth	0.37**	1				
No. of leaves plant^{-1}	0.27*	0.50**	1			
No. of tillers	-0.24	0.32**	0.44**	1		
Yield plot^{-1}	0.07	0.23	0.01	0.02	1	
No. of Survived weeds	0.02	-0.07	0.14	0	-0.54**	1

n=48; df=n^{-2}; *Significant liner correlation p=0.05 and; **Significant liner correlation p=0.01

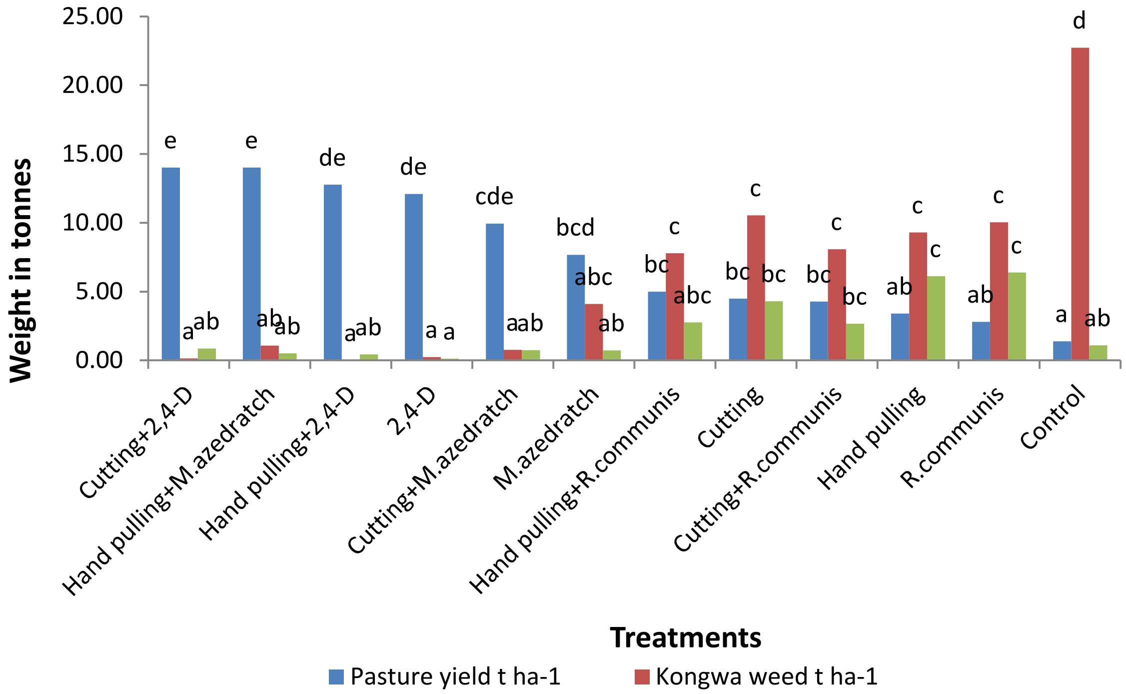

Figure 4 Treatments effect on weed weight and pasture yield at site B.

that, the pasture (*Cynodon dactylon*) girth, number of leaves per plant, number of tillers were significantly positive collated to pasture height R=0.37, pasture girth R=0.5 and number of leaves R=0.44 respectively at p<0.01 while number of leaves per plant was significantly positive collated to pasture height with R=0.27 at p<0.05. However, regression analysis showed significantly negative collation between numbers of surviving weed and pasture yield R=-0.54 at p<0.01. The remaining variables were not significantly collated at P<0.05.

Percentage pasture yield loss due to Kongwa weed in site

Results on yield loss coursed by Kongwa weed infection on pasture yield are shown in **Figure 5**. Yield losses ranged from 10 for hand pulling+*M. azedarach* to 90% for the control treatments at site B which had Kongwa weed infestation.

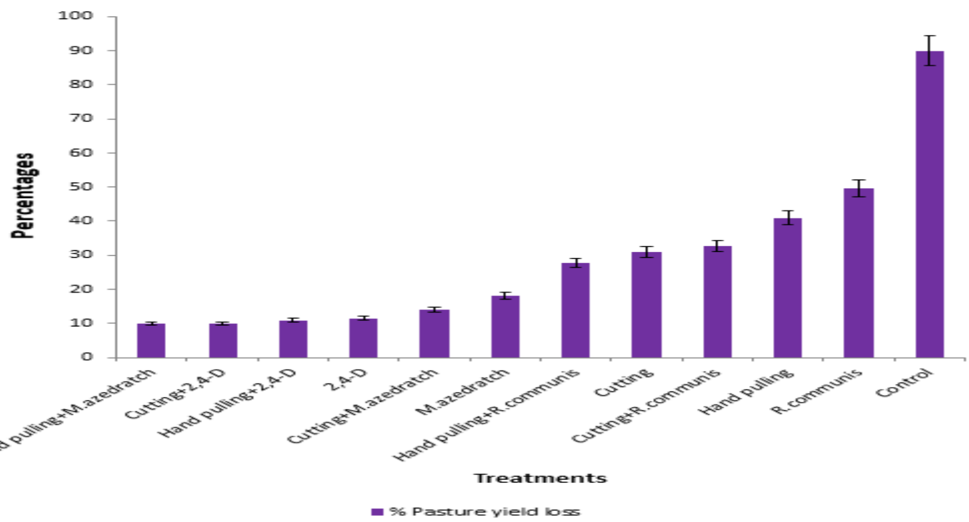

Figure 5 Percentage pasture yield loss at B.

