Farmers' Knowledge and Perception of Crenate Broomrape (*Orobanche crenata*) and Management Practices in Faba Bean Farming System in Northern Ethiopia

Takele Negewo[1*], Taye Tessema[2], Tamado Tana[3] and Seid Ahmed[4]
[1]*Ethiopian Institute of Agricultural Research, Ambo Agricultural Research Center, P.O. Box 37 Ambo, Ethiopia.* [*]*Email:* takelenegewo27@gmail.com
[2]*Ethiopian Institute of Agricultural Research, P.O. Box 2003 Addis Ababa, Ethiopia,*
[3]*Department of Crop Productions, Faculty of Agriculture, University of Eswatini, P.O. Luyengo M 205, Eswatini.* [4]*International Center of Agricultural Research in the Dry Areas, Rabat, Morocco.*

Abstract

Faba bean (*Vicia faba* L.) has a significant potential for nutrient source, income generation and soil fertility management in smallholder farming systems of northern highlands of Ethiopia. However, its cultivation is strongly hampered by the occurrence of the obligate root holo-parasite, crenate broomrape (*Orobanche crenata* Forskal). To gather baseline data for developing a sustainable crenate broomrape management, 33 faba bean growers' households in South Gondar, and South Wollo Zones of the Amhara Regional State and Southern Tigray of the Tigray Regional State of Ethiopia were surveyed during the 2018 cropping season using a structured questionnaire. Most of the respondents (61%) believed that crenate broomrape was introduced in the 1990s with grain meant for food aid. All respondents believed that the weed is highly problematic and difficult to control. Sixty-seven percent of the respondents practice cultural control to minimize its infestation but all perceived that the current management practices were ineffective. The rest of the respondents (33%) did not practice any control measure and preferred abandoning faba bean cultivation in their field. Thus, this survey work indicated that the spread and dense infestation of crenate broomrape is causing considerable impacts on faba bean production. A coordinated management strategy with intensive public awareness creation program that can restrict its infestation and associated socio-economic impacts on farming systems in northern highlands of the country is required.

Keywords: broomrape, cool-season legumes, faba bean growers, infestation

Introduction

Grain legumes are cultivated for human consumption as the main source of protein, cash values, animal feed, and as rotational crop to improve soil fertility and reduce pest infestation. Several grain legumes are widely cultivated and form an

important component of the mixed farming systems in Ethiopia. The major grain legumes are faba bean (*Vicia faba* L.), field peas (*Pisum sativum* L.), lentils (*Lens culinaris* Medik), chickpea (*Cicer arietinum* L.), grass pea (*Lathyrus sativus* L.) and lupin (*Lupinuss* spp).

Faba bean is produced in several agroecosystems providing numerous advantages to the farming communities in Ethiopia particularly when grown through crop rotation and intercropped with cereals like wheat and barley (Landry *et al.*, 2015). Faba bean takes the largest share of the area under legumes (30.4%) and the volume of legumes production (34.6%) in the country [Central Statistical Agency (CSA), 2019]. According to Raval & Navarro (2019) faba bean in Ethiopia is cultivated on 0.519 million hectares of land with production volume of 0.92 million tonnes and productivity of 1.8 tonnes per ha. Ethiopia is the second largest faba bean growing country in the world next to China. The national average productivity is low as compared to other countries due to extreme climate events, ecological impacts, socio-economic factors, and most importantly biotic stresses such as diseases and weeds (Kemal and Olivera, 2016).

The yield of faba bean varies depending on the growing conditions, management practices, weed infestation level and weed species type (Rezene, 1998). Faba bean production is highly threatened by emerging parasitic weeds in northern parts of the country (Rezene and Kedir, 2006; Teklay *et al.* 2013). Abu-Irmaileh & Bayaa (2005) reported the spread of *O. crenata* to Ethiopia and Sudan, where farmers were not even aware of its introduction and options for management.

