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Research Article

Evaluation of Seed Dressing Fungicides Against Barley (*Hordeum vulgare* L) Loose Smut (*Ustilago nuda* L) in the Bale Zone, Oromiya

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Abstract

Biotic factor is the main factor that reduce the quality and production of Barley in Ethiopia. Among biotic factors loose smut (Ustilago nuda) is the one factor. This study was commenced to determine the effects of seed dressing fungicides on loose smut incidence and yield and yield components. The field experiment was conducted at two locations namely Sinana and selka by using a randomised complete block design with two replications. Susceptible Barley seed Guta variety were treated by dressing with different fungicides (Indotwins, Torpedo 250 FS and Proceding plus) and untreated plots in the two tested site. Seed treatment resulted in highly significant ($P \leq 0.05$) differences in days to emergence and flowering, smut incidence and yield, whereas plant height, thousand kernel weight and hectoliter weight were not significantly affected. Minimum (0.00%) loose smut incidence was recorded on seeds treated with Indotwins, Torpedo 250 FS and Proceding plus, while maximum (15%) incidence was recorded for plots sown with untreated seeds. About 3996 kg ha^{-1} maximum yield was obtained from seeds dressed at two locations. From visual observation, Seed dressed fungicide showed better morphology than untreated plots and it showed best fungicides to resist impacts of other factor (s) like Barley Shoot fly. Therefore, seed dressing fungicides (Indotwins and Torpedo 250 FS) would significantly reduce barley loose smut incidence better than Check Fungicides (Proceeding plus) and needs to be promoted. Furthermore, Developing Resistance cultivars against loose smut would be the better option to keep barley production and quality.

Keywords

Loose Smut, Seed Dressing, Resistance, Ustilago Nuda

1. Introduction

Barley (*Hordeum vulgare* L.), were cultivated in Ethiopia as early as 3000 B.C. [4]. In the Ethiopian highlands it has been supplying the basic necessities of life (food, feed, beverages and roof thatching) for many. It is the fifth most important cereal crop after Tef ((*Eragrostis tef*), maize (*Zea mays* L.) sorghum (*Sorghum bicolar* L.) and wheat (*Triticum aesvivum* L.) in Ethiopia where it is grown predominantly between the altitudes of 2000 and 3000 m above sea level (m.a.s.l) [4]. It is one of the favorite crops of Ethiopian farmers because it is a source of food, grows in marginal areas, and the straw is a good source of stock feed and is used for thatching roofs and bedding [17].

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Although Ethiopia is a center of diversity for barley, most of the country's farmers still obtain very low yields due to a combination of biotic and abiotic constraints. This, therefore, yield level is lower than worldwide and national yield potential obtained under good managed plots in the country [9]. The biotic stresses include diseases, such as scald, net blotch, spot blotch, smut (loose, cover) and rusts, which can reduce yields by up to 67%. In Ethiopia 36 diseases of barley have been recorded), with the major ones causing substantial yield losses [5, 3, 12]. Investigations on barley diseases have been going on for several years in Ethiopia.

Barley loose which is caused by Ustilago nuda (Jensen) Rostrup, is a common world-wide seed-transmitted pathogen. The mycelium localized in the embryo spreads systemically and asymptomatically in the developing plant and during flowering the inflorescence is largely replaced by sori containing teliospores of the fungus [10, 17]. This fungus is an important pathogen of cereal crops, reducing yield and quality of harvested grain [13]. According to [6], some farmers' saved barley seeds found that the seeds were low in quality. Barley loose smut is an internally seed-borne disease where the pathogen is localized within the embryo of the seed; hence, contaminated machinery and soil will not be the transmission mechanisms for this disease [13]. Yield losses attributed due to loose smut of barley are generally less than 1% in modern times; but losses of 15 to 25% can occur if proper management practices are not used [10]. Loose smut can effectively be managed through the use of certified seed, smut free seed, as determined using an embryo infection test [8, 11], resistant host varieties, or by applying systemic seed treatment fungicides [1, 2]. However, there is no enough fungicides recomm1endation for barley loose smut in Ethiopia. Hence, the aim this study was to evaluate the effect of seed dressing fungicides against barley loose smut.

