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Integrated Management of Barley Shoot fly at highland of Guji zone southern Ethiopia

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This study was initiated to assess the effect Integrated Management of Barley Shoot fly on yield and yield component of Barley (Hordeum vulgare L. A field experiment was conducted during the 2017-18 main cropping season at Bore Agricultural Research Center to evaluate the effect of integrated barley shoot fly management on yield components and yield; and to determine economically feasible treatments for barley production. The treatments consisted of five levels of insecticides (Apron star, Dynamic, Proseed plus, Joint and Torpedo and four levels of planting dates. The experiment was laid out as a Randomized Complete Block Design in a factorial arrangement with three replications. Analysis of the results revealed that interaction of the two factors (chemicals and planting dates) significantly affect almost all parameters except thousand kernels weight, number of tiller per plant and number of productive tiller per plant. Generally, all parameters recorded over all treated plots were significantly higher than untreated/control plots. Thus using of chemical/pesticide and adjusting planting date improve yield components, yield and decrease barley shoot fly infestation. The highest grain yield (4403 kg h^{-1}) was obtained from combined application of Torpedo + at first planting date whereas the lowest barley shoot fly infestation recorded from application of Torpedo at first planting date. The partial budget analysis revealed that combined applications of Torpedo insecticide and planting in the last week of July gave the best economic benefit 26941.78 Birr ha^{-1}. Therefore, based this study it can be concluded that use of Torpedo insecticide and planting in the late July can be recommended for production of barley in the study area and other areas with similar agro-ecological conditions.

Key words: Insecticide, interaction effect, main effect, shoot fly, sowing date

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INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the main cereal crops produced in the World. It ranks fourth in the world in production after wheat, maize and rice (FAO, 2013). Global barley production is estimated about 141.7 million tons (USDA, 2017). Many countries grow barley as a commercial crop. Globally European Union, Russia, Canada, USA and Argentina are the top five largest world barley producers where, European Union produces the greatest quantities of barley with an estimated production of 20.5 million tons followed by Russian federations with a production of about 8 million tons, whereas Canada, USA and Argentina barley production was estimated 7.3, 3.1 and 2.8 million tons respectively (USDA, 2017).

Ethiopia is one of the major producer of barley in Sub-

Saharan Africa and the second largest producer in Africa next to Morocco, accounting for about 26 percent of the total barley production in the continent (Shahidur *et al*., 2015). In 2017/18, about 3.5 million smallholder farmers grew barley on more than 0.95 million Meher hectares of land and produce 2.053 million tons (CSA, 2018).

In Ethiopia, Barley production started long years ago and is largely grown as a food crop in the central and northern parts of Ethiopia, with Oromia, Amhara, Tigray, and Southern Nations, Nationalities, and People's Region (SNPPR) as the main areas of production (Abate. *et al*., 2015).

Farmers in different parts of the country are growing different types of cereal crops based on their agro-ecological suitability to address their family food demand. Particularly, farmers in high land parts of the country are producing barley for home consumption and income generation. As a result, it's commonly called as a poor man's crop that can able to give yield in environments unsuitable to other crops at higher elevation (Zerihun *et al*., 2007).

Barley grows well at altitudes of 1500–3500 m.a.s.l. and is predominantly grown at 2000–3000 m.a.s.l. (MoA, 1998). Highland parts of Guji Zone is also found within the suited agro-ecological range for barley crop production. Farmers in the area are usually producing barley as major crop for home consumption as well as for cash generating. It ranks second next to maize both in area (20,982.04 ha) and production (324,834.66). However, the production and productivity of the crop remains low (1.548 ton ha^{-1}) as relation to the national (2.11ton ha^{-1}) and regional (2.41 ton ha^{-1}) productivity (CSA, 2017). This may be due to several production constraints like in insect pest, low soil fertility, diseases, lack of improved varieties and etc.

From these constraints, barley shoot fly one of the major barley production problem in Guji highlands. A survey of *Barley shoot fly* incidence and damage level conducted in 2014 and 2015 indicated that there is high infestation which can cause high yield loss in barley production. However there were no management practices done even though it is yield loss causing problem. Therefore, there is a need to evaluate and recommend different management options such integrated management which are economically and environmentally viable for the producing farmers. Hence, this activity was proposed with the objective; Evaluating integrated approaches in barley shoot fly management and recommend the best option. To determine economically appropriate management for barley production in study area.

