Vol. 20(8), pp. 641-649, August 2024
DOI: 10.5897/AJAR2024.16689
Article Number: 6DFC0AB72456
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

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African Journal of Agricultural Research

Full Length Research Paper

Effects of *Tithonia diversifolia* on species composition of other weeds

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Received 7 May, 2024; Accepted 25 June, 2024.

***Alien* species, such as *Tithonia diversifolia*, if introduced to areas outside of their natural distribution range, subsequently become invasive, and threatens biodiversity and agricultural productivity. A field survey to determine the potential allelopathic effects of *T. diversfiolia* on species composition was conducted in Goromonzi, Zimbabwe using two different sizes quadrats. The quadrats were randomly placed at different locations as follows: under the canopy of *T. diversifolia,* 10 m away, 20 m away and 30 m away from *T. diversifolia* infested area. The quadrats were randomly thrown four times to represent four replications. Four different weed species (*Cynodon dactylon*, *Hyparrhenia* species, *Melinis repens* and *Sporobolus* species) were identified using species index catalogue. The results postulate that there was a significant difference (P >0.01) between species found under the canopy and those found away from *T. diversfiolia* plants. *T. diversifolia* affects species composition, as distance from infested area increases species richness and evenness. Therefore, *T. diversfiolia* affects species diversity, and it is possible that this could be due to allelochemicals produced by the invasive plant. Future studies can quantify allelopathic compounds in the invasive plant and test allelopathic effects of the compounds on the four weed species.**

Key words: *Alien* species, allelochemicals, invasion, species evenness, species richness.

INTRODUCTION

Ecological invasion by exotic weeds has been sighted as the major threat on species composition especially on grassing lands (Jäger et al., 2007). Allien species may rather be drivers than passengers of species composition when climate change causes decline of native species. The perennial shrub *Tithonia diversifolia* (Hemsl) A. Grey, also known as Mexican sunflower or tree marigold, is native to Mexico and Central America (Kato-Noguchi, 2020). It is an aggressive colonizer belonging to the Asteraceae family. It can successfully occupy natural and agricultural ecosystems due to its allelopathic properties and competitive ability (Shackleton et al., 2019).

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Competitive ability is a long-standing hypothesis regarding invasive potential of species which stipulates that invaders are strong competitors for limited resources and have strong competitive ability (Perkins and Nowak, 2013). *T. diversifolia* is one of the most important invasive weed in world and its physiological and ecological characteristics made it well known competitive weed for other plant species (Shackleton et al., 2019). It possesses *a*llelopathic properties that can affect all ecological factors, e.g. growth, plant canopy succession, survival, extension and crop production (Yarnia et al, 2009). This has a significant effect on biodiversity and directly affects livestock production. Stocking density and intensity will rapidly decline in *T. diversifolia* infested area. Across vast expenses of rangelands, prairies, woodlands, and forests and throughout many wetlands and riparian corridors, invasive plant species have established and continue to threaten species composition (Young, 2012). Once invasive plants become established, they pose a major threat to native species diversity and this causes negative impact on livestock fodder (Hammer, 2019). Allelopathic interaction in development and growth is complex process that affects all development and growth aspects like protein, hormone and chlorophyll synthesis (Vilà et al., 2011).

Invasive plant species often outcompete native plants for resources and space through a suite of mechanisms including increased uptake of resources, differential timing of resource use, and habitat alterations to benefit the invader. *T. diversifolia* decrease carbohydrate achievement rate by allelochemical inhibitors led to decrease in plant total growth and crop dry weight. Colonization by *T. diversifolia* can have many direct and indirect impacts on population dynamics, native species composition, and species richness (Levine et al., 2003). *T. diversifolia* invaded areas experience impacts to ecosystem functioning and changes to plant community structure, it is likely that invasions will also alter the many benefits that humans receive from natural ecosystem processes (e.g., water filtration, carbon sequestration, and flood mitigation) (Perkins and Nowak, 2013). The aim of the study is to determine the allelopathic effects of *T. diversifolia* on species diversity.

