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Weed Species Composition and Dynamics of the Major Weeds in Tef (*Eragrostis Tef (Zucc.) Trotter)* Cultivated Area, Central Tigray, Ethiopia

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Tef is a crucial staple food crop in Ethiopia, Characterized by diverse genetic variability. However, weeds significantly limit yields across all tef growing regions. The objective of the survey was to determine the species prevalence, species composition and dynamics of the major weeds in tef. The tef weed survey was done in 19 sub-districts (kebeles) in eight districts in August 2020. Districts were selected based on their tef growing potential and quadrants (1mx1m) were randomly placed in a W –pattern for data collection. 39 weed species in 18 weed families were identified. The most abundant weed families were *Poaceae, Asteraceae* and *Caryophyllaceae.* Weed diversity

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varied across the being the surveyed areas, with 18 to 23 species collected from five districts. The most frequently observed species included *Cyperu rotundus (L.) Galinoga parviflora, Setaria viridis, and Dianthus hyssopiflius(L.).* The density of weed species was measured from the species of *Setaria viridis, Dianthus hyssopifolius L. and Galinsoga parviflora Cav* with maginted of 18, 19 21plants /m^2 respectively. The diversity value Shannon weiner index 2.644 indicating a moderate level diversity without dominant species in any district. Laleay Machiew and Hahayle have similar weed composition for all districts except Tahtay Machiew, which helps to develop similar weed management. Whereas, the rest locations are demands different controlling methods. The identification weed species these leads to development weed management strategy. The strategies will be the most common weed control methods:tillage, appropriate planting time, optimum seed rate, hand weeding, and application of herbicide, rotation of cereal crops and development of integrated weeds management strategy. The finding suggests that specific weed management strategies are necessary for effective control of tef weeds in the study area and similar agroecologies.

Keywords: Tef weed species identification; frequency of weed species; density and weed composition.

1. INTRODUCTION

Tef is the most stable food crop, widely grown with diverse genetic variability in Ethiopia [1]. It has numerous, merits, including coping with erratic climates, generating household income (grain and straw), fulfilling nutritional needs [2] being gluten free [3], and encountering relatively few disease and insect pest problems [4]. The tef has usefull over other cereal crops by tolerance to both drought and water-logging conditions; fitness for various cropping systems and crop rotation schemes; usefulness as a reliable and low-risk catch crop at times of failures of other cereals and low risk of storage problems can save 3-5years without loss of considerable viability [5]. In Ethiopian, it is well known by making good quality injera a traditional flatbread. In the current, the market value of tef in Tigray region raised more than $124,00 USA triple than maize and wheat cereal crops.

Despite these merits, its yield remains low at 1900 kg/ha [6] due to various factors such as drought, lodging, weeds, insect pests, poor agronomic practices, low yielding cultivars, inputs etc. Whereas, socioeconomic constraints are lack of global and local attention on tef research and limited availability of seeds of improved varieties [7]. Research has shown that tef yield can reach 2800 kg /ha, while the yield potential is 6000 kg/ha [8]. Bridging the gap between national yield and research and potential productivity is crucial.

A weed is a serious problem to worldwide agriculture, cause over 80% yield loss [9]. Weeds are yield limiting factors in all tef growing regions because tef plants are weak competitor and all weeds suppress it [5,10]. Thus, tef grain yield losses due to weeds ranges from 18% to 94% [11,10]. Moreover, cost of hand weeding varies between 40 and 138 men per hectares [12]. Species richness, population dynamics, and strong competitive ability are the major weed characteristics that contributed to weed problems in tef production [13]. Tef weed types and densities is influence by different factors such as soil type, cost of labour, planting time, rain fall, herbicide applications [10].

Tef is infested by 68 weed species in 61 genera that are in 25 plant family [10]. The family Poaceae, Asteraceae, and Cyperaceae are the most common tef weed families [10]. Zewdie and Damte [14,5] stated that common weeds in major tef growing areas are *Gallinsoga parviflora, Guizotia scabra, Cyperus* spp., *Plantago lanceolata, Digitaria spp.*, *Setaria* spp., *Commelina benghalensis, Cynodon dactylon, Oxalis corniculata, Argemone ochroleuca*, and *Echinocloa* spp. The national tef weed survey (2016-2017) identified over 40 weed species, with most dominant one being *Arthraxon hispidus, Bulbostylis aestivalis,Cyperus rotundus, Galinsoga proviflora, Dianthus hyssopifolius* and *Setaria viridis.*

In recent years, there has been an increased use of herbicides including pre-emergence application of non-selective herbicide (glyphosate or Round-up), and post-emergence use of broad-leaved herbicides like 2,4-D, and grass weed killers such PALLAS 45 OD [14] and Tribenuron-methyl 75%WDG.

Moreover, production of tef in wider range of agro-ecology exposes it to different flora which requires separate identifications and control methods [15]. Weed affects tef production due to its high competition with tef for light, water and nutrients, reduces seed/grain quality, host for pests, labor and cost implication, environmental impact due to using herbicide. Tef weed causes significant yield loos. and some grass weed species have not effective herbicide chemical in the tef growing areas as well as the manpower which was used for hand weed are raising their cost from 300-500 Ethiopian birr per man per day. The cost of workers for hand weeding increased from 233% to 455% birr than before five years, which was 90 birr per man per day. Therefore, survey and identification of major tef weeds in tef production areas of central zone of Tigray Ethiopia is needed. As weed surveys can serve as a tool for the development and improvement of strategies for a sustainable, long-term weed control and the maintenance or even creation of biodiversity in arable land [16]. This in turn requires understanding the current weed prevalence, species composition and dynamics in the tef growing areas of the region. That implies familiarizing of tef weed community helps for prioritize under development of weed control methods and research.