MATERIALS AND METHODS

Description of the Study Area

The experiment was conducted at two high land districts of Guji Zone; for two years (2017 and 2018) Bore and Ana Sora to evaluate and promote economically and agronomical feasibility of chemicals against *shoot fly* on food barley and appropriate sowing date at studied areas. Bore and Ana Sora were located at 385 and 410 km from capital city of the country Addis Ababa to the South respectively. The climatic condition of both districts comprises an annual rain fall of 1250 mm/annual, mean temperature of 17.5-28 ^{o}c. Both district were selected for this experiment based on potentiality of barley production and shoot fly infestation history.

Plant materials and Experimental Design

For this experiment five pesticides (chemicals) (Joint 246 FS, Torpedo 250 FS, Dynamic 400 FS, Proseed Plus 63 WS and Apron star 42 WS) with control (pesticide treatment free) and four planting date with seven days interval were used. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each experimental plot has 2.5 m long and 1.2 m wide, with 6 rows 20 cm apart, giving a gross plot area of 3 m^2. Spacing for adjacent blocks 1.5 m and 1 m between plots was used. Sowing was done by hand drilling and covered lightly with soil. The seed rate and fertilizer rate were applied at the national recommendation for barley production. All other agronomic practices were also applied as recommended for barley production.

Data Collection

Data was collected from a net plot of four rows and selected plants of the plot for agronomic and diseases data. Collected agronomic data includes; Days to heading (DTH), Days to 90% maturity (DTM), Plant height (PH), Spike length (SL), Total number of tillers/plant, number of fertile tillers/plant, 1000-kernel weight (TKW),Grain yield/ha (GY kg/ha) whereas shoot fly infestation and dead heart data's were collected.

Data Analysis

The recorded data was subjected to analysis of variance (ANOVA) as suggested by Gomez and Gomez (1984) using GenStat 18th Version. Mean separation was carried out using Least Significant Difference (LSD) at 5% levels of significance.

RESULT AND DISCUSSION

Days to heading

The analysis of variance revealed that the main effect of planting date is highly significant (P < 0.01) on days to heading of barley while the two-factor interactions of Chemical x planting date significantly (P<0.05) influenced days to 50% heading. However, the main effect of chemical did not significantly affect days to 50% heading of the crop.
The highest prolonged duration to reach 50% heading was observed in response to the combination of planting date one and two across all pesticides. However, the minimum duration to 50% heading was observed in the application of Apron star 42 WS at fourth planting date (Table 1).

Table 1. Mean of pooled data analysis (2017-2018) results of interaction effect of chemical and planting date on days to heading of barley at Bore and Ana sora districts.

Treatments	Days to heading				Days to maturity			
	Planting date				Planting date			
	P1	P2	P3	P4	P1	P2	P3	P4
Control	83^{a}	83.33^{a}	79.33^{bc}	75^{e}	146^{a}	139.7^{c}	134.3^{d}	127.3^{e}
Apron Star 42WS	83^{a}	83^{a}	79.67^{b}	73.33^{f}	144^{b}	139.7^{c}	133^{d}	127.3^{e}
Dynamic 400 FS	83^{a}	83^{a}	78.33^{d}	75^{e}	144^{b}	139^{c}	133^{d}	127.3^{e}
Proseed Plus 63WS	83^{a}	83^{a}	79^{bcd}	74.67^{e}	144^{b}	139.3^{c}	133.3^{d}	126.3^{e}
Joint 246 FS	83^{a}	83^{a}	79^{bcd}	74.67^{e}	144^{b}	139.7^{c}	133.7^{d}	126^{e}
Torpedo 250 FS	83^{a}	83^{a}	78.67^{cd}	75^{e}	144^{b}	139.3^{c}	133^{d}	127.3^{e}
LSD(0.05)	0.91				1.55			
CV (%)	0.7				0.7			

Means with the same letter(s) in the columns and rows are not significantly different at 5% level of significance, CV (%) = Coefficient of variation, NS= non significant, LSD = Least Significant Difference at 5% level

Days to physiological maturity

The main effect of planting date and interaction of the factors were highly significantly (P < 0.01) influenced days to physiological maturity of barley. But the main effect chemical did not significantly affect days to physiological maturity.
The longest days to physiological maturity (168.7 days) was recorded at first planting date with control/untreated whereas the shortest days to physiological maturity (126 days) was obtained from combination of Joint at fourth planting date. The increase in days to maturity of barley at the control might be due to rejuvenation of the crop as infestation is high at control.