The yield loss due to crenate broomrape (*Orobanche crenata* Forscal) can reach up to 100% depending on levels of infection on the crop that vary with infestation level, host-parasite interaction and environmental conditions during the crop growing period. Under serious infection, farmers are forced to abandon faba bean cultivation that impacted availability of faba bean grain for food, incomes and its straw for animal feed (Teklay *et al.* 2013; Takele *et al*. 2019; Negewo *et al.* 2022).

Management of the parasitic weed is challenging, as there are no resistant varieties or effective management practices to small holder farmers. Hand weeding has been practiced by farmers but found to be ineffective.

Information on the socio-economic impact of the parasitic weed and its management practices is the basis for developing effective management program. Therefore, the objective of this study was to assess knowledge and perception of smallholder farmers about crenate broomrape spread, impact and management practices in

faba bean production in northern highlands of Ethiopia.

Materials and Methods

Questionnaire development

Eighty-five open and close-ended questions related to broomrape were included in the questionnaire. The major topics of the questionnaire were house head farmers' demographic parameters, crop characteristics (main crops grown and practices of cropping), awareness of the parasitic weed (crenate broomrape), perceived spread and impacts on the cropping system, the effectiveness of farmer-level management practices, and desired assistance from the government in terms of professional support in the process of combating the problem.

Survey areas and sample size

A survey was conducted in faba bean-growing highlands of northern Ethiopia in October and November 2018. Perception of farmers on crenate broomrape was assessed on individual household in major faba bean-growing highlands. The survey area included South Gondar and South Wollo Zones in Amhara region, and Southern Tigray Zone in Tigray region and located between 2200 to 3200 m a.s.l. (Fig 1). The indicated zones and districts under each zone were selected on the basis of level of faba bean production and suspicion of broomrape occurrence.

A total of 33 faba bean growers (households) 10 Km apart along the main road of the target district were interviewed. Districts and number of interviewees are shown in Table 1. To encourage in-depth discussion, the interview was conducted using local languages, *i.e.,* Amharic for South Gondar and South Wollo Zones, and Tigrigna for Southern Tigray Zone.