Once a weed species has been correctly identified, it is time to design a successful weed management program that saves producers and land managers time and money, and reduces more herbicide use. Then, one of the effective weed management is a development of an integrated weed management (IWM) program can be designed that combines the use of biological, cultural, mechanical, and chemical practices to manage weeds [17]. Manipulating weed species composition into a desirable and manageable direction is a basic principle of integrated weed management. The objective of the survey was to determine the species prevalence, species composition and dynamics of the major weeds in tef

2. METHODOLOGY

2.1 Description of the Study Areas

The tef weed survey was done in 19 sub-districts(kebeles) in eight districts of the Central zone of Tigray, Ethiopia (Table 1), This work was done at the end of August in 2020.The districts were selected based on the tef area coverage history and growing potential.

2.2 Sampling Techniques and Procedures

In each sub-district (kebele) three tef fields, except in Adwa were four fields were sampled, were randomly selected at 5 km intervals. Then, in each selected tef field a quadrant that measured 1 m $\times$ 1 m was thrown at random following W-pattern. Therefore, total field count was 19*3=57 with one more at Adwa is 58 quadrants.Weeds in each quadrant were counted and identified to species level. The tef weed species were identified using plant net identifier of application and crosschecked in Google.

2.3 Data Analysis

From the collected data weed composition, richness, weeds density, abundance, dominance, frequency, similarity index, important value index, morphological growth, weed characterization were determined following the methods of Curtis and McIntosh [18]. The data was analyzed by excel for all parameters using by the given formula.

Frequency

1. **Frequency (%):** is the percentage of sampling plots on which a particular weed species is found in a field. It shows how often a weed species occur in the survey area.

$$frquency = \frac{total\ number\ of\ quadrants\ in\ which\ the\ species\ occurred}{total\ number\ of\ quadrants\ studied} x100$$

2. **Abundance:** Population density of a weed species expressed as the number of individuals of weed plants per unit area.

   Abundance= sum of individual a particular weed species across all sample / Total number of sample in a field

$$A = \frac{\sum W}{n}$$

Where A=abundance, $\sum W$ =sum of individual a particular weed species of individual weed plant per unit n,= total number of samples in the field.

Table 1. Location and coordination of the districts

S. no	District	Altitude (masl)	Longitude	Latitude	Rainfall		Temperature	
					min	max	Min	Max
1	T/Machiew	1966-2001	38.5511767-38.593428	$14^{0}07^{0}1695$-$14^{0}07^{0}08255$	500	700		
2	Adet	2000-2100	38.63700-38.8478	$13^{0}78^{0}757$-$13^{0}98^{0}0250$	-	-	12.5	28.9
3	Adwa	1798-2200	38.861933-38.949266	14.105435-14.253580	-	-		
4	Mayqinetal	1964-2000	39.010082-39.031483	13.965525-14.033698				
5	Edaga Aribe	1938-1943	39.1657683-39.165878	14.056883-14.058472				
6	Embasneyti	1961-1983	39.210707-39.212474	14.071743-14.085508				
7	L/machiew	2100	38.786	14.13768	401	800	15^{0}	28^{0}
8	Hahaile	1981-2200	39.037313-39.080913	14.186785-14.27353				

T/Machiew=Tahtay Macheiw, L/machiew=Laley machiew, Min=Minimum, Max=Maximum, masl=meter above sea level

Dominance (%): abundance of an individual weed species in relation to total weed abundance.

$$Dominance = \frac{A}{\sum A} * 100$$

Where D=dominance, A= Abundance, $\sum A$=total abundance of all species

4. **Density** measures the number of target species per given area (e.g.square meter or hectare).

$$Density = \frac{number\ of\ individual\ target\ occurred}{surafce\ area\ of\ sampling\ unit}$$

Tef weed having between 0 to 10 plants per meter square are lower category, tef weeds density between 10 to 30 are intermediate whereas, more than 30 plants per meter squares are highest density.

5. **Similarity Index:** Similarity of weed communities between any two different locations, soil types, surveys, and crop stages in terms of weed composition.

$$Similarity\ index = \frac{EPg * 100}{(EPg + EPa + EPb)}$$

Where, SI= similarity index, Epg = number of species found in both locations, Epa = number of species found only in location a, Epb = number of species found only in location b.

6. **Important Value Index (IVI):** The important value index is valuable tool for assessing the ecological importance of different weed species within a plant community. It considers both the abundance and frequency of each species providing a a comprehensive measure of their overall impact.

IVI=Relative density + Relative frequency + Relative Abundance

7. **Shannon weiner index(H')**: Tef weed species diversity in plots was calculated by the Shannon diversity index as Shannon & Weaver [19].

$$H' = \sum_{i=1}^{s} p_i(lnp_i)$$

where *pi* is the proportion of individuals belonging to the *i*th species and S is the total number of species. The values of this index range between 1.5 and 3.5 [20]. The higher Shannon weiner index shows there is a diversity while the lower value also one species has a dominance on the field.