Plant height

The two factor interaction and main effect of chemicals significantly (P < 0.05) influenced plant height. On the other hand, the main effect of planting date had no significant effect on this parameter.
The result indicated that height of barley plants increased as infestation decreased (Table 2). The tallest plant (115.8cm) was recorded at Joint at second planting date while the shortest plant (101.9 cm) was obtained at control combined with third planting date of the two factors.

Spike length

The analysis of variance revealed significant (P < 0.05) interaction of the two factors and main effect of planting date on the spike length whereas the main effect of chemical did not have significant influence on this parameter.

Thus, the longest spikes (9.00 cm) were obtained at combination of Joint and first planting date whereas the shortest spikes were produced at the combination of the Proseed Plus and first planting date (Table 2). The highest spike length at the treated rather than control might have resulted from improved root growth and increased uptake of nutrients and better growth favoured due to decrement of shoot fly infestation.

Table 2. Mean of pooled data analysis (2017-2018) results main effect of chemicals and planting date on plant height and spike length of Barley at Bore and Ana sora districts.

Treatments	Plant height (cm)				Spike length (cm)			
	Planting date				Planting date			
	P1	P2	P3	P4	P1	P2	P3	P4
Control	103.6^{cd}	102.5^{d}	101.9^{d}	102.7^{d}	7.778^{c-f}	8.944^{ab}	8.944^{ab}	8.611^{abc}
Apron Star 42FS	113.7^{ab}	115.1^{a}	110.6^{a-d}	102.6^{d}	7.5 0^{def}	8.500^{abc}	7.889^{c-f}	7.944^{c-f}
Dynamic 400FS	111.0^{a-d}	105.1^{bcd}	111.2^{a-d}	113.8^{ab}	7.833^{c-f}	8.222^{a-d}	8.00^{b-e}	8.278^{a-d}
Proseed Plus 63WS	110.2^{a-d}	109.4^{a-d}	113.1^{ab}	114.6^{a}	7 .00^{f}	8.944^{ab}	8.611^{abc}	8.500^{abc}
Joint 246FS	112.8^{abc}	115.8^{a}	109.7^{a-d}	107.8^{a-d}	9.00^{a}	8.667^{abc}	8.167^{a-d}	8.111^{a-d}
Torpedo 250FS	107.6^{a-d}	114.2^{ab}	109.1^{a-d}	115.1^{a}	7.111^{ef}	8.611^{abc}	7.889^{c-f}	8.444^{a-d}
LSD(0.05)	9.33				0.98			
CV (%)	5.2				7.3			

Yield Component and Yield

Number of tillers per plant

The main effect of chemical and planting date did not significantly (P<0.05) influenced the number of tillers of barley. Similarly the two-factor interaction (chemical x planting date) also did not significantly affect this parameter. This finding agrees with that of Wakene *et al* (2014).

Table 3. Mean of pooled data analysis (2017-2018) results interaction effect of chemical and planting date on number of tillers and number of productive tiller per plant of barley

Treatments	Number of tiller/plant				Number of fertile tiller/plant			
	Planting dates				Planting dates			
	P1	P2	P3	P4	P1	P2	P3	P4
Control	3.222	3.667	3.722	3.611	2.833	3.167	3.278	3.111
Apron Star 42 WS	3.667	3.056	3.556	3.389	3.222	2.833	3.056	3.056
Dynamic 400 FS	3.50	3.444	3.389	3.278	3.111	3.00	3.00	3.278
Proseed Plus 63 WS	3.722	3.50	3.389	3.722	3.167	3.111	3.056	3.056
Joint 246 FS	3.389	3.389	3.50	3.389	2.889	2.944	3.056	3.278
Torpedo250FS	3.778	3.278	3.444	3.722	3.222	2.722	3.056	3.222
LSD (0.05)	NS				NS			
CV (%)	9.9				11.2			

Means with the same letter(s) in the columns and rows are not significantly different at 5% level of significance, CV (%) = Coefficient of variation, LSD= Least Significant Difference at 5% level

Number of productive tillers

The main effect of chemical and planting date did not significantly (P<0.05) influenced the number of productive tillers of barley. Similarly the two-factor interaction (chemical x planting date) also did not significantly affect this parameter.

