Available Online at ESci Journals
ESci Journal of Crop Production
ISSN: 2305-2627 (Online), 2306-4064 (Print)
http://www.escijournals.net/EJCP

DISTRIBUTION AND ECONOMIC IMPORTANCE OF BROOMRAPE (OROBANCHE CRENATA) IN FOOD LEGUMES PRODUCTION OF SOUTH TIGRAY, ETHIOPIA

Teklay Abebe, Hadas Beyene, Yemane Nega
Tigray Agricultural research Institute, Alamata research center, Alamata, Ethiopia.

A B S T R A C T

Annual surveys for Orobanche crenata Forsk, were carried out during seasons 2012 and 2013 at pulse growing localities of south Tigray, Ethiopia, to determine the intensity of infestation, study farmers attitude and awareness towards the parasite, discuss the dangers of the weed and develop a future strategy for checking dispersal by creation of necessary legislative measures. The surveys were based on filed survey at highland legumes growing areas and interview using semi-structure questionnaires. Results revealed that Orobanche occurred in 28.6-83.9% of the surveyed fields in Enda-Mekoni and Ofla districts, respectively. Ofla district was the hot spot area and the up-downstream spreads from the original infestation to the rest of districts worsen the problem. The highest frequency and abundance were displayed in Ofla, while, the lowest was in Enda-Mekoni and Raya-Alamata. During the surveys, more than sixty stakeholders were interviewed. Farmer's response to the questionnaire revealed that they were aware of the adverse effects of O. crenata, but malpractices and ignorance about the seriousness of the threat were very common among farmers. The spread of the weed escalated at alarming speed putting all food legumes at jeopardy and indirectly the productivity of cereals is regularly diminution due to the limitation rotational crops resulted cereal based mono-cropping production system. Hence, development of future strategy for checking dispersal by creation of necessary attitudinal and legislative measures is paramount significance to tackle the problem.

Keywords: Broomrape, Food legumes, *Orobanche crenata*.

INTRODUCTION

Food legumes are of a big importance in the human feeding mainly based on grains. However, these cultures are subjected to biotic and abiotic stresses that compromise seriously the yields. Of the former category, the parasitic weed namely *Orobanche crenata*, which is known to be very detrimental (Rubiales *et al*., 2006; Mabrouk *et al*., 2010). *O. crenata* (broomrape) is root parasitic angiosperm lacking chlorophyll and is totally dependent on its host for the supply of nutrients and organic compounds (Mabrouk *et al*., 2010; Gevezova *et al*., 2012). It is considered to be among the most serious agricultural pests of economic importance in many parts of the world. The distribution of *O. crenata* is restricted to the Mediterranean regions, the Middle East and East Africa (Ethiopia), while other species have a wider spread (Cubero, 1994; Pérez-de-Luque *et al*., 2010). *O. crenata* is immense importance in Ethiopia where it infests many of the most important legume crops, particularly faba bean, field pea, chickpea, lentil and dekoko (*Pisum sativum* var. *abyssinicum*) (Rezene and Gerba, 2003; Rubiales *et al*., 2006; Abebe *et al.,* 2013) from which it absorbs much of the root sugars. The damage caused by the parasite is significant. It causes yield losses up to 100 percent in faba bean and field pea fields (Rezene and Gerba, 2003). The distribution of the weed in Tigray region is escalating at alarming speed from some localized areas (District) to almost throughout the whole southern zone of the region (Abebe *et al*., 2013). In highly infested areas, farmers generally avoid growing food legume crops, resulting in substantial reductions to both the extent of cultivated areas and to food legume production (Besufikad *et al*., 1999). Nonetheless, the exact abundance and extent of distribution of the parasitic weed and consequent economic negative impact is yet well determined. Hence, this survey investigated the distribution and intensity of

* Corresponding Author:
Email ID: teklayabebe6@gmail.com

infestation level, the social attitude and economic influence of the invasive weed in pulse growing areas of south Tigray, Ethiopia.