3. RESULTS

In the current survey sites, 39 weed species in 18 weed families were identified. Among 39 tef weed species, 20 (51.28%) were broadleaved, 12 (30.77%) were grass weeds, and the least represented were 7 (17.95) sedges.

Weed diversity: The abundance of tef weed families were Poaceae(9),Asteraceae(6), Caryopyllaceae (4), Cyperaceae (3) and Brassicaeae (2), the remained species were in the rest species (Table 2).The higher number of species were collected from Adwa(23), Hahayle (20) and Tahitay machiew and laelay Machiew both counted 19 species, while at Mayqnetal(18) and the remained where the rest species were from others sites. Weed diversity in surveyed area was ranged from 18-23 weed species collected from the five districts. These are 23 tef

weed species at Adwa, 20 tef weed species at Hahayle, 19 tef weed species from Tahtay and Laelay macheiw and 18 tef weed species from Mayqnetal. While the remained district had a tef weed species ranging from 11-12. The richness of the collected tef weed species dominated by Poaceae and Asteraceae families hold 38% of the total species. (Table 2). The major weed family relative diversity had recorded from Poaceae and Asteraceae. The diversity and richness of the weed species is as follow the Shannon weiner index values 2.644, which is moderate, so this indicates there, is tef weed diversity in the weed composition in tef field.

Weed frequency: From the conducted tef weed survey area, the most frequency species, which are more than 50%, were C*haiturus marrubias trum(L.)Ehrh.Rchb(53.48),Cyperus rotundus (L.) (65.5%), Galinosoga parivflora (58.52%), Setaria viridis (68.96%), Dianthus hyssopifolius (L.) 75.86%)* as presented in (Table 4). This indicated that *Dianthus hyssopifolius(L.)*followed by *Setaria viridis* are most prevalent tef species weed in the surveyed areas.

Weed density: Weed density is the number of individual weed plants present in a given area. Weed species that had more than 10 plants/ square meter were *Cerastium glomeratum thuill, Scleranthus annuus L., Cynodon dactylon L. pers., Lobularia maritima* (L) Desv., *Bulbostylis aestivalis*(Retz.) Vakl., *Galinsoga parviflora* Cav., *Dianthus hyssopifolius* L., and *Setaria viridis* (Table 4). From the 39 weed species *Setaria viridis* had the highest weed density value followed by *Dianthus hyssopifolius L. and Galinsoga parviflora Cav*. Their magnitude of the weed density is 18, 19 21 plant per meter square respectively. However, *Crepis sancta (L.) Bornm* had *density* of 44 plant/square meter only in one quadrant (Table 4).

Dominant weed: The dominant tef weed species which had greater than 13% value were Galinsoga *parviflora* Cav., *Dianthus hyssopifolius* L., and *Setaria viridis* prented in (Table 4). The weed species are more prevalent in tef growing and survey areas.

Important value index (IVI): Weed species which score more than 50 are the most important weed in tef growing areas . Weed species that had IVI value of 50 or more serious *Dianthus hyssopifolius L., Setaria viridis, Cyperus rotundus L., Galinsoga parviflora Cav, Chaiturus marrubias trum(L.) Ehrh.exRchb and Bulbostylis aestivalis(Retz.) Vakl., Coreopsis lanceolata (L.)P. Beau.* Presented in (stable 4). Individual location/districts specifically occurred tef weed species on their density and frequency explained as following below.

Table 2. Weed family richness and relative diversity in tef production areas of central Tigray in 2020

S.no	Weed families	Richness	Relative diversity
1	Poaceae	9	23.07692
2	Asteraceae	6	17.9487
3	Caryophyllaceae	3	7.692308
4	Cyperaceae	3	7.692308
5	Brassicaceae	2	5.128205
6	Lamiaceae	2	5.128205
7	Mugworts	1	2.564103
8	Plantaginaceae	1	2.564103
9	Polygonaceae	1	2.564103
10	Scrophulariaceae	1	2.564103
11	Solanceae	1	2.564103
12	Fabaceae	2	5.128205
13	Euphorbiaceae	1	2.564103
14	Coreopsis pachvloma oliv. & hiern.)	1	2.564103
15	Buckhorn plantain	1	2.564103
16	Onagraceae	1	2.564103
17	Amaranthaceae	1	2.564103
18	Convolvulaceae	1	2.564103
	Total	**39**	**2.564103**

