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Demonstration of the integrated management of orobanche on faba bean in South Tigray, Ethiopia

[1*]Tsehaye Brhane, [2]Ftaneges Alem

[1,2]Tigray Agricultural Research Institute at Alamata Agricultural Research Center, Tigray, Ethiopia
P.O.Box. 56 , Alamata, Tigray, Ethiopia

Abstract: *Integration of Glyphosate and tolerance faba bean variety demonstration was conducted at Adigollo kebelle (Ofla district) in 2017 main cropping season to demonstrate the efficacy of herbicide to control orobanche weed. The herbicide chemical was applied using the improved Hashenge faba bean variety as treated and untreated (control) plots. The analysis of variance of O. crenata severity showed significant ($p<0.05$) difference on the orobanche number per square meter but no significant difference among orobanche severity, incidence and grain yield of faba bean variety. Moreover, the result indicated that the highest O. crenata number per plant (7) was observed in untreated Hashenge variety while the lowest (3.4) was recorded on the treated plot. Based on this, the treated plot of Hashenge variety with glyphosate was reduced by 49% O. crenata number than the untreated plot. The severity and incidence of orobanche on Hashenge variety inoculated with glyphosate was reduced by 53.33% and 21.79 % than the uninoculated plot of Hashenge variety, respectively. The Orobanche resistant variety, Hashenge treated with glyphosate, had 9.30% more seed yield than untreated plots and this management practice has to be popularized and scaled up/out to the orobanche infested areas of the Ofla district of the southern Tigray and other similar areas.*

Index Terms **– Glyphosate, Hashenge, herbicide, orobanche, and infestation**

I. INTRODUCTION

Ethiopia is the largest producer of faba bean in Sub-Saharan Africa, and it is an important crop for smallholder farmers in the highlands of Ethiopia, which practice mixed crop-livestock farming. Faba bean is an important crop in the wheat/barley-based cropping systems of the Ethiopian highlands. It is the largest legume crop in terms of area and an important food and cash crop for many households. In 2012/13, about 4.4 million smallholder farmers planted 574,000 ha of faba bean producing 0.9 million tones at an average productivity of 1.6 tons per ha (FAO, 2015). In rural areas, where diets are cereal based, faba bean is an extremely important source of household nutritional security as it is high in protein and is important in diversifying diets (Crepona *et al.*, 2010). Faba bean also helps to improve soil fertility and soil health and sustain the productivity of barley and wheat through nitrogen fixation and when used as a rotational crop, it also helps reduce pest and weed infestations (Sahile *et al*., 2008).

Crenate broomrape (*Orobanche crenata*) is occasionally known by the synonym *Orobanche speciosa.* This out-crossing species shows genetic diversity, but no clearly defined local races (Paran *et al.,* 1997). The parasite belongs to the class Dicotyledonae order Scrophulariales, and family Orobanchaceae. Orobanche is commonest in the Mediterranean countries, the Middle East and East Africa (Ethiopia), while other species have a wider distribution (Perez-de-Luque *et al.*, 2010). *O. crenata* is important in Ethiopia where it infests many legume crops, particularly faba bean, field pea, chickpea, lentil and dekoko (*Pisumsativum var. abyssinicum*) (Rezene and