2. Materials and Methods

2.1. Description of Experimental Sites

The Field experiment was conducted at Sinana- on station and Selka Farm site in 2020/21 main cropping season. These locations are hot spots for barley Loose smut. SARC is located at 7 °7' N and 40 °10' E, at 2400 meters above sea level (m.a.sl) and 463 km Southeast of Addis Ababa in Bale zone. The average rainfall is about 590 mm in the Ganna and 560 mm in main cropping season. Minimum and maximum temperatures are 9.42 and 21.16 ℃, respectively (figure 1). Weather Condition during Experimentation are shown in Figure 1.

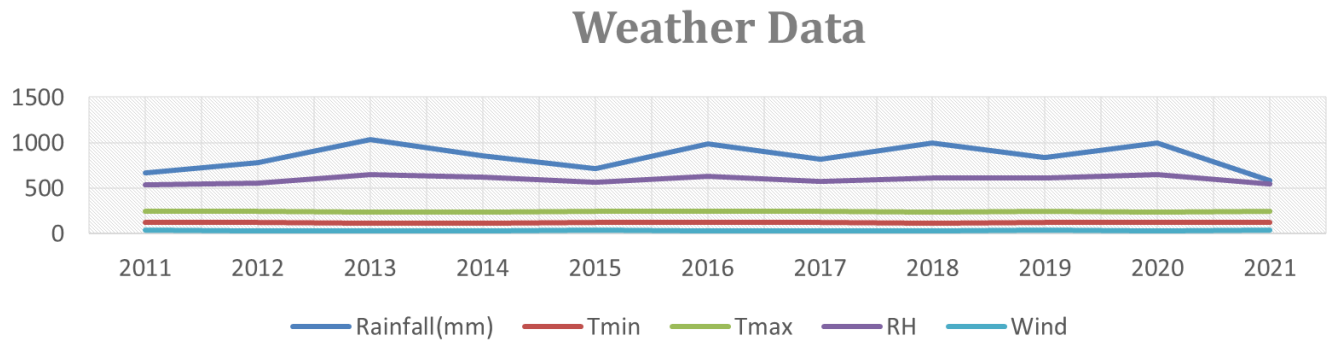

Figure 1. *Weather conditions.*

2.2. Experimental Materials: Treatments

The experiment was conducted at two sinana, and selka farm site in two replications. Plots size of the experiment was 2 m x 3 m size. Susceptible Barley loose smut (Guta variety) with three seed dressing fungicides and untreated plots were sown. The block was spaced one meters apart and 0.5 m between plots. Three seed dressing (Indotwins, Progress 25 EC, *Torpedo 250 FS*) were used with untreated plots. Three seed fungicides were used on Guta variety before sowing. Fungicides were dressed with Guta barley done for twelve hours before planting. A seed rate of 100 kg/ha and a fertilizer rate of N/P_2O_5 41/46 kg/ha were used. Weeding was done manually two times.

2.3. Experimental Procedures, Design and Field Management

A Randomized Complete Block Design was used and replicated two times at each location (Sinana and selka) in main cropping season. Seed dressing fungicides namely Indotwins, *Torpedo 250 FS*, Progress plus were dressed on Guta variety (Table 1). Total areas of the experiment were 8 m *19.5 m = 156 m^2) were divided into blocks with spacing between blocks of 2 m and between adjacent plots of 0.5 m. Each plot had a size of 3 × 2 m and contained rows (with four net harvestable rows), spacing between rows was 0.2 m. Planting

was done by drilling in rows in each plot at a seed rate of 150 kg ha-1 of barley and fertilized with 50 and 100 kg ha-1 urea and NPS, respectively. Weeding practices have been done manually.

Table 1. *Seed dressed of fungicides and Untreated plot used to treat barley seeds with loose smut infection.*

S. N	Treatments	Rate of seed dressed fungicides application per ha
1	Indotwins	100 kg/ha
2	*Torpedo 250 FS*	1 l/ha
3	Progress plus	100 kg/ha
4	Untreated	

2.4. Data Collection

The necessary agronomic parameters and loose smut data were recorded according to their growth period of the crop: Days to heading (DH): The number of days from sowing to when 50% of plants in a net plot had headed. Days to maturities**,** Plant height (plant height): Plant height was measured at physiological maturity stage as the average heights of the main tillers of four randomly selected each plot. Biomass; Loose smut: assessment of randomly selected plants from four central rows of each plot at the time of heading. Grain yields: Measured after threshing the sun-dried plants harvested from each net plot, adjusted to 12.5% grain moisture content. Thousand kernel weights: Weight of 1000 seeds counted by a seed counting machine, taken from the bulk of threshed produce from the net plot area. Hectoliter weight: The hectoliter weight was measured at 12.5% grain moisture content.