Table 3. List of tef weed species density, Abundance and frequency of the surveyed districts in 2020

s.no	Weed species	T/Macheiw		Adet		Adwa		Mayqnetal		L/Macheiw		Hahayle		E/Arebe		E/sneyti	
		D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F
1	*Setaria viridis*	31.22	22.50	28.00	17.50	17.67	15.0	2.25	10.00	25.29	17.50	11.14	17.50				
2	*Dianthus hyssopifolius* L.	15.12	18.60	15.50	18.60	20.00	16.3	20.00	11.63	9.67	6.98	26.75	18.60	11.00	2.33	21	6.98
3	*Galinsoga parviflora* Cav.	34.60	15.15	5.86	21.21	23.17	18.2	19.50	12.12	30.50	12.12	14.33	18.18		0.00	3	3.03
4	*Cyperus rotundus* L.	8.66	17.14	23.25	11.43	12.71	20.0	7.33	17.14	3.67	17.14	2.00	5.71	11.00	5.71	5	5.71
5	Bulbostylis aestivalis(Retz.) Vakl.	16.20	17.86	11.50	21.43	11.25	14.3	10.33	10.71	10.67	10.71	5.60	17.86	1.00	3.57	29	3.57
6	*Arthraxon hispidus thunb. Makino*	19.00	28.57	35.75	28.57		0.0	1.00	7.14	17.50	28.57	11.00	7.14		0.00		0.00
7	Coreopsis lanceolata(L.)P. Beau	4.67	10.71	3.00	7.14	8.25	28.6	16.50	7.14	17.20	17.86	3.00	14.29	20.33	10.71	1	3.57
8	Lobularia maritima (L) Desv.	0.00	0.00	1.00	9.52	11.67	28.6	9.50	19.05	2.00	4.76	14.67	28.57		0.00	0	9.52
9	*Brassica Juncea* (L.) Czern.	0.00	0.00	8.75	14.81	2.83	22.2	3.75	14.81	1.50	7.41	12.67	33.33	5.00	3.70	7	3.70
10	C*haiturus marrubias trum*(L.) Ehrh.exRchb	11.00	16.13		0.00	1.88	25.8	2.25	12.90	4.00	9.68	7.29	22.58	6.00	9.68	29	3.23
11	Cynodon dactylon(L.) Pers.	1.67	13.64	6.50	9.09	8.50	27.3	5.33	13.64	4.00	13.64	21.00	4.55	0.00	9.09	3	9.09
12	*Amaranthus spp*.	1.33	12.50	5.00	16.67	2.83	25.0	1.00	8.33	1.00	4.17	6.29	29.17		0.00	1	4.17
13	*Trifolium resupinatum* L	1.50	20.00		0.00	2.50	20.0	4.00	10.00	5.20	25.00	2.00	10.00	6.00	10.00	1	5.00
14	Digitaria Sanguinalis (L) Scop	0.00	0.00		0.00	2.00	11.1	5.00	11.11	5.00	44.44	19.00	11.11	3.00	22.22		0.00
15	*Eleusine indica* (L.) Gaertn	4.50	28.57	32.00	14.29	1.00	14.3		0.00	1.00	14.29	0.00	14.29		0.00	0	14.29
16	*Crepis capillaris*(L.) Wallr	0.00	0.00		0.00	10.00	27.3	1.00	9.09	1.00	18.18	0.00	36.36	0.00	9.09		0.00
17	*Scleranthus annuus* L	0.00	0.00		0.00	2.33	33.3	1.00	11.11		0.00	5.00	44.44		0.00	1	11.11
18	Salviia tiliifolia Vahl	0.00	0.00		0.00		0.0		0.00		0.00	3.00	50.00	7.00	100.00		0.00
19	*oxygonum sinuatum*(Hochst. & steud. Ex Meis	0.00	0.00		0.00		0.0	3.00	20.00		0.00		0.00		0.00		0.00
20	*Epilobium tetragonum* L.	0.00	0.00		0.00		0.0		0.00		0.00	5.00	100.00		0.00		0.00
21	Diqitaria ternata (A. Rich.) Stapf	0.00	0.00		0.00	4.00	100.0		0.00		0.00		0.00		0.00		0.00
22	Eragrostis plana Nees	3.00	50.00		0.00		0.0		0.00	3.00	50.00		0.00		0.00		0.00
23	Bidens Pilosa L.	0.00	0.00		0.00	3.00	100.0		0.00		0.00		0.00		0.00		0.00
24	*Vicia lens* (L.) Coss. &Germ.	1.00	50.00		0.00		0.0		0.00		0.00	1.00	50.00		0.00		0.00
25	Bidens pachvloma (Oliv. & Hiern.) Cuf.	1.00	100.00		0.00		0.0		0.00		0.00		0.00		0.00		0.00
26	*Euphorbia nutans lag*	1.00	100.00		0.00		0.0		0.00		0.00		0.00		0.00		0.00
27	*Nicandra Physalodes*	0.00	0.00	1.00	100.00		0.0		0.00		0.00		0.00		0.00		0.00
28	Guizotia abyssinica(L.f.) Cass.	0.00	0.00		0.00	1.00	100.0		0.00		0.00		0.00		0.00		0.00
29	Sweet wormwood	0.00	0.00		0.00		0.0	1.00	100.00		0.00		0.00		0.00		0.00
30	Striga hermonthica (Del.) Benth.	1.00	100.00		0.00		0.0		0.00		0.00		0.00		0.00		0.00
31	*Plantago lanceolata*	9.00	100.00		0.00		0.0		0.00		0.00		0.00		0.00		0.00
32	Echinochloa Crus-galli(L.) P.	0.00	0.00		0.00	2.00	20.0		0.00	1.00	40.00	7.50	40.00		0.00		0.00