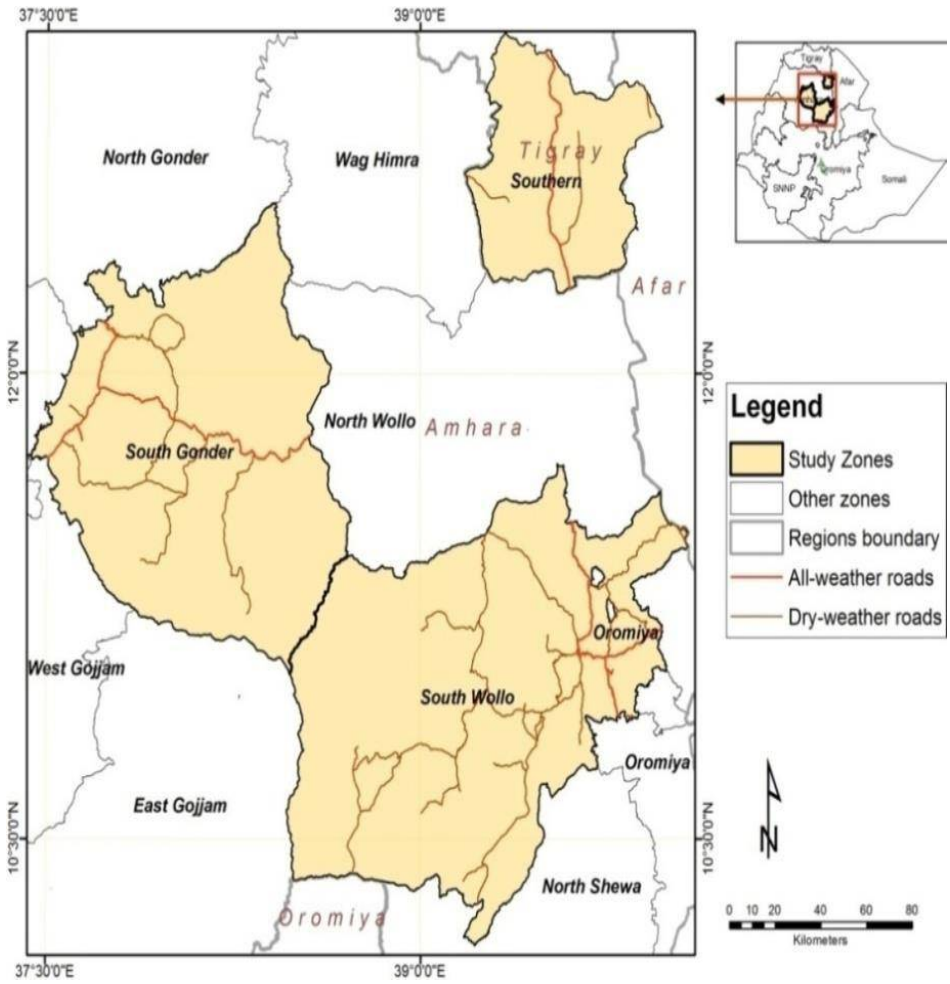

Figure 1. Map showing surveyed areas in northern Ethiopia

Table 1. The sample size of the respondents in the study areas in October and November 2018

Region	Zone	District	Sample size (n)
Amhara	South Gondar	Tach-Gaint	12
	South Wollo	Dessie-Zuria	3
		Kutaber	6
		Tenta	6
Tigray	Southern Tigray	Enda-Mahony	3
		Ofla	3
	Total sample size		33

Data analysis

Descriptive statistics (mean, frequency and percentage of a variable group) were used to summarize the information gathered. The weighted perception index was used in assessing the perception of faba bean growers on

crenate broomrape infestation status, socio-economic impacts and management practices effectiveness. Pearson Chi-Square test was used to compare the significance of a categorical variable among farmers over different study zones (IBM SPSS statistics, 2015).

Results and Discussions

Demography of faba bean growers

Frequency of sex-group, age group educational status and family of the interviewees is shown in Table 2. Most of the respondents were male (94%) with age group between 30 to 60 years accounting for 70%. Respondents with no formal education accounted for 48% and this assisted in understanding knowledge and perception of farmers about the weed from various educational backgrounds. It is also useful to determine the communication medium during awareness campaign. For such groups radio broadcasting and training are preferable to distributing written documents like leaf lets and brochures.

Table 2. Frequency of sex-group, age-group, educational status and family size of faba bean growers interviewed in the surveyed areas in 2018

Zone	District	Sex		Age group			Education status				Family size (#)	
		Male	Female	<30	30-60	>60	No	Basic	1ry	2ry	<five	≥five
S-Wollo	Dessie-Zuria	3	0	0	3	0	0	0	3	0	0	3
	Kutaber	6	0	0	6	0	0	0	4	2	4	2
	Tenta	6	0	0	6	0	6	0	0	0	2	4
S-Gondar	Tach-Gaint	10	2	0	2	10	4	6	0	2	2	10
S-Tigray	Enda-Mahony	3	0	0	3	0	3	0	0	0	3	0
	Ofla	3	0	0	3	0	3	0	0	0	0	3
Total		31	2	0	23	10	16	6	7	4	11	22
Percentage		94	6	0	70	30	48	18	21	12	33	67

Farming practices of faba bean growers

All the respondents were landowners and 24% of them owned more than one-hectare farmland. They grow majorly legumes, cereals and oil crops. Table 3 shows land holdings and farming experiences of the interviewees. The crops cultivated include faba bean, field peas, chickpea, lentil, grass pea, lupin, common bean and cowpea from legumes; wheat, barley, tef, maize and sorghum from cereals; and niger seed, fenugreek and linseed from oil crops.