2.5. Partial Budget Analysis

Economic data were collected to compare the economic advantage of treatment combinations according to CIMMYT (1988). it involved all variable input costs and fungicide costs and labor cost. The different cost of this experiment includes cost of seed; cost of the fungicide and labor cost to fungicides applications among different treatments were considered. Cost of fungicide was obtained from pesticide companies and local distributing agencies. Land ploughing was 400 ETB and Daily laborer was: 200 ETB. Selling price of biomass; 280 ETB. For all treatments, total cost and net benefit were calculated. To calculate gross income, yield obtained from each treatment were adjusted by 10%. The following formulas were used to compute partial budget and marginal rate of return (MRR) analysis, respectively. Net field benefits (NBs) = Gross field benefits (GB) - Total Variable costs (TVC) and MRR = DNI/DIC, where: MRR = the marginal rate of return; DNI = difference in net income compared with control; and DIC = difference in input cost compared with control.

2.6. Data Analysis

Data was analyzed by using 4.2.1 statistical software and least significant difference (LSD) were used for comparison.

3. Result and Discussion

3.1. Effect of Seed Dressing Fungicide Against Loose Smut Incidence

Seed dressing with fungicides on susceptible loose smut variety showed highly significantly ($P \leq 0.05$) reduced loose smut incidence at both Sinana and selka farm sites over the untreated check (Table 2). Three tested fungicides (Indotwins, Torpedo 250 FS, and Progress 25 EC), resulted in up to 100% control of loose smut. At selka location, Day's maturity showed no significantly difference of seed dressing fungicide (Indotwins, *Torpedo 250 FS*) over Untreated plots but Progress 250 EC were showed significant difference over untreated plots and two dressed fungicides. Plant height, Biomass, Grain yield, thousand kernel weight, and Hectoliter weight showed no significant different of dressed fungicides with Untreated plots (Table 2). all dressed fungicides were shown best results to control loose smut over untreated plots at selka location. Numerically, yield advantage was seen on dressed fungicides than untreated plots (Table 2).

3.2. Effects of Loose Smut on Yield and Yield Related at Selka Location

The statistical analysis demonstrated that there were no significant differences observed between the Dressed fungicides and Untreated fungicides in day's maturity, plant height, biomass, grain yield, thousand kernel weight and hectoliter weight (Table 2). Progress 25 EC showed significant difference between the two dressed fungicides (Indotwinss and Torpedo 250 FS) and untreated plots in Days to maturity. Therefore, dressed fungicides (Indotwinss and Torpedo 250 FS) and check seed dress fungicide (Progress 25 EC) controlled Loose smut disease as compared to unsprayed check on highly susceptible variety Guta (Table 2).

Table 2. *Effect of barely seed dressing on, smutted heads (SMT), yield (YLD), thousand kernel weight at Selka location 2020/21 main cropping season.*

Treatments	DM	PH	BM	GYD (kg/ha)	TKW	HLW	LS
Indotwins	115.5b	106.0a	7.250a	3996.333a	35.0a	61.8a	0b
Torpedo 250 FS	117.0ab	105.0a	8.250a	3287.750a	34.4a	60.4a	0b
Progress 25 EC	122.0a	101.5a	6.500a	1238.750b	28.5a	30.0a	0b
Untreated	115.5b	100.0a	4.000a	2516.583ab	31.1a	59.0a	1a
Mean	117.5	103.1	6500	2759.9	32.25	52.8	0.25
LSD 0.05%	4.16	ns	ns	1926.92	ns	ns	3.082473e-16
CV	1.277	6.66	23.39	25.14	6.98	40.29	23.39

* DM (Days to heading), PH (Plant height), BM (Biomass), GYD (Grain yield). Thousand Kernel Weight (TkW) and hectoliter weight (HLW) at Selka.

Normality of data were tested by using shapro test. so, the data were normally distributed (figure 2).