Thousand Kernels weight

The main effect of chemical and planting date did not significantly (P< 0.05) influenced thousand kernels weight of barley. Similarly the two-factor interactions did not significantly affect thousand kernels weight of barley.
The highest thousand kernels weight (60.42 g) was recorded at combined application of Torpedo at first planting date whereas the minimum thousand kernel weight (32.11 g) was observed at application of Torpedo at fourth planting date, even though there were not statistically different.

Table 4. Mean of pooled data analysis (2017-2018) results of interaction effect of chemicals and planting date on number of kernels per spike of barley at Bore and Ana sora districts.

Treatments	Grain yield (kg/ha)				TKW (g)			
	Planting date				Planting date			
	P1	P2	P3	P4	P1	P2	P3	P4
Control	2296de	2724^{b-e}	2185^{e}	2352de	36.69	37.47	40.41	48.71
Apron Star 42 WS	3961^{ab}	2719^{b-e}	3543^{a-d}	2667^{b-e}	42.11	36.38	36.82	37.7
Dynamic 400 FS	3331^{a-e}	2728^{b-e}	2886^{b-e}	3277^{a-e}	60.42	39.17	40.54	46.07
Proseed Plus 63 WS	3894^{ab}	2468^{cde}	3967^{ab}	3962^{ab}	44.42	36.27	35.73	38.98
Joint 246 FS	3853^{ab}	3108^{a-e}	2880^{b-e}	2721^{b-e}	36.22	42	36.32	50.64
Torpedo 250 FS	4403^{a}	3727^{abc}	3231^{a-e}	2877^{b-e}	48.53	36.17	36.19	32.11
LSD(0.05)	1327.15				NS			
CV (%)	25.6				17.8			

Means with the same letter in the columns and rows are not significantly different at 5% level of significance, CV (%) = Coefficient of variation, LSD=Least Significant Difference at 5% level

Grain yield

The main effects of chemicals and planting date and their interactions significantly (P< 0.05) affected the grain yield of barley.

Late sowing significantly decreased grain yields. Thus, the highest grain yield (4403 kg ha^{-1}) was obtained at combined application of Torpedo at first planting date and it was statistically at par with Proseed Plus at first planting date and Joint at first planting date whereas the lowest grain yield (2185 kg ha^{-1}) was recorded at the combinations of control at third planting date (Table 4). The highest grain yield at the Torpedo and first planting date might have resulted from better growth favoured due to decreased shoot fly infestation which enhanced yield components and yield. In general, grain yield obtained from the treated plots exceeded the grain yield from the untreated/control plots by about 33.13%. This result is in agreement with that of Tekalign *et al.*, (2017), who reported that application of pesticides brought significant increase in grain yield of barley varieties as compared to pesticide free plot. A similar result was reported by Adame *et al.* (2016) where application of pesticides significantly increased grain yields of teff was obtained from the control (pesticide free) plots.

Barley Shoot Fly Infestation

The main effects of chemicals and their interactions highly significantly (P< 0.0) affected the barley shoot fly infestation of barley. The highest infestation (62.84) was obtained from combination of control and third planting date whereas the lowest barley shoot fly infestation recorded from application of Torpedo at first planting date (Table 5). This indicated that grain yield is correlated with infestation level. In line with the result of this study, Tafa and Muluken (2017) reported early sowing date to minimize shoot fly infestation. This result is in agreement with that of Tekalign *et al.*, (2017), who reported that application of pesticides brought significant decrease barley shoot fly infestation percentage on barley varieties as compared to pesticide free plot.

Table 5. Mean of pooled data analysis (2017-2018) results of interaction effect of chemicals and planting date on barley shoot fly infestation percentages on barley at Bore and Ana Sora districts.