Gerba, 2003; Rubiales *et al.,* 2006; Teklay *et al.,* 2013). The distribution of the weed in Tigray region is increasing at alarming speed from some localized areas to almost throughout the whole southern zone of the region (Teklay *et al*., 2013; Tsehaye *et al* 2016, unpublished data). In highly infested areas, farmers are avoiding growing food legume crops, resulting in substantial reductions to both the extent of cultivated areas and to food legume production (Besufikad *et al.,* 1999). The parasitic weed *O. crenata,* though known to have been a problematic weed in parts of North Wello and neighboring areas in the Amahara region for quite some period, and has become a major pest of faba bean and field pea in the highlands of the southern zone of Tigray in the last two decades. The weed reduces the ability of the host plant to absorb water from the soil under moisture stress conditions, and causes drought stress and wilting of the host resulting in heavy yield loss. The effect is more pronounced in northern Ethiopia where moisture availability is limited. The total areas infested in Tigray region have been estimated more than 5000 ha in five districts. Faba bean yield losses due to this weed reneges from 0-99.2 % in Tigray (unpublished data). Due to orobanche infestation measures that have been taken so far including chemical herbicide sprayings and manual weeding of *O. crenata* plants in the Tigray were not effective enough to reduce the parasitic weed population and curb further distribution of the weed and as a result it has become a major threat to faba bean production in the region and is colonizing previously un-infested neighboring districts (Kiros and Mulubrhan, 2005). However, an integrated approach has to be devised to alleviate the problem that is challenging faba bean production.

Alamata Agricultural Research Center, in collaboration with ICARDA has been developed many faba bean technologies that include demonstration of glyphosate orobanche tolerate faba bean variety in southern zone of Tigray region. However, there are constraints that hinder faba bean production in the farmers of Ofla district (South Tigray) which includes very limited management practices on faba bean crop varieties compared with wheat crop and biotic factors like weed, disease and insect pests. Thus, we aimed with the present study to demonstrate the efficacy of glyphosate in faba bean to control orobanche weed and increase faba bean productivity and production in the orobache infested area of Ofla district".

2. Materials and Methods

2.1 Description of the Study Areas

Faba bean demonstration was carried out in the orobanche infested areas of Adigollo kebelle (testing location) during 2017 main growing season. Adigolo kebelle is found in Ofla district, south Tigray which have an altitude of about 2446 meter above sea level. According to the 14 years data collected from Ofla district bureau of agriculture, the study area has maximum and minimum temperatures of 5.4 to 20.2 ^{0}c, respectively (Ofla BoA, personal communication). Moreover, it is located 12 ^{o} 31' N latitude and 39^{o} 33' E longitude with its annual rainfall of about 654.4 mm (Tigray region metrological data service 2017). The soil characteristics of the testing location are described as below (Table 1).

Table 1 Soil characteristics of the study area

pH	OM	OC	T N	C:N	P (ppm)	CEC	EC	Soil Type
6.167	2.343	1.36	0.14	9.91	13.6	19.2	0.17	Clay

Source: Alamata Agricultural Research Center review report ,2017

OM: Organic matter (%), OC: Organic carbon (%), TN: Total nitrogen (%), C:N: Carbon-to-nitrogen ratio , P: Phosphorus (ppm), CEC: Cation exchange capacity ((cmol(+)/kg soil, EC: Electrical conductivity ((ms/cm)

2.2 Treatments and Design

Glyphosate demonstration on improved Orobanche tolerant faba bean variety was carried out in the Orobanche infested areas of Adigollo kebelle to increase tolerant of the variety on Orobanche (Ofla district, South Tigray). One variety (Hashenge) with glyphosphate treated and untreated (control) was used in a single plot of seven farmers (a farmer as one replication). Farmers' fields were selected based on previous history of orobanche infestation. A plot size of 10m*10m and the glyphosate 48% WSC with the rate of 80 g a.i/ha was used to the treated plots 1times after 28 days of sowing. knapsack sprayers are used for glyphosate applications. Hand compression sprayer pressure is used to force the glyphosate solution from a supply tank to the nozzle.

Incidences were estimated using a 0 to 100% scale . On this scale, 0% represents a row in which no *O. crenata* had emerged and 100% represented a row in which all the host plants carried emerged spikes of *O. crenata* (Ghannam *et al*.,2017).