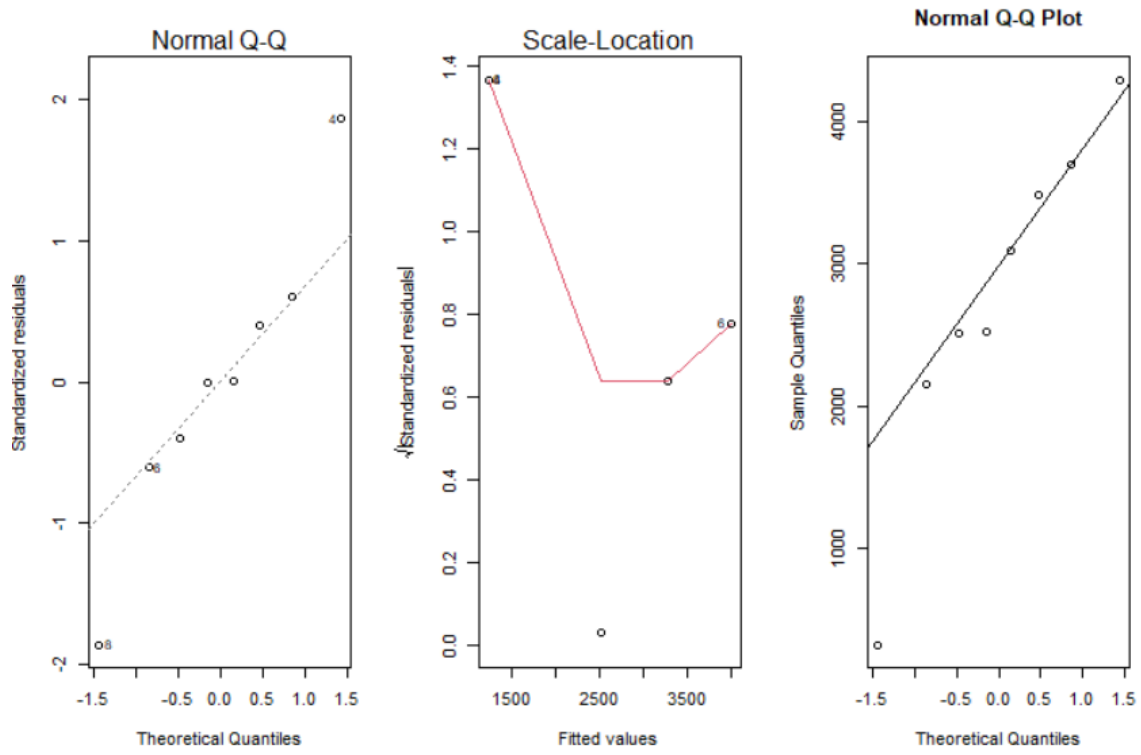

Figure 2. *Normality of data.*

3.3. Mean Effects of Loose Smut Incidence Over Other Fungicides and Untreated Plot at Selka

Seed dressed fungicides were reduced loose smut severity compared to untreated plots. Indotwins, Progress 25 EC and Torperod were showed best result to control Loose smut incidence at selka location (Figure 3). High Mean of Grain yield was obtained with seed dressed fungicide of Indotwins and Torpedo 250 FS over untreated and Progress 25 EC at Selka test site (figure 3).