MATERIALS AND METHODS

Allelopathic effects of *T. diversifolia* on biodiversity at flowering stage

Experimental layout and treatments

Field work was carried out in August to September 2023 at Domboshava Training Centre fields, Goromonzi District (GPS coordinates 17.8252 S latitude and 31.1915 E longitude), Mashonaland East Province, Zimbabwe. The training centre is situated 30 km from Harare along the Borrowdale/Domboshava Road and 3 km West of Mverechena Growth Point. The study area was in cropping field were agrarian activities were taking place. It falls under Natural Region IIb. The experiment was set in a randomized complete block design replicated four times. The blocking factor was distance from *T. diversifolia* plant.

Treatments

Four treatments were going to be used through the use of a 50 x 50 cm quadrat, under canopy of *T. diversifolia,* 10 m, 20 and 30 m away.

Trial management

Experiment A: Effects of T. diversifolia on biodiversity

Species composition and richness were quantified by comparing measurements under the *T. diversifolia* plant and surrounding areas. The sampling procedure consisted of laying out 50 x 50 cm quadrant on the four treatments replicated four times. All species were counted regardless of their height. The experiment was conducted on *T. diversifolia* plant peripherals.

Experiment B: Determination of carrying capacity (livestock) for the area

A 1 × 1 m quadrat was used to collect biomass (1 × 1 m) on the four treatments and it was replicated four times (under *T. diversifolia* plant, 10, 20 and 30 m away from the plant. The method was similar to experiment A.

Data collection

Experiment A

Data on species composition were collected by counting the number of species and the number per species quadrant. The data were calculated using Shannon's diversity index (H = Pi × ln (Pi)). Data on species richness and evenness were calculated using H ÷ the natural log of the richness (Hmax). At the end of the experiment, all the species in the quadrants were harvested and measured using a weighing scale to determine the biomass.

Experiment B

Data on species composition for the sample was collected and classified into palatable and non-palatable species. Poisonous species were determined and calculated as a percentage of the whole species composition. Using 1 livestock unit as 800 kg, the total carrying capacity was determined for non-infested and infested areas.

Data analysis

Weed counts were tested for normalcy before being subjected to analysis of variance (ANOVA) using GenStat version 18. Where treatment means were statistically significantly different, they were separated using Fisher's protected least significant different (LSD) at the 5% significant level.

RESULTS AND DISCUSSION

Allelopathic effects of *T. diversifolia* on biodiversity at flowering stage

There was a significant different ($P > 0.01$) between

Table 1. Species composition on 50 x 50 cm quadrant.

Grass species	Under canopy	10 m away	20 m away	30 m away
Cynodon dactylon	1.000[a]	2.392[a]	3.142[a]	3.382[a]
Hypparrhenia spp.	1.207[b]	1.992[b]	2.445[b]	3.158[a]
Melinis repens	1.000[b]	2.266[c]	2.802[c]	3.278[b]
Sporobolus spp.	1.494[c]	2. 163[c]	1.866[d]	2.059[c]
P value	<0.01	<0.01	<0.01	<0.01
Sed±	0.3490	0.3490	0.3490	0.3490
CV%	1.1	1.1	1.1	1.1

Means followed by different letter are significantly different at 0.001 probability level.

species found under the canopy and those found 10, 20 and 30 m away from *T. diversifolia* plants. Species increases gradually as the distance increases away from *T. diversifolia* plants. Four species were occupying the area infested with *T. diversifolia;* these are *Cynodon dactylon*, *Hyparrhenia* species, *Melinis repens* and *Sporobolus* species. *Sporobolus* spp. was not highly affected by *T. diversifolia* and some plants were found establishing under the canopy of *T. diversfolia* although some other weeds were inhibited under the canopy. *Sporobolus* spp. is known for its non palatability effects on livestock. There is no significant different (P < 0.01) on the establishment of *Sporobolus* spp. between under the canopy, 10 m away and 20 m away. *C. dactylon* were greatly affected under the canopy of *T. diversifolia* (Table 1).

Species richness under the canopy of *T. diversifolia*

Species richness "S" Number of species in *T. diversifolia* infested area under the canopy. Two species were found: *Hyparrhenia* and *Sporobolus* spp. These species establish themselves under the canopy although the sample shows only three plants from the four replicates. Number of species increases further away from infested area.