Table 3. Frequency of landholding-group and farming experience of faba bean growers in the surveyed areas, 2018

Zone	District	Landholding (ha)		Farming experience (Years)	
		0.5-1	>1	<30	30-60
S-Wollo	Dessie-Zuria	3	0	3	0
	Kutaber	2	4	6	0
	Tenta	6	0	1	5
S-Gondar	Tach-Gaint	8	4	2	10
S-Tigray	Enda-Mahony	3	0	0	3
	Ofla	3	0	1	2
Total		25	8	13	20
Percentage		75.75	24.24	39	61

The faba bean farmers plough their land once or twice (82%) and sow in mid to late June (85%) by broad-casting (73%) with a seed rate ranges of 100 to 150 kg/ha (79%) depending on the locality (Tables 4 and 5). Regarding fertilization, 73% of them use the inorganic fertilizer DAP or NPS at 100 kg/ha and/or bio-inoculant fertilizer at 0.5 to 1 kg/ha (Table 5). Low level of farm input such as fertilizer and broadcast sowing may aggravate broomrape infestation However, with availability of diverse crop types to grow, majority of the farmers can practice, crop rotation and intercropping to improve faba bean productivity, and reduce crenate broomrape infestation and associated socio-economic impacts. Adjusting sowing date, optimizing seed rate and fertilize application method may assist in reducing the crenate broomrape-infestation.

Table 4. Frequency of ploughing and seed sowing month of faba bean growers in the surveyed areas, 2018

Zone	District	Ploughing frequency			Seed sowing month		
		once	Twice	Trice	early June	mid-June	late June
S-Wollo	Dessie-Zuria	0	3	0	0	3	0
	Kutaber	2	2	2	0	0	6
	Tenta	2	4	0	0	4	2
S-Gondar	Tach-Gaint	4	4	4	2	8	2
S-Tigray	Enda-Mahony	0	3	0	0	0	3
	Ofla	3	0	0	3	0	0
Total		11	16	6	5	15	13
Percentage		33.33	48.48	18.18	15.15	45.45	39.39

Table 5. Frequency of seed sowing pattern, sowing rate, and fertilizer application of faba bean growers in the surveyed areas, 2018

Zone	District	Seed sowing pattern		Seed sowing rate (kg/ha)			Fertilizer type applied		
		Broad casting	Row planting	<100	100-150	>150	Organic	Inorganic	Bio-
S-Wollo	Dessie-Zuria	3	0	0	3	0	0	0	3
	Kutaber	2	4	0	6	0	0	4	2
	Tenta	6	0	2	4	0	2	4	0
S-Gondar	Tach-Gaint	10	2	0	10	2	0	10	2
S-Tigray	Enda-Mahony	3	0	0	0	3	0	3	0
	Ofla	0	3	0	3	0	0	3	0
Total		24	9	2	26	5	2	24	7
Percentage		72.72	27.27	6.06	78.78	15.15	6.06	72.72	21.21

Infestation of crenate broomrape in faba bean fields

All the respondents said crenate broomrape is well known as a highly unique, problematic and difficult to control parasitic plant. Sixty-one percent of them said that the parasitic weed was introduced to the area in the 1990s at specific sites in the highland area (Table 6). Most of them (85 %) agree that the weed plant was observed for the first time about 30 years back at the highland of their locality following the drought outbreak in 1985 mainly at the storage areas of grains meant for food aid as earlier reported by Teklay *et al.* (2013). Because of the parasitic nature of the weed and the extent of damage it caused to their crop field, respondents assumed the weed crenate broomrape as a different type from the rest of the weed species they are familiar with for years.