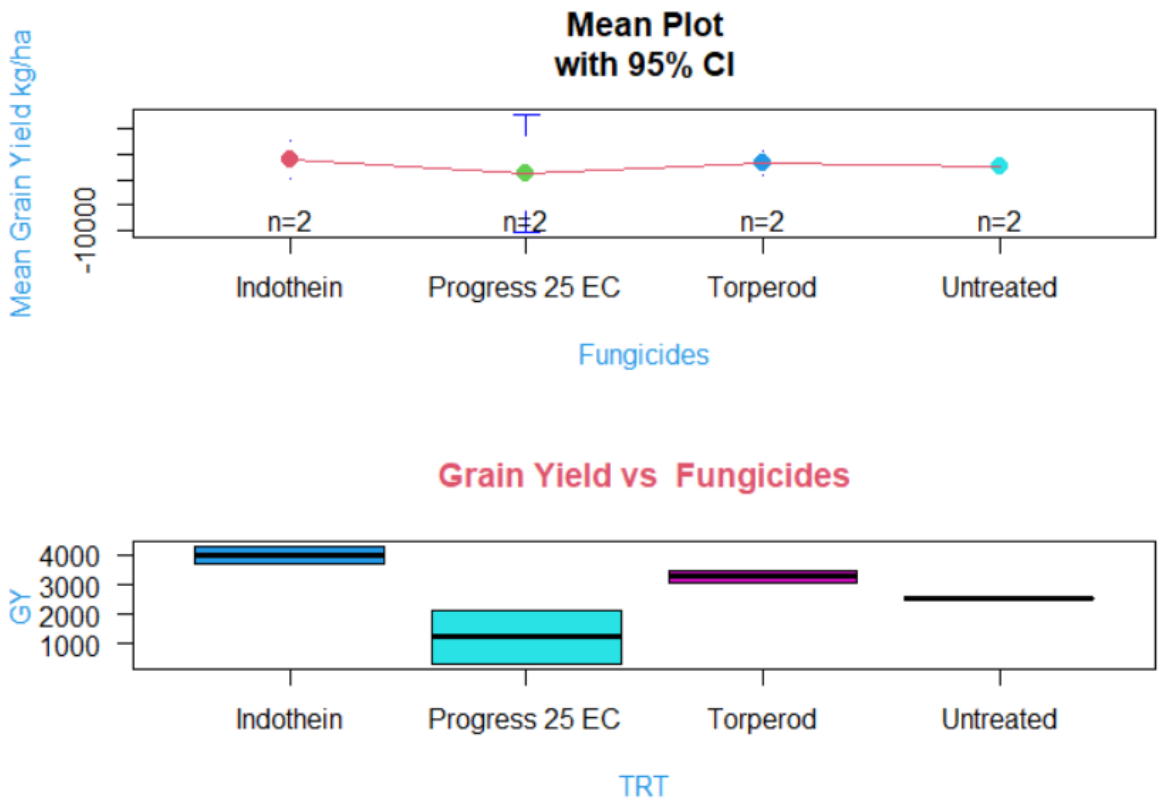

Figure 3. *Mean effects of loose smut Incidence over other fungicides and Untreated plots.*

3.4. Effect of Barley Seed Dressing, Loose Smut, Grain Yield, Thousand Kernel Weight and Hectoliter Weight (HLW) at Sinana

At Sinana location Statistical analysis (0.05%) revealed that there was no significant difference observed between the dressed fungicides and Untreated fungicides in Day's maturity, plant height, Biomass, grain yield, thousand kernel weight and hectoliter weight (Table 3). Progress 25 EC showed significant difference between the two dressed fungicides (Indotwins and Torpedo 250 FS) and untreated plots in Days to maturity. Significantly difference was observed between seed dressing fungicides and Untreated plots. This indicated seed dressing fungicides was reduced Loose smut incidence 100 % over untreated plots. Based on Observation from the field The seed which were dressed showed efficacy performance over untreated plots. That results yield advantage over untreated plots. For example, Indotwins, Torpedo 250 FS, seed dressing fungicides had given 1480 kg/ha, 770 kg/ha over untreated plots (Table 3). However, check fungicides showed lower yield 440 kg/ha than untreated plots due to lodging at fields. Management of loose smut (Ustilago nuda) of barley (Hordeum vulgare) through seed dressing and coating materials on barley in Bale highlands, Ethiopia. This result is aligned with [15, 16] report. To sum up, Seed dressing fungicides showed best results over check fungicides (Progress 25 EC) and untreated plots. Therefore, Seed dressed fungicides (Indotwinss and Torpedo 250 FS) and check seed dress fungicide (Progress 25 EC) controlled Loose smut disease as compared to unsprayed check on highly susceptible variety (Table 3).

According to Zegeye et al., (2017) and Yirgu (1967) and Mamluk The efficacy of seed dressing fungicides increased the barley productivity.