Discussion

The current study findings revealed that, in rangelands occupied with low Kongwa weed infestation during vegetative stage, herbicide 2, 4-D and plant extract *M. azedratch* applied singly at high concentration have the ability to suppress these weeds. Low Kongwa weed and other weeds growth could possibly be due to decrease in number of surviving Kongwa weed, number of weed leaves, weight of Kongwa and other weeds species similar findings were also reported by Shapla et al., [14]. Who observed that such results were due to allelopathic effects of *M. azedarach* in mung bean and soybean crops whereby the number of leaves, shoot length, leaf length and shoot biomass was significantly reduced? Several studies have shown that the phytotoxicity/inhibitory effect of *M. azedarach* extract was proportional to the concentration of the extract applied; where by higher concentration has a stronger inhibitory effect which decreased root and shoot development of crops such as lettuce and radish [15,16]. In their results it was indicated that, *M. azedarach* allelochemical produced an imbalance in the oxidative status of cells such as the change in activity of Catalase (CAT), Ascorbate Peroxidase (APX), Guaiacol Peroxidase (GPX), membrane lipid peroxidation electrolytes leakage, the levels of H_2O_2 and assimilatory pigments in radish seedlings.

Herbicide 2, 4-D applied singly in rangelands with high Kongwa weed infestation and during flowering stage has high ability to suppress these weeds unlike plant extract *M. azedarach***.** The decreased number of weed leaves, weed height, weed girth and weight of other weeds was likely due to de-regulation of the weed cell growth process by 2, 4-D herbicide. According to Hall et al. and Bhatla, herbicide 2, 4-D works by interfering with growth, either by blocking photosynthesis and protein synthesis or by inhibiting weeds root system and also interferes with the plant growth regulator such as Indole Acetic Acid (IAA) or Auxin that controls cell enlargement, division and plant development. 2, 4-D penetrates the stomata and is translocated to the meristems of the weed, resulting into uncontrolled and unsustainable growth consequently, weeds wilt and die [17,18].

Integrated Weed Management (IWM) involving cultural, chemical (2, 4-D) or biological (*M. azedarach*) decreased weight and number of survived Kongwa weed and resulted in increased pasture yield. As the weeds were either uprooted by hand pulling or cut to a large extent and later suppressed by the chemicals and/or bio-herbicides that likely affect Kongwa weed chlorophyll content, leading to lower weed population and suppression of weed growth as also reported by Akacha et al., [16]. The minimum weed weight was probably due to higher suppression of weeds. These results are in agreement with Bari et al. who reported that cultural and herbicidal treatments suppressed the weed weight considerably than the untreated control [19]. Although currently study does not show strong significant pasture-tiller collection (R=0.26) The increased pasture yield as a result of high number of tillers could be due to a smaller number of weeds and reduced pasture-weed competition for the available resources such nutrient, moisture and light. Further this study results indicated that, there was a negative collection ($R=-0.64^*$) between the number of surviving weeds and pasture yield. Such results are in line with Jabran et al., Khan et al., Moraes et al., who reported an increase in number of tillers due to better weed control and elimination of weed-crop competition for nutrients, moisture, light and better utilization of available resources by the crops such as wheat and pasture [20-22].

In totality pasture yield loss caused by Kongwa weed that ranged from 32 to 68% at site A under low Kongwa weed infestation of this study was slightly lower (75%) than that reported by Nkombe et al. in the same ecological area. The difference between current results and those reported by Nkombe et al. could be due to fact that the early results were from farmer's perception. However, results at site B agreed those by Nkombe et al. and Rwomushana et al. who reported the highest value of 75 and 90 pasture yield loss respectively [6,23].

Conclusions and Recommendation

Agronomically, the study concludes that Integrated Weed Management (IWM) practices are more effective than single treatments applications such as hand pulling, cutting, 2, 4-D, *M. azedarach*, and *R. communis* when applied in infested rangelands. The results show that appropriate weed control provided a favourable environment for the pasture growth, development and yield. Therefore, a proper combination of cultural practices with plant extracts significantly reduces the frequent use of herbicides, and improves pasture productivity.

It is therefore recommended that, the integrated weed management such hand pulling+*M. azedarach* (14.02 t ha^{-1}), (cutting+2, 4-D 14.02 t ha^{-1}), hand pulling+2,4-D (12.76 t ha^{-1}), be applied in areas infested with Kongwa weed, conversely 2, 4-D (12.1 t ha^{-1}) applied singly had also effective in weed suppression. Further studies are required to compare extract from different parts of *M. azedarach* such as roots and shoots on management of Kongwa weed.

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