In "S" = In (2) (0.693):

(a) P(i) *Hyperrhenia* spp. / Total number of species
1 / 3 = 0.333

(b) P(ii) *Sporobolus* spp. / Total number of species
2 / 3 = 0.666

(c) Shannon diversity index *Hyperrhenia* spp. "H" = $\sum P(i)\ x\ InP(i)$
$=\sum P(0.333)\ x\ InP(-1.099)$
= -0.366

(d) Shannon diversity index *Sporobolus* spp. "H" = $\sum P(ii)\ x\ InP(ii)$
$=\sum P(0.666)\ x\ InP(-0.406)$
= *-0.27*

Therefore, Shannon diversity index for each species is as follows: *Hyparrhenia* spp. equals -0.366 and *Sporobolus* spp. is -0.27. Shannon diversity index for all species is -0.366 plus -0.27 which equals (-1 × -0.636) 'H' = 0.636.

Species evenness under the canopy of *T. diversifolia*

Divide Shannon diversity index H by natural logarithm of species richness In(S). Species richness (0.636 / 0.693). Species evenness is equals 0.917. The results show there is no complete evenness. Species evenness ranges from zero to one, zero signifying no evenness and one a complete evenness.

Species richness 10 m away from *T. diversifolia*

Species richness "S" Number of species in *T. diversifolia* infested area 10 m (4) four. *Hyparrhenia* spp. 4, *Sporobolus* spp. 5, *C. dactylon* 6, and *M. repens* 7.

In "S" = In (4) (1.386):

(a) P(i) *Hyperrhenia* spp. / Total number of species
4 / 22 = 0. 1818

(b) P(ii) *Sporobolus* spp. / Total number of species
5 / 22 = 0.227

(c) P(iii) *C. dactylon* / Total number of species
6 / 22 = 0.2727

(d) P(iv) *M. repens* / Total number of species
7 / 22 = 0.318

(e) Shannon diversity index *Hyperrhenia* spp. "H" $\sum P(i)\ x\ InP(i)$

$$\sum P(0.1818)\ x\ InP(-1.7048)$$
=-0.309

(f) Shannon diversity index *Sporobolus* spp. “H”
$$\sum P(ii)\ x\ InP(ii)$$
$$\sum P(0.227)\ x\ InP(-1.482)$$
=-0.336

(g) Shannon diversity index *C. dactylon* “H”
$$\sum P(iii)\ x\ InP(ii)$$
$$\sum P(0.2727)\ x\ InP(-1.299)$$
=-0.354

(h) Shannon diversity index *M. repens* “H”
$$\sum P(iv)\ x\ InP(ii)$$
$$\sum P(0.318)\ x\ InP(-1.145)$$
=*-0.364*

Therefore, Shannon diversity index for each species is as follows: *Hyperrhenia* spp. equals -0.309, *Sporobolus* spp. is *-0.336*, *C. dactylon -0.354* and *M. repens -0.364*. Shannon diversity index for all species is equals (-1 × -1.363) ‘H’ = 1.363

Species evenness 10 m away from *T. diversifolia*

Divide Shannon diversity index H by natural logarithm of species richness In(S). Species richness (1.363 ÷ 1.386). Species evenness is equals 0.983. The results show there is no complete evenness. Species evenness ranges from zero to one, zero signifying no evenness and one a complete evenness.

Species richness 20 m away from *T. diversifolia*

Species richness “S” Number of species in *T. diversifolia* infested area 20meters away (4) four. *Hyperrhenia* spp. 6, *Sporobolus* spp. 3, *C. dactylon* 12 and *M. repens* 10.
In “S” = In (4) (1.386):

(a) P(i) *Hyperrhenia* spp. / Total number of species
6 / 31 = 0. 096

(b) P(ii) *Sporobolus* spp. / Total number of species
3 / 31 = 0.227

(c) P(iii) *C. dactylon* / Total number of species
12 / 31 = 0.387

(d) P(iv) *M. repens* / Total number of species
10 / 31 = 0.322

(e) Shannon diversity index *Hyperrhenia* spp. “H”
$$\sum P(i)\ x\ InP(i)$$
$$\sum P(0.096)\ x\ InP(-2.343)$$
=-0.224

(f) Shannon diversity index *Sporobolus* spp.__“H”
$$\sum P(ii)\ x\ InP(ii)$$
$$\sum P(0.227)\ x\ InP(-1.482)$$
=-0.336

(g) Shannon diversity index *C. dactylon* “H”
$$\sum P(iii)\ x\ InP(ii)$$
$$\sum P(0.387)\ x\ InP(-0.949)$$
=-0.367