s.no	Weed species	T/Macheiw		Adet		Adwa		Mayqnetal		L/Macheiw		Hahayle		E/Arebe		E/sneyti	
		D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F
	Beauv.																
33	*Cymvopogon citratus(DC.) stapf*	7.00	100.00				0.0		0.00		0.00		0.00		0.00		0.00
34	*Convolvulus arvensis L.*	0.00	0.00		0.00		0.0		0.00	4.00	50.00		0.00	0.00	50.00		0.00
35	Cerastium octandrum Hocbst. ex Rich.	0.00	0.00	9.00	50.00	15.00	50.0		0.00		0.00		0.00		0.00		0.00
36	*Carex strigosa Huds.*	0.00	50.00		0.00	0.00	50.0		0.00		0.00		0.00		0.00		0.00
37	*Plantago afra L.*	0.00	14.29		0.00	4.00	28.6		28.57	8.00	14.29		14.29		0.00		0.00
38	*cerastium glomeratum thuill.*	0.00	0.00		0.00	16.67	100.0		0.00		0.00		0.00		0.00		0.00
39	*Crepis sancta(L.)Bornm*	0.00	0.00		0.00	44.00	100.0		0.00		0.00		0.00		0.00		0.00

D=density, A=abundance, F=frequency, T/Mchiew= Tahteay Machiew, L/Machiew=Lalaey Machiew E/Arebe=Edaga Arebe, E/sneti=Embasneyti

Table 4. Frequency, Abundance, Dominance, Density, Important value index for central zone of Tigray at 2020

s.no	Weed species	Frequency%	Abundance	Dominance	Density	IVI
1	*Setaria viridis*	68.966	14.60	17.675	21.18	78.423
2	*Dianthus hyssopifolius L.*	74.138	13.83	16.736	18.65	84.282
3	*Galinsoga parviflora Cav.*	56.897	11.07	13.397	19.45	64.687
4	*Cyperus rotundus L.*	60.345	5.79	7.012	9.60	68.536
5	*Bulbostylis aestivalis(Retz.) Vakl.*	48.276	5.45	6.594	11.29	54.838
6	*Arthraxon hispidus thunb. Makino*	24.138	5.19	6.281	21.50	27.449
7	*Coreopsis lanceolata(L.)P. Beau*	48.276	4.50	5.447	9.32	54.827
8	*Lobularia maritima* (L) Desv.	36.207	3.57	4.320	9.86	41.122
9	*Brassica Juncea* (L.) Czern.	46.552	3.38	4.090	7.26	52.857
10	Chaiturus marrubias trum(L.) Ehrh.exRchb	53.448	3.26	3.944	6.10	60.680
11	Cynodon dactylon(L.) Pers.	37.931	2.14	2.588	5.64	43.061
12	*Amaranthus spp.*	41.379	1.53	1.857	3.71	46.966
13	*Trifolium resupinatum L*	34.483	1.16	1.398	3.35	39.137
14	*Digitaria Sanguinalis (L) Scop*	15.517	0.90	1.085	5.78	17.616
15	*Eleusine indica (L.) Gaertn*	12.069	0.74	0.897	6.14	13.702
16	*Crepis capillaris(L.) Wallr*	18.966	0.57	0.689	3.00	21.525
17	*Scleranthus annuus L*	15.517	0.50	0.605	3.22	17.611
18	*Salviia tiliifolia Vahl*	3.448	0.29	0.355	8.50	3.916
19	*oxygonum sinuatum(Hochst. & steud. Ex Meis*	8.621	0.16	0.188	1.80	9.783
20	*epilobium tetragonum L.*	1.724	0.09	0.104	5.00	1.957
21	*Digitaria ternata (A. Rich.) Stapf*	1.724	0.07	0.083	4.00	1.957
22	*Eragrostis plana Nees*	3.448	0.05	0.063	1.50	3.913
23	*Bidens Pilosa L.*	1.724	0.05	0.063	3.00	1.957
24	*Vicia lens (L.) Coss. &Germ.*	3.448	0.03	0.042	1.00	3.913
25	*Bidens pachvloma (Oliv. & Hiern.) Cuf.*	1.724	0.02	0.021	1.00	1.956
26	*Euphorbia nutans lag*	1.724	0.02	0.021	1.00	1.956
27	*Nicandra physalodes*	1.724	0.02	0.021	1.00	1.956

s.no	Weed species	Frequency%	Abundance	Dominance	Density	IVI
28	*Guizotia abyssinica*(L.f.) Cass.	1.724	0.02	0.021	1.00	1.956
29	Sweet wormwood	1.724	0.02	0.021	1.00	1.956
30	Striga hermonthica (Del.) Benth.	1.724	0.02	0.021	1.00	1.956
31	*Plantago lanceolata*	3.448	0.31	0.376	9.00	3.916
32	*Echinochloa Crus-galli(L.) P. Beauv.*	8.621	0.33	0.396	3.80	9.785
33	*Cymvopogon citratus(DC.) stapf*	1.724	0.12	0.146	7.00	1.958
34	*Convolvulus arvensis L.*	3.448	0.10	0.125	3.00	3.914
35	*Cerastium octandrum Hocbst. ex Rich.*	3.448	0.41	0.501	12.00	3.917
36	*Carex strigosa Huds.*	3.448	0.28	0.334	8.00	3.916
37	*Plantago afra L.*	12.069	0.43	0.522	3.57	13.698
38	*Cerastium glomeratum thuill.*	5.172	0.86	1.043	16.67	5.879
39	*Crepis sancta(L.)Bornm*	1.724	0.76	0.918	44.00	1.965