MATERIALS AND METHODS

Description of study area: The surveys were conducted in the south Tigray, Ethiopia. South Tigray is one of the seven administrative zones in the Tigray National Regional State. It is located in the southern most boundary of Tigray region bounded by Afar region in the East, Eastern zone of Tigray in the North, Amhara Region in the South and South West. It lies 12°57'37''.19 North latitude and 39°31'41''.91 East longitude.

The zone includes five districts namely, Raya-Alamata, Ofla, Enda-Mekoni, Emba-Alaje and Raya-Azebo. The former four districts are the major pulse growing areas of the region.

Survey of *Orobanche crenata* in southern zone of Tigray: Survey on distribution and abundance of *Orobanche crenata* was conducted in 2012 and 2013 main cropping season in the highlands of South Tigray, Ethiopia. Field surveys were conducted at private farms in each district, research plots and representative sites. It was conducted at 3-5km interval depending on the legumes available and data were collected from five stops within the field using quadrants. Data on the occurrences, abundance, Orobanche population per unit area and plants were observed and noted. The abundance categories of *Orobanche crenata* was based on the percentage cover estimation with modification developed by (Booth *et al.,* 2003) i.e. very abundant, abundant, frequent, occasional, rare, present and absence (Table 1).

Table 1. Abundance and coverage estimation used in Orobanche crenata assessment.

Abundance category	Description
Absent	No Orobanche is found
Present	Individuals plentiful, but coverage small
Rare	Individuals very numerous at least coverage 5% of the area
Occasional	Plant Covering 6-25% of the area
Frequent	Individuals few or many collectively, covering 26-50% of the area
Abundant	Plant covering 51-75%of the area
Very Abundant	Plant covering 76-100% of the area

Source: Booth *et al*., (2003).

Attitudinal towards *Orobanche crenata* and economic consequences: Both primary and secondary data were collected from different stakeholders (farmers, experts and subject matter specialists) regarding information on occurrence and infestation level of broomrape (*Orobanche crenata),* social attitude towards the weed, temporal and spatial introduction and distribution, economic shock etc. More than 60 stakeholders were interviewed using semi-structured questionnaires. Key-informant discussions were made with experts or subject mater specialies as well as elders of the community on the detail historical introduction and threats.

RESULTS AND DISCUSSION

Distribution and abundance of *Orobanche crenata*:During the biophysical survey, about 57 fields were assessed. Of which, *O. crenata* was found on in all districts at varied infestation level with overall frequency of 59.6%. As it was observed during the survey, *O. crenata* was distributed in all highland pulse growing districts at vary abundance. It was abundantly found in Ofla district at nine peasant associations namely Wonberet, Hayalo, Zata, Fala, Adigolo, Menkere, Hashenge, Hugumbirda and Sesela (Table 2). Ofla district was the first infested area by the invasive weed for two to three decades. The distribution of the weed has got increasing every year. The cultivation of food legumes in the aforementioned peasant associations were nearly stoppage. According to Besufikad *et al*., (1999) most of the profitable food legumes are of out of production on Orobanche infested areas. Of the highly infested localities, Fala, Sessela, Adigolo and Menkere peasant associations displayed up to 100% plant infestation at very abundant category. The infestation of the weed per plant legume and meter square were reached as high as 21 and 54.3, respectively. Three peasant associations (Hashenge, Wonberet and Hayalo) were recently affected areas reached more than 45% of infestation. According the survey report before a decade indicated that Orobanche was only present in some localized spot

areas such as Ofla and Raya-Alamata districts (Rezene and Gerba, 2003). The easily upstream and downstream spread of the weed through unintentional and malpractices makes a big challenge over wide area and potential legumes. The magnitude of the broomrape problem increases each year. In addition, peasant associations such as Tekea, Abeda, Atsela from Emba-Alaje district, Mekhan from Enda-Mekoni district and Merewa from Raya-Alamata district were the infested area by broomrape. Its restricted and contiguous local range in these districts (Enda Mekoni, Raya-Alamata and Emba-Alaje) implies a recent introduction.