(h) Shannon diversity index *M. repens* “H”
$$\sum P(iv)\ x\ InP(ii)$$
$$\sum P(0.322)\ x\ InP(-1.133)$$
=-0.364

Therefore, Shannon diversity index for each species is as follows: *Hyperrhenia* spp. equals -0.224, *Sporobolus* spp. is *-0.336*, *C. dactylon -0.367* and *M. repens* -0.364. Shannon diversity index for all species is equals (-1 × -1.291) ‘H’ = 1.291

Species evenness 20 m away from *T. diversifolia*

Divide Shannon diversity index H by natural logarithm of species richness In(S). Species richness (1.2910 ÷ 1.386). Species evenness is equals 0.93**.** The results show there is no complete evenness. Species evenness ranges from zero to one, zero signifying no evenness and one a complete evenness.

Species richness 30 m away from *T. diversifolia*

Species richness “S” Number of species in *T. diversifolia* infested area at 30 m (4) four. *Hyperrhenia* spp. 10, *Sporobolus* spp. 4, *C. dactylon* 12 and *M. repens* 10
In “S” = In (4) (1.386):

(a) P(i) *Hyperrhenia* spp. / Total number of species
10 / 36 = 0. 2777

(b) P(ii) *Sporobolus* spp. / Total number of species
4 / 36 = 0.111

(c) P(iii) *C. dactylon* / Total number of species
12 / 36 = 0.333

(d) P(iv) *M. repens* / Total number of species
10 / 36 = 0. 2777

(e) Shannon diversity index *Hyperrhenia* spp. “H”

Table 2. Species diversity on 1 × 1 m quadrant.

Grass species	Under canopy	10 m away	20 m away	30 m away
Cynodon dactylon	1.000[a]	3.231[a]	4.291[a]	4.566[a]
Hepperrhenia spp.	1.207[a]	2.445[b]	3.310[b]	4.396[a]
Melinis repens	1.000[a]	2.869[c]	3.829[c]	4.437[a]
Sporobolus spp.	1.720[b]	2.731[c]	2.396[d]	4.396[a]
P value	<0.01	<0.01	<0.01	<0.01
Sed±	0.1936	0.1936	0.1936	0.1936
CV%	9.5	9.5	9.5	9.5

Means followed by a different letter are significantly different at 0.001 probability level.

$\sum P(i)\ x\ InP(i)$

$\sum P(0.2777)\ x\ InP(-1.283)$

=-0.355

(f) Shannon diversity index *Sporobolus* spp. “H”
$\sum P(ii)\ x\ InP(ii)$

$\sum P(0.111)\ x\ InP(-2.198)$

=-0.244

(g) Shannon diversity index *C. dactylon* “H”
$\sum P(iii)\ x\ InP(ii)$

$\sum P(0.333)\ x\ InP(-1.09)$

=-0.366

(h) Shannon diversity index *M. repens* “H”
$\sum P(iv)\ x\ InP(ii)$

$\sum P(0.277)\ x\ InP(-1.283)$

=-0.355

Therefore, Shannon diversity index for each species is as follows: *Hyperrhenia* spp. equals -0.355, *Sporobolus* spp. is -0.244, *C. dactylon* -0.366 and *M. repens* -0.355. Shannon diversity index for all species is equals (-1 × -1.32) ‘H’ = 1.32.

Species evenness 30 m away from *T. diversifolia*

Divide Shannon diversity index H by natural logarithm of species richness In(S). Species richness (1.32 / 1.386). Species evenness is equals 0.95. The results show there is no complete evenness. Species evenness ranges from zero to one, zero signifying no evenness and one a complete evenness.

Experiment B: Determination of carrying capacity (livestock) for the area

Species richness under T. diversifolia canopy

There was a significant different (P >0.01) amongst under canopy treatment and other treatments on species composition. `Species composition decreased towards areas infested with *T. diversifolia*. Species composition increased further away from *T. diversifolia* infested. *Sporobolus* spp. proved that it can withstand the negative effects of *T. diversifolia* allelochemicals. *C. dactylon* and *M. repens* establishment under canopy were completely inhibited.

There is no significant different (P > 0.05) between *Hyperrhenia* spp. on 10 and 20 m away from *T. diversifolia* on species composition. There is no significant different (P > 0.05) between *M. repens* on 10 and 20 m away from *T. diversifolia* on species composition. There is a significant (P < 0.05) between *C. dactylon* on 10 and 20 m away from *T. diversifolia* on species composition (Table 2).