Table 6. Farmers perception of crenate broomrape's year and place of first introduction to the surveyed areas, 2018

Zone	Year			Place	
	1980's	1990's	2000's	Upland	Low-lying
S-Gondar	2	6	3	10	2
S-Tigray	10	0	10	6	0
S-Wollo	0	0	2	15	0
Frequency (#)	11	20	2	31	2
Percentage (%)	33.33	60.61	6.06	93.94	6.06

Means are different at an asymptotic significance of 0.002 for year and 0.155 for place

Eighty-two percent of the respondents rated its dispersal as high and 97% said it occurred in their vicinity at a high infestation level (Table 7). Reports on the occurrence and invasion of crane broomrape in Ethiopia have been made by several authors since 1990s (Asefa & Endale (1994), Adugna *et al.* (1998), Besufekad *et al.* (1999), Teklay *et al.* (2013). These reports indicate that the level of infestation and dispersal of crane broomrape on cool-season legumes particularly faba bean is increasing from year to year. Low-intensity crop production system (Negewo *et al*. 2022) coupled with dry weather conditions, light soil and poor soil fertility in the northern Ethiopia might have favored the crenate broomrape invasion. Awareness campaign on the biology and control of crane broomrape along with strict domestic quarantine can help in restricting its invasion and impact.

Table 7. Farmers' perception of crenate broomrape's mechanism of introduction, inter-locality dispersal and infestation in the surveyed areas, 2018

Zones	Introduction mechanism		Dispersal rate			Infestation level	
	Food aid	Seed exchange	Low	Medium	High	Medium	High
S-Gondar	7	5	0	2	10	2	10
S-Tigray	6	0	2	2	2	0	6
S-Wollo	15	0	0	0	15	0	15
Frequency (#)	28	8	2	4	47	2	31
Percentage (%)	84.85	15.15	6.06	12.12	81.82	3.13	96.87

Means are different at an asymptotic significance of 0.155 for infestation level

Most of the respondents (88%) explained that the main agents assisting the dispersal of crenate broomrape seeds include natural and human agents like wind, flood, livestock, farm products and farm tools. Most of the respondents believe that the occurrence and dense infestation of the parasite is favored by prolonged dry growing season but disfavored by an extended rainy season (Table 8). The recorded spread mechanisms lead to understanding the future weed prevention and management programs. In agreement with our survey results, Goldwasser & Rodenburg (2013) reported that alarming cross-border and local spread of orobanche were occurred mostly due to human-mediated dispersals like allowing free grazing of animals, and movement of infested farm products and farm tools. In addition, a prolonged dry growing season that results in moisture stress during the crop growing period can aggravate infection and associated impacts of the parasite. Parker (2013) indicated that where there was a moisture stress, there were greater damages to the point of total crop failure due to *Orobanche* spp.

Table 8. Farmers perception of crenate broomrape's seeds dispersal agent, and infestation favoring and disfavoring situations (weather and farm practice) in the surveyed areas, 2018

Zone	Seed dispersal agent			Infestation favoring situations		Infestation disfavoring situations	
	H	N	H. and N.	PDS	PDS + unfertile soil	ERS	ERS + fertile soil
S-Gondar	0	2	10	8	4	9	3
S-Tigray	0	0	6	6	0	5	1
S-Wollo	2	0	13	10	5	12	3
Frequency (#)	2	2	29	24	9	26	7
Percentage (%)	6.06	6.06	87.88	72.73	27.27	78.79	21.21

Means are different at an asymptotic significance of 0.197 for seed dispersal agents
Note: H =human, N =natural agents, PDS =prolonged dry season, ERS =extended rainy season

The majority of the interviewees realized that the parasitic weed plant can bear seeds in millions per plant per season which can remain viable for 10 or more years in soil (Table 9). However, many of the respondents underestimated the seed bearing capacity of the parasitic plant and seed longevity.

Most of the respondents know that a single crenate broomrape can lead to a substantial increase of the seed bank in soil, increase the plant population per unit area and spread to weed-free neighboring areas. The extent of *O. crenata* plant infestation in faba bean fields can be closely related to the number of seeds in soil bank at the survey area. Sauerborn (1991) reported that most damages from crenate broomrape occurred before it emerged from the ground, and only 10–30% of the attached parasites emerged above the ground. Gevezova *et al*. (2012) and Habimana *et al.* (2014) reported that a single plant of crenate broomrape can set more than 500,000 minute seeds per season which can easily disseminate over long distances by various mechanisms or remain viable in soil for about two decades. As it spreads quickly to neighboring areas, the parasite has been recognized as a national problem.