Table 3. *Effect of Seed dressing Fungicides, yield and yield components at Sinana locations.*

Treatments	Rate	Variety	DM	PH	BM	GY (kg ha-1)	TKW	HLW	LS
Indotwins	100 kg/ha	Guta	115.5b	106.0a	7.250ab	3996.3 a	35.0a	61.8a	0.00 b
Torpedo 250 EC	250 L ha^{-1}	Guta	117.0ab	105.0a	8.250a	3287.9ab	34.4ab	60.4a	0.00b
Progress 25 EC	100 kg ha^{-1}	Guta	122.0a	101.5a	4.000b	2072.0c	28.5b	59.0a	0.00b

Treatments	Rate	Variety	DM	PH	BM	GY (kg ha-1)	TKW	HLW	LS
Untreated	-	Guta	115.5b	100.0a	6.500ab	2516.5bc	31.1ab	59.0a	1.5a
Mean			117.5	103.1	6500	2968	32.25	60.05	0.375
LSD 0.05%			4.164	19.06	422.2	71.81	6.25	4.88	0.98
CV			1.27	6.65	23.39	8.71	6.98	2.9320	34.28

* DM: Days to maturity: PH: Palnt height, BM: Biomass, GY: Grain yield, TKW: Thousand kernel weight, HLW: Hectoliter weight, LS: Loose smut

Normality of data has been checked by using shapro test and it showed normally distributed and it was possible for Analysis of Variance (Figure 4).