Species richness “S” Number of species in *T. diversifolia* infested area under the canopy (2) two: *Hyperrhenia* spp. 1 and *Sporobolus* spp. 3.

In “S” = In (2) (0.693):

(a) P(i) *Hyperrhenia* spp. / Total number of species
1/ 4 = 0. 25

(b) P(ii) *Sporobolus* spp. / Total number of species
1 / 4 = 0.75

(c) Shannon diversity index *Hyperrhenia* spp. “H” $\sum P(i)\ x\ InP(i)$

$\sum P(0.25)\ x\ InP(-1386)$

=-1.386

(d) Shannon diversity index *Sporobolus* spp. “H” $\sum P(i)\ x\ InP(i)$

$\sum P(0.75)\ x\ InP(-0.287)$

=-0.215

Therefore, Shannon diversity index for each species was as follows: *Hyperrhenia* spp. = -0.386 and *Sporobolus* spp. = *-0.215*. Shannon diversity index for all species = (-1 × -0.601) ‘H’ = 0.601

Species evenness under the canopy of T. diversifolia

Species evenness was obtained by dividing Shannon diversity index H by natural logarithm of species richness In(S). Species richness (0.601 / 0.693). Species evenness is equals 0.867. The results show there is no complete evenness. Species evenness ranges from zero to one, zero signifying no evenness and one a complete evenness.

Species richness 10 m away from T. diversifolia

Species richness "S", is the number of species in *T. diversifolia* infested area 10 m (4) four: *Hyperrhenia* spp. 6, *Sporobolus* spp. 8, *C. dactylon* 12, and *M. repens* 10.
In "S" = In (4) (1.386):

(a) P(i) Hyperrhenia spp. / Total number of species
5 / 36 = 0. 166

(b) P(ii) *Sporobolus* spp. / Total number of species
8 / 36 = 0.222

(c) P(iii) *C. dactylon* / Total number of species
10 / 36 = 0.3333

(d) P(iv) *M. repens* / Total number of species
10 / 36 = 0.277

(e) Shannon diversity index *Hyperrhenia* spp. "H"
$\sum P(i)\ x\ InP(i)$
$\sum P(0.166)\ x\ InP(-1.795)$
=-0.298

(f) Shannon diversity index *Sporobolus* spp. "H"
$\sum P(ii)\ x\ InP(ii)$
$\sum P(0.222)\ x\ InP(-1.505)$
=-0.334

(g) Shannon diversity index *C. dactylon* "H"
$\sum P(iii)\ x\ InP(iii)$
$\sum P(0.333)\ x\ InP(-1.09)$
=-0.366

(h) Shannon diversity index *M. repens* "H"
$\sum P(iv)\ x\ InP(iv)$
$\sum P(0.277)\ x\ InP(-1.283)$
=-0.355

Therefore, Shannon diversity index for each species is: *Hyperrhenia* spp. = -0.298; *Sporobolus* spp. = -0.334; *C. dactylon* = -0.366; *M. repens* = -0.355. Shannon diversity index for all species is equals (-1 × -1.353) 'H' = 1.353.

Species evenness 20 m away from T. diversifolia

Species evenness was obtained by dividing Shannon diversity index H by natural logarithm of species richness In(S). Species richness (1.353 / 1.386). Species evenness = 0.976. The results show that there was no complete evenness. Species evenness ranged from zero to one, zero signifying no evenness and one a complete evenness.

Species richness 20 m away from T. diversifolia

Species richness "S" Number of species in *T. diversifolia* infested area 20 m away (4) four. *Hyperrhenia* spp. 12, *Sporobolus* spp. 5, *C. dactylon* 20 and *M. repens* 15

In "S" = In (4) (1.386)

(a) P(i) *Hyperrhenia* spp. / Total number of species
10 / 52 = 0. 230

(b) P(ii) *Sporobolus* spp. / Total number of species
5 / 52 = 0.096

(c) NP(iii) *C. dactylon* / Total number of species
20÷ 52 = 0.384

(d) P(iv) *M. repens* / Total number of species
15 / 52 = 0.288

(e) Shannon diversity index *Hyperrhenia spp* "H"
$\sum P(i)\ x\ InP(i)$
$\sum P(0.230)\ x\ InP(-1.469)$
=-0.338