Table 9. Farmers' perception of crenate broomrape's estimated seeds number per a plant and longevity in soil in the surveyed areas, 2018

Zone	Seed numbers/plant			Seed longevity (yr.)		
	100s	1000s	1 000 000s	<10	10-20	>20
S-Gondar	4	6	2	8	2	2
S-Tigray	0	0	6	0	3	3
S-Wollo	3	2	10	6	2	7
Frequency (#)	7	8	18	14	7	12
Percentage (%)	21.21	24.24	54.54	42.42	21.21	36.36

Means are different at an asymptotic significance of 0.009 for seed number & 0.057 for longevity.

Socio-economic impacts of crenate broomrape

Most of the respondents (97%) indicated that crenate broomrape has been causing higher social and economic impacts (Table 10). These include malnutrition, animal feed scarcity, and low crop productivity. The local common names given to the parasitic weed which include *Akenchira, Daymerch, Gelmit, Kiting, Metselema* and *Yejibras* explain the level of its impact on cool-season food legumes production system.

Crenate broomrape causes a high level of damage on pulses both in yield and quality mainly because of its underground close physiological connection with the host plants (Negewo *et al*., 2022). The same authors indicated that its damage to the legume crops has been generally intensified by prolonged drought stress in the study area which is the case faced by many African smallholder farmers. Due to the severe effects of the parasitism on the host crops and the long persistence of the seed-bank in agricultural soils, abandonment of legumes cultivation in most pulse growing areas is being observed.

Table 10. Farmers perception of crenate broomrape's negative social and economic impacts on the farming system of the studied areas, 2018

Zone	Social impact		Economic impact	
	Medium	Higher	Medium	Higher
S-Gondar	2	10	2	10
S-Tigray	0	6	0	6
S-Wollo	0	15	0	15
Frequency (#)	2	31	2	31
Percentage (%)	3.13	96.87	3.13	96.87

Means are different at an asymptotic significance of 0.155 for both social and economic impacts

Because of substantial damage of crenate broomrape on faba bean, a reduction of hectarage in faba bean production both in mono-cropping and intercropping system is being observed (Besufekad *et al*. (1999); Rezene and Kedir (2006); Teklay *et al.* (2013)).

Cereal-based mono-cropping as a consequence has caused reduction in soil fertility status of farm lands, increment of pest pressure and loss of biodiversity in the area. By limiting the traditional crop rotation practice, crenate broomrape has also hindered social, economic and ecological benefits from diversified cropping systems. The parasite has generally brought negative impacts on farm productivity, farmers' livelihood and the economic development of the country at large (Takele *et al.* 2019). Despite all these limitations, the increasing interest in sustainable agriculture promotes the cultivation of legumes as a tool for ecological

optimization of resource use and promotion of pest resilience in cropping systems.

Farmer-level crenate broomrape management practices

Hand weeding and intercropping were mentioned as crenate broomrape management practices by 67% of the respondents. Thirty-three percent of the respondents preferred abandoning cultivation of the crop (Table 11). All respondents rated the management practices ineffective. This rating is expected as most farmers are unaware of the biological differences of parasitic and non-parasitic weeds and hence differences in success of control using their indigenous knowledge of weed management.

Hand pulling was the only available control practice widely used in suppressing crenate broomrape (Asefa, 2008), but it was not efficient because a) damage from the parasite normally occurs before its emergence b) hand removal of the weed at vegetative growth stage causes uprooting of host plants and c) multiple reemergence of new flashes of the weed following hand weeding. Thus, timing of hand weeding after flowering but before seed shading helps to minimize problems of host plant uprooting and re-sprouting of more shoots from underground buds of crenate broomrape plant. Moreover, hand pulling becomes impractical with an escalating dense infestation of the parasite weed.