Table 2. The distribution and abundance of *O. crenata* in south Tigray.

District	Location/PA	Broomrape count per m^2	Broomrape count per plant	% of infestation	General field coverage
Ofla	Zata	4	2	5	Present
	Zata	0	0	0	Absent
	Zata	0	0	0	Absent
	Fala	7	2	10	Present
	Fala	14	5	94	Abundant
	Fala	37	4.5	85	Abundant
	Fala	42	12	80	Abundant
	Sessela	32.5	9	75	Very abundant
	Adigolo	54	10	100	Very abundant
	Adigolo	23	11	100	Very abundant
	Adigolo	54	16	100	Very abundant
	Adigolo	31.2	7	100	Very abundant
	Adigolo	25	6.3	100	Very abundant
	Adigolo	49	5.6	100	Very abundant
	Wonberet	12	1.6	50	Frequent
	Wonberet	8.5	1.2	20.5	Occasional
	Hayalo	14	4	50	Frequent
	Hayalo	4	3.5	15	Occasional
	Hayalo	0	0	0	Absent
	Menkere	23	12	100	Very abundant
	Menkere	71	17	100	Very abundant
	Menkere	16.5	21	100	Very abundant
	Menkere	54.3	16	100	Very abundant
	Hashenge	39.6	8	40	Frequent
	Hashenge	41	6.9	45	Frequent
	Hashenge	26	4.3	40	Frequent
	Hashenge	1.2	1.1	2	Present
	Hashenge	0	0	0	Absent
	Hugumbirda	3	1	2	Present
	Hugumbirda	6	2	5	Rare
	Hugumbirda	0	0	0	Absent
Enda-Mekoni	Mekhan	4.5	2	5	Rare
	Mekhan	3	1	3	Present
	Mekhan	0	0	0	Absent
	Embahasti	0	0	0	Absent
	Teklehaimanot	0	0	0	Absent
	Senay	0	0	0	Absent
	Meswaeti	0	0	0	Absent

Emba-Alaje	Aiba	0	0	0	Absent
	Aiba	0	0	0	Absent
	Aiba	0	0	0	Absent
	Tekea	0	0	0	Absent
	Tekea	3	2	2.5	Present
	Tekea	0	0	0	Absent
	Bora	0	0	0	Absent
	Bora	0	0	0	Absent
	Abeda	5	4.4	40.5	Frequent
	Atsela	2	3	3.6	Present
	Atsela	13	9	30	Frequent
	Atsela	0	0	0	Absent
	Atsela	0	0	0	Absent
Raya-Alamata	Merewa	2	2	3.9	Present
	Merewa	4	1	2	Present
	Merewa	0	0	0	Absent
	Merewa	0	0	0	Absent
	Tsetsera	0	0	0	Absent
	Tsetsera	0	0	0	Absent

Awareness towards the parasitic weed and economic consequences

Community perception on time and way of introduction: The primary and secondary information sources on the first time and way of introduction of the parasitic weed to the area seemed questionable, but the majority (71.67%) revealed that it was introduced through food aid and contaminated seeds since 1985 drought season from abroad. In the same way, considerable respondents (20%) perceived that it was probably introduced from neighboring region through contaminated seed from market. These ideologies could be possibly right as the weed was first seen on the seed distribution storage surroundings. About 8.3% of the respondents replied that the means of introduction to their area was unknown.

Table 3. Means of introduction of *O. crenata* into the highlands of south Tigray.