(f) Shannon diversity index *Sporobolus* spp. "H"
$\sum P(ii)\ x\ InP(ii)$
$\sum P(0.096)\ x\ InP(-2.343)$
=-0.224

(g) Shannon diversity index *C. dactylon* "H"
$\sum P(iii)\ x\ InP(iii)$
$\sum P(0.384)\ x\ InP(-0.957)$
=-0.367

(h) Shannon diversity index *M. repens* "H"
$\sum P(iv)\ x\ InP(iv)$
$\sum P(0.288)\ x\ InP(-1.244)$
=-0.358

Therefore, Shannon diversity index for each species is:

Hyperrhenia spp. = -0.338;
Sporobolus spp. = -0.244;
C. dactylon = -0.367;
M. repens = -0.358.

Shannon diversity index for all species = (-1 × -1.307) 'H' = 1.307.

Species evenness 20 m away from T. diversifolia

Species evenness was obtained by dividing Shannon diversity index H by natural logarithm of species richness In(S). Species richness (1.307 / 1.386).

Species evenness = 0.94.

The results show there is no complete evenness. Species evenness ranges from zero to one, zero signifying no evenness and one a complete evenness.

Species richness 30 m away from T. diversifolia

Species richness "S" Number of species in *T. diversifolia* infested area 30 m away (4) four: *Hyperrhenia* spp. 24, *Sporobolus* spp. 7, *C. dactylon* 25, and *M. repens* 20
In "S" = In (4) (1.386):

(a) P(i) Hyperrhenia spp. / Total number of species
24 / 76 = 0. 3157

(b) P(ii) *Sporobolus* spp./ Total number of species
7/ 76 = 0.092

(c) P(iii) *C. dactylon* / Total number of species
25 / 76 = 0.328

(d) P(iv) *M. repens* / Total number of species
20 / 76 = 0. 263

(e) Shannon diversity index *Hyperrhenia* spp. "H"
$\sum P(i)\ x\ InP(i)$
$\sum P(0.315)\ x\ InP(-1.155)$
=-0.363

(f) Shannon diversity index *Sporobolus* spp. "H"
$\sum P(ii)\ x\ InP(ii)$
$\sum P(0.092)\ x\ InP(-2.385)$
=-0.219

(g) Shannon diversity index *C. dactylon* "H"
$\sum P(iii)\ x\ InP(ii)$
$\sum P(0.328)\ x\ InP(-1.114)$
=-0.365

(h) Shannon diversity index *M. repens* "H"
$\sum P(iv)\ x\ InP(ii)$

$\sum P(0.263)\ x\ InP(-1.335)$
=-0.351

Therefore, Shannon diversity index for each species is:

Hyperrhenia spp. = -0.363;
Sporobolus spp. = -0.219;
C. dactylon = -0.365;
M. repens = -0.351.

Shannon diversity index for all species is (-1 × -1.298) 'H' = 1.298.

Species evenness 20 m away from T. diversifolia

Species evenness was obtained by dividing Shannon diversity index H by natural logarithm of species richness In(S). Species richness (1.298 / 1.386).

Species evenness = 0.93.

The results show there was no complete evenness. Species evenness ranged from zero to one, zero signifying no evenness and one a complete evenness.

Species composition for the sample and classified into palatable and non-palatable

The following species were identified in the study area during the survey: *Hyperrhenia* spp., *Sporobolus* spp., *C. dactylon* and *M. repens.* *Hyperrhenia* spp. is palatable during early stages of vegetative growth. During flowering and reproductive stage, the weed become unpalatable and the greater part of carbohydrates will be partitioned towards flower and seed production, which make the weed unpalatable to most livestock. *Sporobolus* spp. was one of the species which was identified in *T. diversifolia* infested areas. It is known for its non palatability effects in most livestock.

Effects of *T. diversfolia* on species composition

Biological invasion has been recognized as one of the most severe threats to species composition within an ecological-system. Numerous studies have cited that introduction of exotic, alien, non-native species have some ecological impacts on biodiversity (Linders et al., 2019; Wilgren et al., 2020; Lazzarro et al., 2020; Zengeya et al., 2020; Gentili et al., 2021; Kacheche and Mzuza, 2021; Alidoost Salimi et al., 2021). The results from the study clearly showed that *T. diversifolia* has a normative impact on species richness and evenness within an ecosystem. The results show that *T. diversifolia* has the capacity to affect species evenness. According to (MacDougal and Turkington, 2000) non-native species may be rather passengers than drivers of community change when anthropogenic disturbances directly cause decline of native species. Data from this study indicate that *Sporobolus* spp. composition was not affected by the presence of wild sunflower, rather the weed increases towards an infested area. Unlike *T. diversifolia* it is a driver for community diversity according to the study *C. dactylon, Hyperrhenia* spp. and *M. repens* composition decline towards *T. diversifolia* infested area and increases away from the infested area.