Owing to the complex relationship that exists between the parasite and its host plant, the development of effective control strategy is very difficult. Hence, farmers were advised to practice an extended crop rotation, repeated hand removal before seed set, improved soil fertility and crop management, and use of resistant faba bean varieties although the options are not readily available for the subsistence farmers of the area (Negewo *et al*., 2022).

Table 11. Farmers-level management practices against crenate broomrape in the surveyed areas, 2018

Management practice	Zone			Frequency(#)	Percentage(%)
	S-Gondar	S-Tigray	S-Wollo		
Hand weeding (HW)	2	0	2	4	12.12
Intercropping (I)	2	0	0	2	6.06
HW + I	8	6	2	16	48.48
Not growing faba bean	0	0	11	11	33.33

Means are different at an asymptotic significance of 0.000

All the respondents demanded assistance from the government which include technologies like resistant faba bean cultivars and effective herbicides (Table 12).

Cropping systems and farm practices such as ecological conservation, water harvesting, growing resistant faba bean cultivars and inoculation of the crop seed with beneficial microbes can contribute well to reduce the dense infestation and high socio-economic impact of the parasite.

Table 12. Farmers desired assistance to react against crenate broomrape infestation and impacts in the surveyed areas, 2018

Desired assistance	Zone			Frequency (#)	Percentage (%)
	S-Gondar	S-Tigray	S-Wollo		
Knowledge (K)	0	0	7	7	21.21
Technology (T)	8	0	8	16	48.48
K + T	4	6	0	10	30.30

Means are different at an asymptotic significance of 0.000

Conclusion and Recommendation

The study has shown that crenate broomrape is the major bottleneck in faba bean production in the northern highlands of Ethiopia. A significant number of farmers are aware of the damage caused by the weed and difficulty of controlling it although they are unaware of its biology. Rapid spread and increasing infestation of the parasite is causing serious social and economic impacts which need to be addressed. Its impact includes complete crop loss, increased management cost and forced change in the farming system from pulse based to non-host cereal mono-cropping. In summary, the parasitic plant dense infestation is a serious constraint to food security, cash income, crop diversity, and ecological balance. Hence, a national crenate broomrape management strategy encompassing awareness creation and local quarantine based on the socio-economic conditions of the farming community needs to be developed.

Acknowledgements

The authors are thankful to the Ethiopian Institute of Agricultural Research for the financial support to execute the study and to Ambo Agricultural Research Center for providing a vehicle for field work. The authors thank Ambo Agricultural Research center staff members, Getachew Bekele and Eyasu Wolde, for their active involvement in data collection during the field work. The authors also extend their thanks to the crop protection experts of respective agricultural offices and farmers of the survey areas for their cooperation in sharing their time and information.

References

Abu-Irmaileh B. E, Bayaa B. 2005. Report of the FAO technical cooperation project, *No. 3004*. FAO, Rome.

Adugna Wakjira, Amare Gizaw, Kemal Ali, Berhanu Bekele. 1998. Crop losses assessment of 1997 in Gojem and Gondar of Amhara National Regional State. *A survey report submitted to HARC*, Holetta, IAR, Ethiopia.

Asefa Admasu. 2008. Integrated *Orobanche* Management in Food Legumes (Faba Bean): Experience of Farmers' Field School (FFS) in Dessie-Zuria District, Ethiopia. *In*: *Progress on farmer training in parasitic weed management*. FAO, Rome.

Asefa Admasu, Endale Berhe. 1994. *Orobanche crenata:* A potential threat of food legumes in Ethiopia. Ethiopian Weed Science Society (EWSS) Newsletter 2:1. 75 pp.