Means of introduction	Sample(N=60)		Remark
	Numbers	Freq. (%)	
Food aid and contaminated seeds	43	71.7	Through food aid from abroad starting since 1985
Neighboring region	12	20.0	From Amhara regional state
Unknown	5	8.3	-

Respondents' awareness on the invasiveness and spread status of *O. crenata*: The study on farmers' attitude towards the invasiveness and spread of the weed revealed that they were aware of the danger it caused only those located on the hot spot area. According the primary and secondary sources, heavy *Orobanche* infestation does not only lead to a complete crop failure, but make field soils *Orobanche*-sick over a long period of time, preventing the reasonable production of legumes in the infested fields for many years to come. Similarly, the continuous spread of *Orobanche* limits the choice of rotational crops and often force farmers to give up growing the most profitable host crops (Besufikad *et al*., 1999; Abebe *et al*., 2013). Many farmers in the areas infested abandon growing of legumes altogether, forced to mono-cropping based agriculture. The spread and the impact of the parasite are increasing ever since. The continuing invasion of *Orobanche* is exacerbated by the lack of knowledge of the farmers about means of spread and management of this parasite. Many of the inherent practices spread both inter and intra localities. Planting contaminated locally produced seeds (especially exchange of seeds in the market and cultural farmer to farmer seed exchange), spreading contaminated manure and soil, uncontrolled movement of grazing animals immediately after

harvesting of the crop for feed and, moving contaminated farm equipments and lack of proper phytosanitary measures are among the malpractices that encourage the fast spread of Orobanche in many of these infested and neighboring districts (Table 4). The culture of working in group especially in plowing (farm to farm) exaggerated the movement of the weed through farm equipments within neighboring localities. A considerable number of respondent were stated that strong wind or hearken during winter/dry season facilitated the short and/or long dispersal of broomrape seeds. Most of the respondents stated that *O. crenata* is a highly invader weed. In this regard, from the stated infestation level categories 95% of them declared it is highly invasive, whereas 5% categorized the invasiveness of *O. crenata* as medium (Table 5).

Table 4. Agents facilitating intra and inter spreading of *O. crenata* in south Tigray.

Means of spread	Overall sample (N=60)		Remark
	Number	Freq. (%)	
Contaminated seed	38	63.3	Market and seed exchange
Free grazing/Livestock movement	37	61.67	-
Farm equipments	24	16.7	Within localities
Transport vehicles	4	6.7	-
Wind	16	26.7	-

Table 5. Perception on invasiveness of *O. crenata* in the highlands of Southern of Tigray.

Invasiveness	Overall Sample (N=60)	
	Sample	Frequency (%)
High	57	95
Medium	3	5
Low	0	0

Perception of community on the threat of *O. crenata* on crop production: The highland area of southern Tigray is known for its high potential of high land pulses production. According to the respondents, the adverse effect of the parasitic weed categorized as direct and indirect impacts (Table 6). Among the indirect classes, reduce the fertility status of the soil and high disease pressure as the result of cereal based mono-cropping, malnutrition of households, cost incurred for buying of legume grains and loss biodiversity these crops were the priority stated. Of the direct threats stated, it increased cost of production incurred for clearing the infested lands and force farmers to give up of the most profitable legume crops. Similarly, about 73% of the respondents notify that *O. crenata* makes food legumes out of production and loss of rotational crop. The respondents also alerted that the intensity of the weed increases at times erratic rainfall patterns or warms. According to Mohamed *et al.*, (2006) the scenario analyses of climatic changes taking form of increased temperatures and drought in many areas of the world, *Orobanche* species could pose greater threats to agriculture.

Table 6. Effect of *O. crenata* on pulse crops production in the highland of Southern Tigray.

Negative Impact on crop production	Overall Sample (N=60)	
	Number	Frequency (%)
Yield loss	60	100
Makes pulses out of production	44	73
Indirect losses (reduce fertility, increase disease, malnutrition, etc)	50	83.3

Control activities undertaken by the farmers and their effectiveness: Ever since the weed became a menace, efforts are being made to manage the weed by different methods. In the study area, majority of the farmers practiced hand weeding and hoeing (79.9%) and crop rotation for more than eight years (63.3%) to reduce infestation (Table 7). However, the control of this parasite is difficult because of the fact that the multiple reemergence of new fleshes within 3-4 days and altogether uprooting of faba bean plants. Furthermore, the problem worsen with the high production potential of hundreds of thousands of minute seeds that are highly persistent to the soil conditions and can easily transfer to new areas (Gevezova *et al*., 2012).