Species richness

Analysis of species richness clearly demonstrated that observed number of plant species was affected by the presence of *T. diversifolia* (Figure 1). This study reveals that only two species *Sporobolus pyramidalis* and *Hyperrhenia* spp. were found under the canopy of *T. diversifolia*. The study also established that as you move away from the weed, for example 10 m away from *T. diversifolia* two more species appeared at a significant number although the poison and unpalatable weed *Sporobolus* spp. was not greatly affected by *T. diversifolia* than other species. In line with novel weapons hypothesis (which refers to biochemical traits), species traits that distinguish an introduced species from the resident species are supposed to provide competitive advantages for the invader (Callaway et al., 2003). It is possible that *T. diversifolia* exerts significant impacts on native species that these impacts decrease with increasing distance from the shrub. Results indicated that *T. diversifolia* had the strongest impacts on invaded communities in terms of both species diversity and composition. It is likely that its vigorous growth reaches a high cover and is much taller than members of invaded resident communities, is responsible for their strong impact.

Species evenness

Data from this study indicate the species evenness in *T. diversifolia* infested area increases further away from infested area. Thus, the observation shows that *T. diversifolia* has a serious impact on species evenness. In a similar study Zhang et al. (2020) observed that allelopathy affects individual performance, community structure, species composition and evenness, as observed in this study. It is also clear from this study, that under the canopy of *T. diversifolia* species evenness is affected and the degree of evenness starts to normalise a distance away from the plants. Allelopathy is one possible reason for the rapid displacement of native species Bais et al. (2003) and a mechanism of the success of invaders (Hierro and Callaway, 2003). Therefore, allelopathy has broad agricultural and ecological implications (Balah et al., 2022). Allelopathy is attributed to the success of an invasive species in natural ecosystems (Kimura et al., 2015.). According to Martin et al. (2009) both the two components of species diversity, richness and evenness focuses of invasive species the impacts have been primarily on richness. However, according to Lora (2013) changes in species evenness may influence invasion resistance, productivity and local plant extinction rates.

During the study, it was observed that the composition of *Sporobolus* spp. increases towards area infested by *T. diversifolia.* Within the sampled area *C. dactylon* was also amongst the sampled weeds. The weed is palatable during the summer season and during winter it will undergo dormancy and becomes unpalatable to a number of animals. *M. repens* tend to lose its palatability as summer progresses, during early stage of growth the weed is highly nutritious contains a lot of crude protein required for beef conformity. According to Perkins and Nowak (2013) negative impacts on the environment (displacement of native plant species) were perceived as the most common negative impacts on human well-being, were fodder and human food are under threat of becoming extinct. The study shows that *T. diversifolia* interfere with basic ecosystem functions and services that are directly linked to the human well-being. This scenario has a profound impact on both agrarian and natural ecosystem which acts as a hub for provision of both cultivated and natural food. Rural populace mostly relies on forest however due infestation by *T. diversifolia* result in scarcity in terms of biodiversity of food staffs.

An understanding on the richness and evenness of an ecosystem after being infested by *T. diversifolia* will put policy makers into action to come up with integrated weed management strategies that facilitate sustainability of native species. Data from this study indicated that *T. diversifolia* is a colonizer that seriously affects species composition.

Conclusion

The study showed potential allelopathic effects of *T. diversifolia* on species composition. Therefore, *T. diversifolia* possesses herbicidal properties that affect species richness and evenness. Establishment of *Hyperrhenia* spp., *Sporobolus* spp., *C. dactylon* and *M. repens* is highly affected by *T. diversifolia*. Their evenness and richness increase further away from *T. diversifolia*. The study therefore shows that *T. diversifolia* has the potential for use in weed management programs.

ACKNOWLEDGEMENT

The authors appreciate Goromonzi District community for providing sites for the experiments.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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