Table 5. Similarity index of tef weeds for eight locations

Locations	TM	Adet	Adwa	Mayqnetal	LM	HAHAl	Edag Arebe	Embasneyti
TM	100	40	34.375	42.307	46.154	39.28571	57.895	40.909
Adet		100	44.44444	54.545	66.667	50	33.33	47.368
Adwa			100	57.692	68	53.57143	36	45.833
Mayqnetal				100	68.182	65.21739	42.857	57.894
LM					100	69.56522	42.857	55
HAHAl						100	47.619	60
Edag Aribe							100	43.75
Embasneytie								100

LM=Laleay Machiew, TM=Tahtay Machiew

Table 6. List tef weed families, species, local name(Tigrgna), Morphological growth categorize and majority, intermediate and minor weed in central zone of Tigray Ethiopia

S.no	Name of weed family	Name of species	Local name (tigragna)	Morphological growth	Inference level	Characterization	
						Plant type	Reproduction type
1	Poaceae	*-Setaria viridis*	Wazwazo	Grass	xxx	a	rs
		- Arthraxon hispidus thunb. Makino	Weddi Arqay	Grass	xx	p	rs
		Digitaria sanguinalis (l) scop	Bariqiay	Grass	X	a	rs
		-Eleusine indica (l.) Gaertn	Ancheqlay	Grass	X	a	rs
		-Eragrostis plana nees	Taftafo	Grass	X	p	rs
		-Echinochloa crus-galli(l.) P. Beauv.	Gonch	Grass	x	a	rs
		-Cymvopogon citratus(dc.) Stapf	Chawchawit	Grass	X	p	both
		-Cynodon dactylon (L.) Pers.	Tihag	Grass	xx	p	rv
		-Diqitaria ternata (a. Rich.) Stapf	Tsaeda Tihag	Grass	X	a	rs
2	Asteraceae	*Galinsoga parviflora* cav.	Tsahiyay Shiwa	Broad	xxx	a	rs
		Coreopsis lanceolata(l.)P. Beau	Aqility	Broad	xx	a	rs
		-bidens pilosa l.	Teneg	Broad	X	a	rs
		Guizotia abyssinica(l.f.) Cass.	Tinigita	Broad	X	a	rs
		-crepis capillaris(l.) Wallr	Demayto/netae	Broad	X	a/b	rs
		-crepis sancta(l.)Bornm	Endaba gerima C	Broad	X	a/b	rs
3	Caryophyllaceae	*Dianthus hyssopifolius l.*	Tsifiri mereat	Sedge	xxx	p	rs
		-Scleranthus annuus l.	Cheguri dimu	Sedge	X	a	rs
		-Cerastium octandrum hocbst. Ex rich.	Unkwon C	Broad	X	a/b	rs
		cerastium glomeratum thuill.	Endaba gerima D	Broad	X	a/b	rs
4	Cyperaceae	*-Cyperus rotundus l.*	Mechiqia	Grass	xxx	p	vr
		-Bulbostylis aestivalis(retz.) Vakl.	Gusae may	Sedge	xx	p	rs
		-Carex strigosa huds.	Unkwon A	Grass	X	p	rs
5	Brassicaceae	*Brassica juncea (l.) Czern.*	Hamli Ef	Broad	xx	a/p	rs
		Lobularia maritima (l) desv	Sibhi tiel	Sedge	xx	a/p	rs
6	Lamiaceae	*-Chaiturus marrubias trum(l.) Ehrh.exrchb*	Rasan	Broad	xxx	a	rs
		-Salviia tiliifolia vahl	Qewey genen	Broad	X	p	rs
7	Mugworts	Sweet wormwood	Sliyan	Sedge	X	a	rs
8	Plantaginaceae	Plantago afra l.	Endaba gerima B	Sedge	X	a	rs
9	Polygonaceae	*Oxygonum sinuatum*(hochst. & steud. Ex meis	Chewmurakh	Broad	X	a	rs
10	Scrophulariaceae	*Striga hermonthica* (del.) Benth.	Metselem	Sedge	x	a	rs
11	Solanceae	*Nicandra physalodes*	Shembaeta	Broad	X	a	rs
12	*Trifolium resupinatum* l	*Trifolium resupinatum* l	Mesi	Sedge	xx	a/b	rs
13	Fabaceae	*Vicia lens* (l.) Coss. &germ.	Ater enchwa	Broad	X	a	rs
14	Euphorbiaceae	Euphorbia nutans lag	Tsaba dimu	Broad	X	a/p	rs
15	Coreopsis pachvloma oliv. &	*Bidens pachvloma* (oliv. & hiern.) Cuf.	Gelegel meskel	Broad	x	a/p	rs

S.no	Name of weed family	Name of species	Local name (tigragna)	Morphological growth	Inference level	Characterization	
						Plant type	Reproduction type
	hiern.)						
16	Buckhorn plantain	*Plantago lanceolata*	Aqilitie zemsil	Broad	x	p	rs
17	Onagraceae	*Epilobium tetragonum* l.	Mereret	Broad	x	P	rs
18	Amaranthaceae	*Amaranthus spp*.	Selato	Broad	x	a/p	rs
19	Convolvulaceae	*Convolvulus arvensis* l.	Hareg/Yenug Ambesa	Broad	x	p	rs