Moreover, due to the intimate connection between these holoparasitic weeds and their hosts, no economically viable and effective control system against the parasites could be developed for several cultivated plants. Lack of effective counter measures against broomrapes contributes to the continuously increasing importance of these weeds in agricultural areas (Bülbül *et al*., 2009). All the farmers were not using chemicals due to the unavailability and affordability issues of selective herbicides.

Table 7. Control techniques used by the community and their effectiveness.

Control techniques	Overall sample (N=60)	
	Number	Freq. (%)
Hand weeding and burning	48	79.9
Crop rotation	38	63.3
Chemical/herbicides	0	0
Effectiveness of control measures		
Not effective	36	60
Minimizing the infestation	10	16.7
Effective	0	0

ACKNOWLEDGMENT

We would like to offer a great thanks to crop core process research team of Alamata Agricultural Center for their valuable encouragement and support during the whole period of the study.

REFERENCES

Abebe T. Meles K, Nega Y, Beyene H, Kebede A. 2013. Interaction between broomrape (*Orobanche crenata*) and resistance faba bean genotypes (*Vicia faba* L.) in Tigray region of Ethiopia. Canadian Journal of Plant Protection. Vol. 1, No. 3 pp 104-109.

Besufikad T, Legesse B, Rezene F. 1999. Orobanche problem in South Wollo. Arem 5:1-10.

Bülbül F, Aksoy E, Uygur S, Uygur N. 2009. Broomrape (*Orobanche* spp.) problem in the eastern Mediterranean region of Turkey. *HELIA*, 32, Nr. 51, pp. 141-152.

Booth BD, Murphy SD, Swanton GJ, 2003. Weed ecology in natural and Agricultural systematicts.CAB International Wallinford,UK. pp,25.

Cubero JI .1994. Breeding work in Spain for *Orobanche* resistance in faba bean and sunflower. In: Biology and Management of *Orobanche*. Proceedings of the Third International Workshop on *Orobanche* and Related Striga Research (Eds) Pieterse AH, Verkleij JAC, Ter Borg SJ), Royal Tropical Institute, Amsterdam, the Netherlands. pp. 465-473.

Gevezova M, Dekalska T, Stoyanov K, Hristeva T, Kostov K, Batchvarova R, Denev I. 2012. Recent advances in Broomrapes research. J. BioSci. Biotech. Pp 91-105, 1314-6246.

Mabrouk Y, Mejri S, Hemissi I, Simier P, Delavault P, Saidi M, and Belhadj O. 2010. Bioprotection mechanisms of pea plant by *Rhizobium leguminosarum* against *Orobanche crenata.* African Journal of Microbiology Research Vol. 4(23), pp. 2570-2575.

Mohamed KI, Papes M, Williams R, Benz BW, Reterson AT. 2006. Global Invasive Potential of 10 Parasitic Witch weeds and Related *Orobanchaceae* AMBIO: A Journal of the Human Environment 35(6):281-288.

Pérez-de-Luque A, Eizenberg H, Grenz JH, Sillero JC, Ávila C, Sauerborn J, Rubiales D. 2010. Broomrape management in faba bean. Field Crop Res. 115:319-328.

Rezene F, Gerba L. 2003. Weed Research in High Land Food Legumes of Ethiopia. *In:* Ali K, Kenneni G, Ahmed S, Malhotra R, Beniwal S, Makkouk, K, Halila MH (eds)2003. Food and forage legumes of Ethiopia: Progress and prospects. Proceedings of the Workshop on Food & Forage Legumes 22-26 September 2003, Addis Ababa, Ethiopia pp 278-287.

Rubiales D, Pérez-de-Luqu A, Fernandez-Aparicio M, Sillero JC, Roman B, Kharrat, M, Khalil S, Joel DM, Riches C. 2006. Screening techniques and sources of resistance against parasitic weeds in grain legumes. Euphytica. 147: 187-199.