Besufekad Tadesse, Legesse Admassu, Rezene Fessehaie. 1999. *Orobanche* problem in south Wollo, pp. 1–10. In: *Proceeding of the Ethiopian Weed Science Workshop, Arem* Vol 5, Addis Ababa, Ethiopia.

CSA (Central Statistical Agency). 2019. Report on area and production of major crops-private peasant holdings, meher season 2018/19. *Statistical Bulletin 589*, Addis Ababa, Ethiopia.

.Gevezova M, Dekalska T, Stoyanov K, Hristeva T, Kostov K, Batchvarova R, Denev I. 2012. Recent advances in broomrapes research. *Journal of Biological Science and Biotechnology*, 1(2): 91–105

Goldwasser Y, Rodenburg J. 2013. Integrated agronomic management of parasitic weed seed banks, pp. 393-409. *In*: Joel D.M, Gressel J. and Musselman L.J. (eds.) Parasitic Orobanchaceae: Parasitic mechanisms and control strategies, *Springer-Verlag* Berlin Heidelberg. DOI: 10.1007/978-3-642-38146-1

Habimana S. A, Nduwumuremyi J. D, Chinama R. 2014. Management of Orobanche in field crops- A review. *Journal of Soil Science and Plant Nutrition*, 14(1): 43–62.

IBM SPSS statistics. 2015. IBM SPSS statistics version 23 computer statistical software. IBM Corporation.

Kemal S, Olivera JR. J. S. 2016. Narrowing the yield gap of food legumes through integrated management of parasitic weeds in the highlands of Ethiopia. ICARDAEMBRAPA. Report for the period 20 Nov 2013 - 19 May 2016.

Landry Erik J, Coyne Clarice J, Hu Jinguo. 2015. Agronomic performance of spring-sown faba bean in southeastern Washington, *Agronomy Journal*, 107:2, pp. 574–578.

Negewo T**,** Ahmed S, Tessema T, Tana T. 2022. Biological Characteristics, Impacts, and Management of Crenate Broomrape (*Orobanche crenata*) in Faba Bean (*Vicia faba*): A Review. *Frontiers in Agronomy*, 4:708187. DOI: 10.3389/fagro.2022.708187

Parker C. 2013. The Parasitic Weeds of the Orobanchaceae, pp. 313-344. *In*: Joel D.M, Gressel J. and Musselman L.J. (eds.) Parasitic Orobanchaceae: Parasitic mechanisms and control strategies, *Springer-Verlag* Berlin Heidelberg. DOI: 10.1007/978-3-642-38146-1

Rawal, V., Navarro, D. K., eds. 2019. The Global Economy of Pulses. Food and Agricultural

Organization of the United Nations, FAO, Rome, Italy.

Rezene Fessehaie. 1998. Review of Broomrapes (*Orobanche* spp.) in Ethiopia. *NVRSRP News letter. Issue No. I*, July – December 1998, p. 20-22.

Rezene Fessehaie, Kedir Nefo. 2006. Weed research in high land food legumes of Ethiopia, pp. 278–287. In: *Proceedings of the Workshop on Food and Forage Legumes*, 22-26 September 2003, Addis Ababa, Ethiopia. ICARDA, Aleppo, Syria.

Sauerborn J. 1991. Parasitic flowering plants in agricultural ecosystems of West Asia. Flora Veget. Mundi 9, 83–91.

Takele Negewo, Etagegnehu Gebremariam, Rezene Fessehaie. 2019. Broomrapes (*Orobanche* and *Phelipanche* spp.) in Ethiopia: Problems and Management-*A Review,* pp. 211-230. *In*: *Proceeding of the 24th Annual Conference and Silver Jubilee of Plant Protection Society of Ethiopian*, 16-17 March 2018, Haramaya University.

Teklay Abebe, Hadas Beyene, Yemane Nega. 2013. Distribution and economic importance of Broomrape (*Orobanche crenata*) in food legumes production of South Tigray, Ethiopia. *ESci Journals of Crop Production*, 02(03): 101–106. www.escijournals.net/EJCP.