X=minor weed,xx= medium weed and xxx=major weed, a=annual, perianal, biennial and rs= reproduction by seed , vr=vegetative reproduction

The weed abundance is which expressed by weed density and frequency. The higher density counted from the weed species is *Cyperus rotundus L.* in Tahetay Machiew. The highest weed frequency indicates the prevalence of tef weed in the counted field. Then, from the collected weed species, frequently counted weed species was *Arthraxon hispidus thunb. Makino*. In Adet district had the following weed with higher density and frequency was counted from *arthraxon hispidus thunb. Makino*. In Adwa except the frequency the density is not different from the total study areas. Whereas the higher frequency at Adwa the most frequent tef weed is *Scleranthus annuus L., Cyperus rotundus L.* and *Coreopsis lanceolata(L.)P. Beau*. The most frequently observed tef weed were *Cyperus rotundus L., Lobularia maritima (L) Desv., and oxygonum sinuatum(Hochst. & steud. Ex Meis)* counted at Mayqnetal). At Hahayle the intermediate tef weed species density *Cynodon dactylodon L. Pers., Digitaria Sanguinalis (L) Scop and Lobularia maritima (L) Desv*. The most frequent weed observed on the collected sample unite *Lobularia maritima (L) Desv*. and *Brassica Juncea (L.) Czern. At Edaga Arebe* weed density *Coreopsis lanceolata(L.)P. Beau*, In this district the relatively higher frequency was observed from Digitaria Sanguinalis (L) Scop, *Coreopsis lanceolata(L.)P. Beau, and Trifolium resupinatum L*. At Embasneyti the weed measured an intermediate weed density from *Bulbostylis aestivalis(Retz.)Vakl.,Chaiturus marrubias trum (L.) Ehrh.exRchb* .The most frequently observed were *Eleusine indica (L.) Gaertn, Scleranthus annuus L., Lobularia maritima (L) Desv*.(Table 3). Therefore, separating specific and general study area of dominance tef weed species is vital for development of weed management strategy.

Weed Management Strategies: In general, identification of weed composition for target weed species leads to develop appropriate controlling methods.The most frequent tef weed species identified are *Chaiturus marrubias trum(L.)Ehrh.Rchb (53.48), Cyperus rotundus (L.)(65.5%), Galinosoga parivflora (58.52%), Setaria viridis (68.96%), Dianthus hyssopifolius (L.)75.86%)* and the most densed tef weed species are *Setaria viridis, Dianthus hyssopifolius L. and Galinsoga parviflora Cav.*this result indicated that ascending order. Whereas, Galinsoga *parviflora* Cav., *Dianthus hyssopifolius* L., and *Setaria viridis are the most dominant tef weed at study areas.*

Therefore, use the most common weed control methods like in different soil type different frequently tillage, selection of appropriate planting time this needs after weeds destroyed by plouging and cleaning and the field must be optimum moisture, optimum seed rate, hand weeding, use of herbicide, rotation of cereal crops. Development of integrated weeds management strategy; preparing a crop rotation interval, determine the weed free time in this study areas, use of appropriate seed system, which is the most problem in Tigray producing standard seed quality weed and other affecting factors, development of effective herbicide. *Setaria viridis* is an important weed it does not controlled by currently available herbicide and the farmer raised as the most problem tef weed having similarity with tef morphology in early stage at hand weeding.

Similarity index: If the index of similarity is greater than 60%, it can be said that the weed composition represents the same community (Unger, 1984). Weed composition >60% indicates similarity between the two locations. While less than 60% shows different weed composition. Therefore, needs different weed management methods and ways. From the study area similar weed composition observed from the location Laley Machiew>60% with others except for Tahetay Macheiw has similarity with following locations Adwa, Mayqnetal, Hahayle, Embasneyti. Hahayle also has similar weed composition with Mayqnetal and Laley machiew (Table 5).

Weed composition is useful tool to understand the diversity and dominance of weed species in field. Thus, leads to prepare these weed controlling managements.

4. DISCUSSION

Identifying, a number of weed species and morphological growth give chance for selection of target management method. Broad-leaved weeds are the most prevalent, highlighting the need to prioritize weed managements strategies for their control. Additionally, grass and sedge species also constitute as substantial portion of the weed population, necessity the development of strategic weed management approaches. This indicated that the more abundance weed family shows dominant weed in the tef growing areas of which survey taken places. Poaceae, Asteraceae and caryphyllaceae are the abundant weed

families. Fessehaie and Tadele, (2000) reported that these families are the most common weed for tef.

Whereas, the most abundant tef weed species are the following which scored greater than 5 are *arthraxon hispidus thunbs, Galinsoga parviflora Cav., Dianthus hyssopifolius L., and Setaria Viridis* from the lowest value to highest respectively. This is aligned to Zewdie and Damte [14] work on tef weed species prevalent. This moderate diversity of tef weed reveals to provide variety of weed control strategies being effectively management of the weed population. The higher diversity has shown from the Poaceae and Asteraceae most then the others.