The severity was determined based on the number of emerged spikes of the parasitic plant per host plant. The severity index was calculated using the formula described by Mokhtar *et al., (*2009) as follows:

$$DS = \frac{\sum(n*c)}{N}$$

Where, DS= disease severity index

n =Number of infected plants per category

c = Category number

N = Total plants examined

3. Results and Discussion

3. 1. Performance of Faba bean yield and yield components in the Orobanche Management

The analysis of variance of *O. crenata* severity showed significant ($p<0.05$) difference on the orobanche number per meter square, but no significant difference among orobanche severity, incidence and grain yield of faba bean variety. The result indicated that the highest *O. crenata* number per plant (6.7) was observed in untreated Hashenge variety while the lowest (3.4) was recorded on treated Hashenge variety(Table 2). The treated plot of Hashenge variety with glyphosate was reduced by 49 % *O. crenata* number than the untreated plot.

The treated Hashenge variety had the lowest percent of O. *crenata* incidence (8.83 %) and severity of 7 % as compared to the untreated plot and had higher incidence (11.29 %) and severity (15 %) of *O. crenata.* The severity and incidence of orobanche on Hashenge variety inoculated with glyphosate were reduced by 53.33 % and 21.79 % than the uninoculated plot of Hashenge variety, respectively.

Table 2. Mean values of Herbicide management practices on Faba bean yield and yield components of Orobanche infestation area

Treatment	DM	PHT	NPPP	NSPP	GY (Kg/ha)	ON/m^2	Incidence (%)	S.I (%)	Rank
Glyphosate treated	112.8	80.7	15.7	3.54	2830	3.4	8.83	7	1
Untreated	113.3	77.0	16.3	3.10	2589	6.7	11.29	15	2
Difference (%)	-0 .5				+9.30	-49	-21.79	-53.3	
T-test	0.4	**0.59**	**0.87**	**0.54**	0.37	2.58	1.15	1.41	

DM: Maturity dayes, PHT: Plant height, NPPP: Number of pods per plant, NSPP: Number of seeds per pod, GY: Grain yield, ON/M^2: Grobanche number per meter square, S.I: Severity index

The Orobanche resistant variety, Hashenge treated with glyphosate, had 9.3 % more grainyield than untreated plots. The difference in faba bean seed yield and *O. crenata* number was attributed to the potential of glyphosate (Ghannam *et al*,,2017). The analysis of variance for plant height, pod number per plant and seed number per pod showed no significant (*$p>0.05$)* difference among the treatments(table 2).

Table 3. Partial Budget Analysis

Variable costs	Glyphosate treated	Untreated
Cost of chemicals(birr/ha)	187.5	0
Total variable cost	187.5	0
Total fixed cost	3500	3500
Yield obtained (kg/ha)	2830	2589
Selling price(birr/kg)	56,600	51,780
Total benefits	56,600	51,780
Net benefit (Birr)	56,412.5	51,780
Change in TR	-	4,820
Change in TVC	-	187.5
MRR (Ratio)	-	24.70
MRR (%)	-	2,470.7

Agricultural growth requires continuous improvement of crop production technology at the farm level, and the objective of a partial budget in faba bean production was to recommend technologies that are ergonomically different, economically superior, and socially acceptable to farmers. Partial budget was used to assess the costs and benefits associated with a specific change in a farm (Table 3). This tool specifically focuses on the implications of the intended change in a business operation by comparing the benefits and costs resulting from implementing the alternative with respect to the current practice, results showed that the marginal rate of returns of changing from Treatment 1 to Treatment 2 was 24.707. It means that investment of 1 birr in 80 gram/ha on faba bean recouped the 1 birr and gave an additional 24.707 birr, also a change from Treatment 1 to Treatment 2 gave a marginal rate of return of 2,470.7 % which was higher than the acceptable minimum rate of return of 160% (Tigner.R., 2006), therefore, glyphosate treated faba bean of 80 gram/ha was recommended.

CONCLUSION

Glyphosate treated Hashenge variety have good yield, good level of resistance against *O. crenata* than the untreated. Therefore, the variety has to be made available to all the farming communities in the *O. crenata* infested areas, Moreover, research studies need to be conducted to evaluate the reaction of faba bean varieties to orobanche and to come up with chemical and other control methods of *O. crenata* to enhance faba bean production. So, we recommended that farmers can be use glyphosate as a package.

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