Treatments	Planting dates			
	P1	P2	P3	P4
Control	44.92 bcd	51.31 abc	62.84 a	57.84 ab
Apron Star 42 WS	34.03 defg	30.5 d-h	21.85 fgh	23.56 fgh
Dynamic 400 FS	39.04cdef	23.56 fgh	25.27 e-h	23.56 fgh
Proseed Plus 63 WS	30.5 defgh	30.47 d-h	20.15 gh	30.95 defgh
Joint 246 FS	41.43 bcde	21.86 fgh	20.14 gh	30.95 d-h
Torpedo 250 FS	16.75 h	19.46 gh	21.51 gh	17.09 gh
LSD(0.05)	17.23			
CV (%)	34.0			

Partial Budget Analysis

Analysis of the net benefits, total costs that vary and marginal rate of returns are presented in Table below. Information on costs and benefits of treatments is a prerequisite for adoption of technical innovation by farmers. The studies assessed the economic benefits of the treatments to help develop recommendation from the agronomic data. This enhances selection of the right combination of resources by farmers in the study area. As indicated in Table below, the partial budget analysis showed that the highest net benefit (Birr 26941.78 ha^{-1}) was recorded at the combination of Torpedo and first planting date and lowest was from control treatment. To use the marginal rate of return (MRR %) as basis of recommendation, the minimum acceptable rate of return should be between 50 to 100% (CIMMYT, 1988). In this study application of Torpedo at first planting date gave the maximum economic benefit (26941.78 ha^{-1}). Therefore, on economic grounds, application of Torpedo at 250ml/100kg seed as seed dressing and sowing at late July would be best and economical, and recommended for production of barley in the study area and other areas with similar agro-ecological conditions.

Table 5. Partial budget and marginal rate of return analysis for management of barley shoot fly through chemical and planting date

Treatments		AGY by 10% (kg ha^{-1})	GB (Birr ha^{-1})	TVC (Birr ha^{-1})	NR (Birr ha^{-1})
Control	P2	2451.82	17162.76	0	17162.76
Control	P3	1966.87	13768.08	0	13768.08
Control	P4	2116.47	14815.32	0	14815.32
Control	P1	2066.61	14466.24	0	14466.24
Dynamic	P2	2455.61	17189.28	475	16714.28

Table 6. continues

Dynamic	P1	2997.69	20983.86	475	20508.86
Dynamic	P3	2597.48	18182.34	475	17707.34
Dynamic	P4	2949.21	20644.44	475	20169.44
Apron Star	P2	2447.40	17131.80	550	16581.80
Apron Star	P1	3565.01	24955.08	550	24405.08
Apron Star	P3	3188.26	22317.84	550	21767.84
Apron Star	P4	2400.05	16800.36	550	16250.36
Proseed plus	P1	3504.43	24531.00	690	23841.00
Proseed plus	P4	3565.73	24960.12	690	24270.12
Proseed plus	P3	3570.14	24990.96	690	24300.96
Proseed plus	P2	2221.41	15549.84	690	14859.84
Joint	P2	2796.98	19578.88	800	18778.88
Joint	P4	2448.54	17139.78	800	16339.78
Joint	P3	2592.44	18147.06	800	17347.06
Joint	P1	3467.49	24272.40	800	23472.40
Torpedo	P1	3963.11	27741.78	800	26941.78
Torpedo	P4	2589.70	18127.92	800	17327.92
Torpedo	P3	2908.05	20356.32	800	19556.32
Torpedo	P2	3353.99	23477.94	800	22677.94

AGY:adjusted grain yield, GB:groth benefit TVC:total variable cost, NR: net return

CONCLUSION

Analysis of the results revealed that interaction of the two factors (chemicals and planting dates) significantly affect almost all parameters except thousand kernels weight, number of tiller per plant and number of productive tiller per plant. Generally, all parameters recorded over all treated plots were significantly higher than untreated/control plot. Thus using of chemical/pesticide and adjusting planting date improve yield components, yield and decrease barley shoot fly infestation. The highest grain yield (4403 kg h^{-1}) was obtained from combined application of Torpedo + at first planting date whereas the lowest barley shoot fly infestation recorded from application of Torpedo at first planting date. The partial budget analysis revealed that combined applications of Torpedo insecticide and planting in the last week of July gave the best economic benefit 26941.78 Birr ha^{-1}. Therefore, based this study it can be concluded that combined application of this chemical and planting in the last July can be recommended for farmers for production of barley in the study area and other areas with similar agro-ecological conditions.

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