The study revealed that richness of tef weeds in the above districts, indicating potential diversity habitats and ecological niches. The weed diversity mainly influenced by variation in topography, soil type, weather variability can contribute to increase tef weed species diversity. This indicated that *Dianthus hyssopifolius(L.)* followed by *Setaria viridis* more prevalent tef species weed in the surveyed areas. The frequency of a weed species indicates how often it occurs within a plant community. A high frequency suggests that species is widely distributed and likely to be encountered in the tef field. The high frequency of these weed species highlights the importance to implement effective weed management strategies in tef production. Understanding the traits of the tef weed integrating approach, farmers can reduce the impact and protect their tef yield.

Identifying weed density helps in weed management to determine the severity of weed infestation and the need for control measures. Therefore, from 39 weed species the higher value of weed density was measured from *setaria viridis*, *Dianthus hyssopifolius L. and Galinsoga parviflora Cav.* Their magnitude of the weed density is 18, 19 21 plants per meter square respectively. However, *Crepis sancta(L.)Bornm* has counted a *density of 44 plants per* meter square this weed is counted from only one quadrant. Then, knowing the higher weed prevalence leading to prepare appropriate weed management control strategy. *setaria viridis*, is difficult in hand weeding because of morphological similarity before heading with tef.

The higher value of weed species suggests that the tef fields are not dominated by a few species but rather have more even distribution of different species. Even though, the tef weed diversity helps to suppers the dominance however it make difficult to control methods may be needed. This result indicates moderate diversity of tef weed in the species of weed community.In addition to diversity, the weed richness means large number of different weed species present in the tef fields. The relative diversity helps in choosing target weed families like Poaceaes, Asteraceae, Caryophyllaceae , Cyperaceae , Brassicaceae and Lamiaceae. This meant diversity of weed species within a specific area relative to the total number of species present.

Considering the abundance and frequency of each species will helps to provide comprehensive measure of their overall impact. The higher important value of index of tef weed indicates reducing yield, increase cost and reduce grain quality. The lower weed density indicated that there not cause significant yield loss in tef production due to small number of quadrant in field. AtTahetay machiew district, *Setaria viridis and Cyperus rotundus* L need to plan strategic control them. At Adet a lower weed density indicated that there not cause significant yield loss in tef production due to small number of quadrant in field. In this district *Setaria viridis and Cyperus rotundus L* need to plan strategic controlling them. The highest weed density counted from the Arthraxon hispidus thumb. Makino is aggressively compete with tef resource cuase to reduce the yield. This is due the weed has the ability to reproduction by both sexually and vegetatively makes to control. The intermediate tef weeds are not dominant for tis locality but it has an impact on tef production. Therefore, the higher weed density observed from *Setaria viridis* leads to prepare appropriate weed management in the future work of research [20] Frequently counted weed species needs more monitoring and timely intervention for controlling them. The minimum weed control method is combined weed management is so good like herbicide application and hand weeding.

The best ways developing weed management in tef production is the following stages. These weed species needs to prepare different controlling methods mainly integrated weed managements like crop rotation, deep and higher

frequency tillage, hand weeding, herbicide application, selection of appropriate time of planting, use weed free seed, use optimum seed rate etc. further research on the understanding of biology and life cycle of the weed species for development of effective herbicide. Monitoring and controlling new weeds. Over all the practice of integrate weed management handling combined sound environmentally is so future work on tef weed species control.

Laleay machiew has similar weed composition except with Tahetay Machiew, whereas, hahayle also has similar weed composition with all location except Tahetay Machiew different weed composition. This might be due to similar agro ecology and farming trend. Whereas, the remained locations were had less than 60 values of similarity, which indicates different, weed community leading different management practices. In this study even though carefully collected the weed species and required data herbarium is not taken. Since the data collected is so adequate drawing conclusion from this study reliable [21].

5. CONCLUSION

The survey of tef weed species across various districts reveals a moderate level of diversity and richness, as indicated by the Shannon-Weiner index value of 2.644. This suggests that tef fields are characterized by a variety of weed species rather than being dominated by a few, which complicates management strategies. Presence of multiple weed families and species highlights the ecological complexity of the tef-growing areas, which necessitates tailored management approaches. Species such as *Dianthus hyssopifolius L., Setaria viridis, Galinsoga parviflora Cav., Cyperus rotundus L.* and Bulbostylis aestivalis (Retz.) Vakl. are identified as the most prevalent, dense weed species indicating their significant impact on tef production. These weed species also had a greater record an important value index. Variability in weed density and frequency across districts suggests localized management strategies are essential. High densities of certain species, particularly *Setaria viridis,* pose a risk to tef yields and require immediate intervention. The Poaceae, Asteraeae and Caryopyllacea tef weed families more emphasis on the development of weed controlling methods in central Zone of Tigray. The findings underline the necessity for integrated weed management strategies, combining cultural practices, herbicide applications, and hand weeding to effectively control weed populations and minimize their impact on tef production. The similarity index revealed that Hahayle has similar weed composition with Laley machiew and mayqnetal this indicated similar weed control managements while Laleay Machiew also similarity weed management methods with Adwa, Mayqnetal, hahayle and Embasneyt. Overall, the results emphasize the need for ongoing monitoring and adaptive management to ensure sustainable tef cultivation in the face of diverse and abundant weed populations.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of this manuscript. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

1. I do have used in my result interpretation, grammar, in determining weed plant type and reproduction style

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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