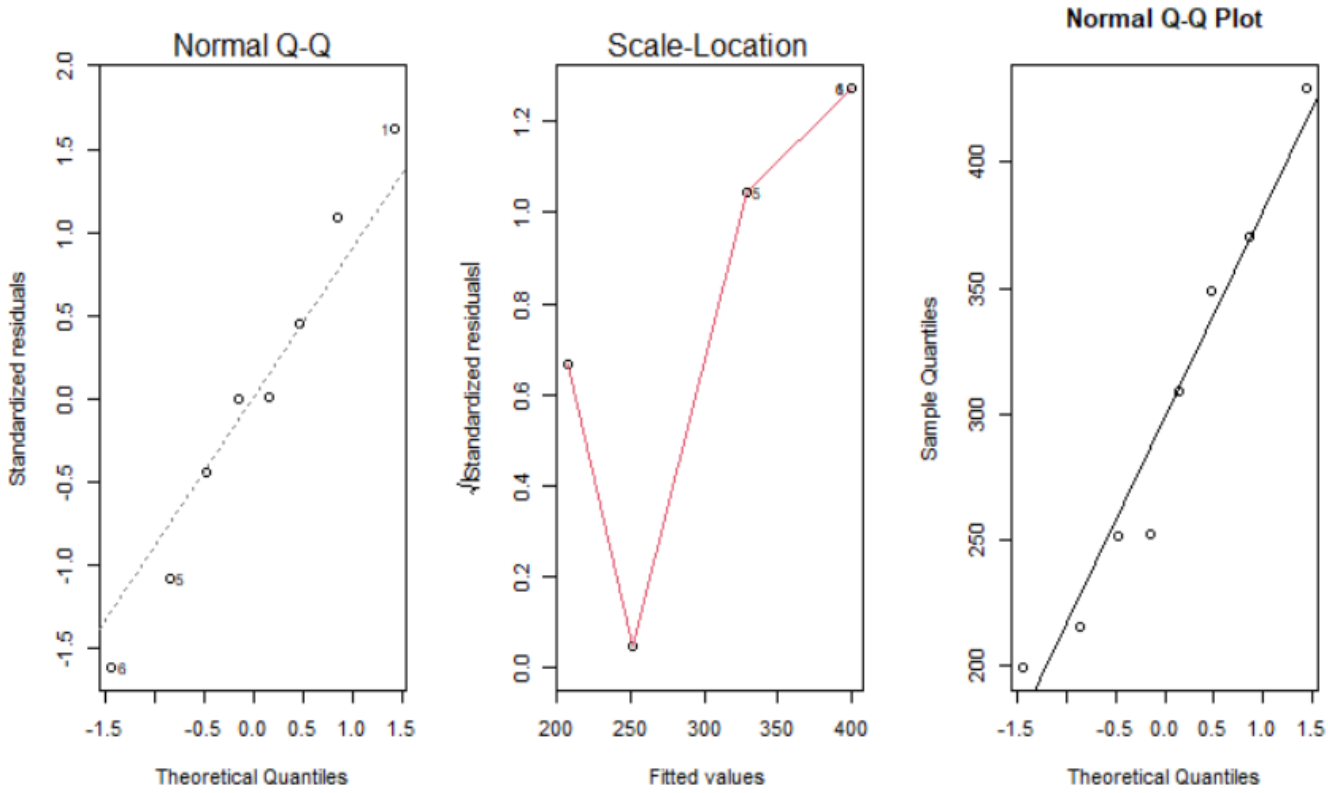

Figure 4. *Normality of data.*

3.5. Mean Effect of Loose Smut Severity over Other Fungicides at Sinana

From the analysis of variance mean plot and Boxplot has been done for tested seed dressing fungicides and untreated plots. Highest grain yield was grain yield obtained from Indotwins and Torpedo 25 EC had given high grain yield over check fungicides and u treated plot. High Loose smut incidence was observed on untreated plot and Seed dressing fungicides were shown best control for loose smut disease at Sinana location (Table 4).

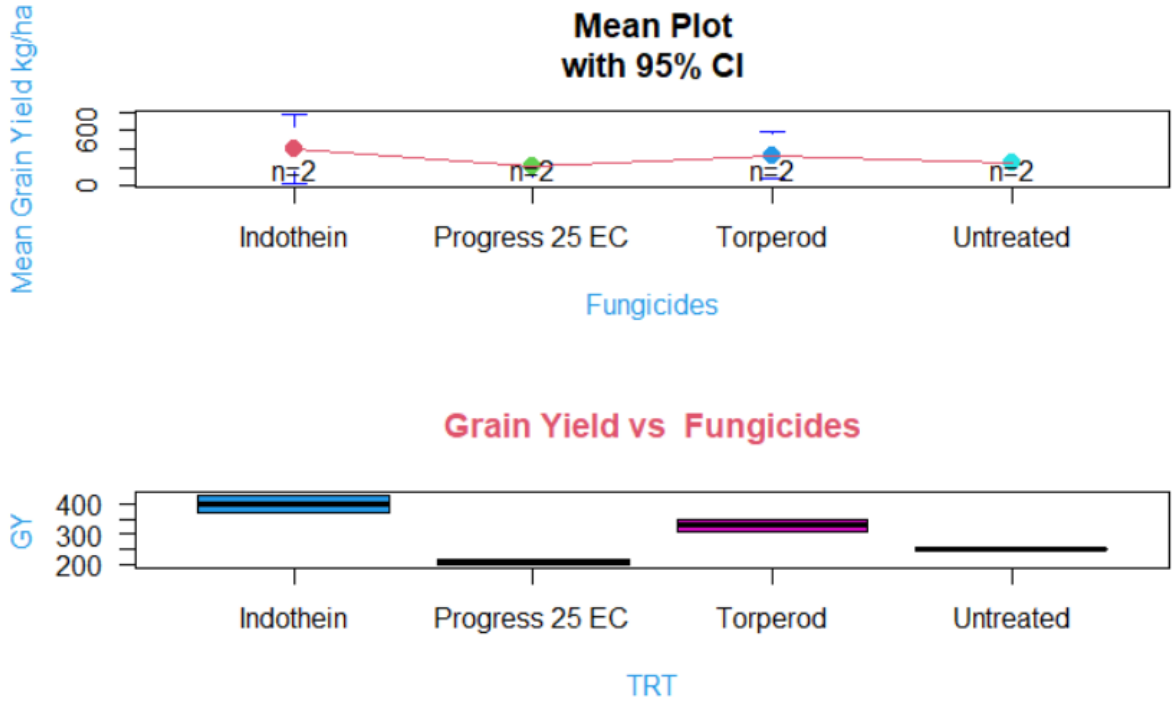

Figure 5. *Mean effect of loose smut severity over other fungicides.*

3.6. Correlation Coefficients of Loose Smut, Yield and Yield and Yield Component

At selka Location, the result showed loose smut was negatively associated with Plant height, grain yield and Thousand kernel weight r = -0.124 and -0.216 respectively (table 4). However, Loose smut was positively correlated with Biomass and Hectoliter weight. Biomass, thousand kernel weight, and Hectoliter weight showed highly corelated with grain yield (table 4). Plant Height was also moderately correlated with grain yield.

At sinana location, Correlation Coefficient showed that Negative correlation have been seen between Days Maturity and Plant height, Biomass, Thousand Kernel Weight, Hectoliter weight and loose smut disease (Table 4). However, positive correlation was seen between plant height and Biomass, Grain yield and High correlation were seen with Thousand kernel weight (Table 4). Plant weight and Hectoliter weight showed negative correlation. Biomass and Thousand Kernel weight and Grain yield and Thousand Kernel Weight showed positive correlation with each other's (Table 4). Loose smut had negative correlation with all parameters and it showed Less correlation with Biomass (Table 4).

Table 4. *Pearson Correlation coefficients of days to maturity (DM), Plant Height (PH), Grain Yield (GY), Biomass (BM), loose smut (Ls), Thousand Kernel Weight (TKW), Hectoliter Weight (HLW) at selka farm site in 2020/21 main cropping season.*

	PH	BM	GY	TKW	HLW	LS
PH	1	0.657	0.540	0.701	0.638	-0.331
BM		1	0.835	0.9301	0.906	0
GY			1	0.869	0.829	-0.124
TKW				1	0.802	-0.216
HLW					1	0.178
LS						1

PH; Plant height, BM, Bio mass, GY; Grain Yield, TKW; Thousand kernel weight, HLW; *Hectoliter* weight, LS; Loose smut

Table 5. Correlation coefficients of days to maturity, Plant Height (PH), Grain Yield, Biomass, loose smut Severity, Thousand Kernel Weight, Hectoliter Weight at sinana.

	DM	PH	BM	GY	TKW	HLW	LS
DM	1	-0.180	-0.743	-0.583	-0.724	-0.547	-0.281
PH		1	0.658	0.3479	0.701	-0.547	-0.144
BM			1	0.599	0.930	0.361	0
GY				1	0.741	0.586	-0.321
TKW					1	0.580	-0.208
HLW						1	-0.522
LS							1

PH; Plant height, BM, Bio mass, GY; Grain Yield, TKW; Thousand kernel weight, HLW; Hecto litter weight, LS; Loose smut

3.7. Economic Analysis

As it is indicated in table 6, the result of economic analysis showed that the maximum net benefit (ETB 74469 ha-1) with an acceptable MRR was obtained on the Indotwins seed dressing fungicide. This has resulted in the net benefit advantage of 31657 ETBirr. The Treatments Torpedo 250 EC showed the next net benefit next to Indotwins (57623). However, other Proceed plus which was used as check showed negative MRR due to high lodging problem. Hence, treatments were eliminated by dominance analysis (CIMMYT, 1988) since the net benefit obtained decreased as the cost increased. Therefore, in the study area the dressed fungicides (Indotwins and Torpedo 250 EC) fungicides are preferable tentatively within acceptable MRR and very large net benefit for all tested.

Table 6. Partial budget analysis for the management of Barley Loose smut at highlands Bale zone.

Treatment	Grain yield kg ha^{-1}	adj	Total benefit cost	variable cost	Net benefit cost	MRR	Rank
Control	25.16	22.64	56610	13798	42812	0	3
Proceed plus	20.72	18.65	46620	15498	31122	-11690	4
Torpedo 250 EC	32.88	29.59	73971	16348	57623	14811	2
Indotwins	39.96	35.97	89917	15448	74469	31657.43	1

4. Conclusion and Recommendation

The Barley Seed dressing fungicides can be concluded that severe occurrence of barley loose smut can have a negative impact on sustainable barley production and productivity in the area, hence dressing barley seed with fungicides (Indotwins or Torpedo 250 EC) at the rate of 100 kg/ha, and 1 l/ha would be recommended. Moreover, in areas where there is widespread incidence of loose smut, farmers should be advised to use certified seed and the recycling of farmers saved infected seeds should be avoided. Furthermore, barley germplasm needs to be screened against loose smut and varieties resistant to this disease should be developed. Hence, Seed dressing fungicide (Indotwins and Torpedo 250 FS) fungicides could be recommended with the rate of 100 kg ha^{-1} and 250 L ha^{-1}, respectively for the control of loose smut (*Ustiligo nuda)* disease in Barley in Ethiopia.

Abbreviations

TKW	Thousand Kernel Weight
HLW	Hectoliter Weight
BM	Biomass
GYD	Grain Yield
LS	Loose Smut
PH	Plant Height
DM	Days to Maturity
TRT	Treatment

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Conflicts of Interest

There is no conflict of interest in this paper.

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