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Valuation of Proceed Plus^{TM}MD and Verification of CelestTop312.5FS Fungicides for the Control of Loose Smut of Wheat in Southeastern Ethiopia

Getnet Muche Abebele [a*] and Alemu Ayele Zerihun [a]

[a] Department of Plant Pathology, Kulumsa Agricultural Research Center, Ethiopian Institute of Agricultural Research, Ethiopia.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Wheat is considered one of the utmost grown agricultural grain crops in the world to meet the food requirements of the domain's population. In Ethiopia, wheat is one of key cereal crops whose area of cultivation and volume of produced boosted year after year. However, the production and productivity of wheat is truncated by various biotic and abiotic stresses. Among the biotic stresses, wheat loose smut disease caused by *Ustilago tritici* is one of quality and quantity incurring diseases but getting lower research attention. A field experiment was conducted with the objective to

**Corresponding author: E-mail: getnetmuche2014@gmail.com;*

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evaluate and verify the efficacy of fungicides against wheat loose smut diseases and put updated recommendation for users. It was executed at three loose smut hot spot locations, Meraro on-station, Kulumsa main center and Wonjigora on farm in 2023 main cropping season. Two different fungicides including the test fungicide (CelestTop312.5FS) and standard check (Proceed Plus^{TM}MD), as well as untreated plot were used as a treatment. The trial was laid out in non-replicated plots at three sites where locations were considered as replica. The result of the research finding revealed that fungicide treated treatments significantly reduced loose smut diseases severity to the lowest level possible over the nil application. However, there was no statistically significant difference ($p \leq 5\%$) between the test and check fungicides in reducing loose smut diseases severity. Test fungicide revealed comparable level of efficacy on loose smut diseases severity reduction compared to the standard check. There was highly significant difference ($p \leq 5\%$) hectoliter weight between fungicide treatments and nil application of fungicide but insignificant variation in grain yield and thousand seed weight. Both fungicide treatments also revealed significant diseases management advantage than untreated plots. Thus, the newly verified fungicide CelestTop312.5 FS at a rate of 200ml fungicide with 1 to 2 liters of water as wetting agent for 100 Kg of wheat seed is found to be very effective in controlling loose smut diseases and is recommended for registration. Similarly, proceed Plus^{TM} MD at a rate of 0.004 liter fungicide per kilogram of seed is suggested for further use for producers to control wheat loose smut diseases as sole or integrated disease management options.

Keywords: Bread wheat; fungicide; Ustilago tritici; loose smut; seed borne disease.

1. INTRODUCTION

"Wheat is cultivated on an estimated area exceeding 217 million ha, making it the utmost extensively cultivated crop in the world. In terms of production, it accounts for 784.91M tones with a continuous global yield increase from 1.09 t/ha in 1961 to 3.45 t/ha in 2023. It is among the most important indispensable food crops and a key source of nutrition that is consumed by more than 2.5 billion people worldwide" [1]. "Wheat in the form of bread pays maximum nutrients to the global population than any other solitary food source" [2].

In Africa, Ethiopia is the second top producer of wheat next to Egypt and produces 5.5Mt, which is equivalent to 21.7% of wheat produced and 18.3 % wheat area harvested in Africa [3]. According to [4], wheat occupies for around 12.2% area cultivated (1.9 million ha), 20.2 % whole assembly and generates employment for 4.9 million subsistent growers. Conversely, the production and productivity of wheat is constrained by numerous biotic and abiotic elements. Among the biotic limiting elements, wheat foliar diseases mainly rusts are the greatest be afraid and wheat production bottlenecks. In addition to foliar diseases, there are different seed borne diseases caused by various pathogens such as loose smut (*Ustilago tritici*), bunt (*Tilletia tritici*), fusarium head blight (*Fusarium graminearum*), Septoria leaf blotch (*Parastagonospora nodorum*) and are known to cause quality and quantity reductions.

"Loose smut caused by the fungi, *Ustilago tritici* is one of the forefront seed borne fungal pathogens that are damaging wheat by reducing yield and quality of harvested grain. In many cases grain receivable points have low or zero tolerance of smut contaminated grain. It has a wide distribution and can occur anywhere wheat is produced but favor a cool and moist climate conditions during anthesis).The optimum time for contagion is amid initial and middle anthesis, but effective contagion can occur even post flowering. The pathogen rests latent in the settled seed at the growing point. After seed sprouting, the mycelium propagates in the crown node and later conquers inflorescence fleshy tissue. This consents the fungus to be conveyed into the developing spike, where it sporulates and diffuses teliospores at spike beginning" [5].

Yield losses associated with loose smut infestation are not overwhelming but can cause judicious economic injuries, resulting in return declines of 5–20% at an infection level of 1–2% [6] Nevertheless, according to Carolina et al. [7], *Ustilago tritici* causes injuries up to 40%. Loose smut is a risk to seed production in developing countries where small scale farmers custom their own yield as seed material. In Ethiopia, studies related with losses associated with loose smut are limited.

"Currently, several methods are available to control loose smut such as the use of resistant wheat cultivars; plant certified seeds and fungicide seed treatments are highly effective in controlling loose smut of wheat. However, majority of the resilient wheat cultivars detected to have a tapered resistance range. Hence, use of seed dressing fungicides as a sole /or integrated circumstances is crucial" [6].

"The best way to achieve a healthy crop is the use of certified seeds, free from the pathogen, with maximum control and economical. Other active ways to regulate the disease are to use resistant varieties or to treat seeds with fungicides" [8,5]. The first chemicals engaged, as systemic fungicidal activity towards the loose smut fungi, were carboxins (1, 4- oxathiin derivatives) (Von Schmeling and Kulka, 1966), marketed as 'Vitavax' and 'Plantvax' (Edgington et al., 1966). The accomplishment of carboxins against loose smut directed to the start of numerous carboxamide seed dressings including fenfuram (Martin and Edgington, 1980).

In Ethiopia, according to Mengesha et al. [9], few systemic fungicides like Carboxin (2006), Dynamic 400 FS (2016), Imidalm T450WS (2010), Proceed Plus 63% WS (2014) and Thiram Granuflo 80 SC (2005) were recommended for managing seed borne diseases including loose smut during the last few years. These chemicals are in use for the last one to three decades, hence there is necessity to identify new fungicides that are effective against loose smut and are ecological. The present multi-location experiment was therefore conducted to test the relative efficacy of a new systemic fungicide; Celest top 312.5FS, along with the earlier recommended ones proceed Plus™ MD, for controlling the loose smut of wheat.

2. MATERIALS AND METHODS

2.1 Experimental Sites

The verification test experiment was conducted at Kulumsa agricultural research center (main station); Meraro (research station for Kulumsa research center) and Wonji Gora (farmer's field). Kulumsa and Wonji Gora, have a mean annual rainfall of 820 mm representing highland and high rainfall agro ecology. The monthly average lowest and highest temperature is 10.5 and 22.8°C respectively. The sites dominant soil type is loam type, which is fertile. While, Meraro substation is located at 07° 24' 27"N, 39° 14'56"E and 2990 m.a.s.l. Its mean yearly shower is 1196mm signifying extreme highland and hoarfrost prone agro-ecology. The minimum and maximum temperature is 5.7 and 18.1°C respectively.

2.2 Experimental Method and Design

To evaluate and verify the intended new fungicide for managing loose smut diseases, a field experiment was prepared with standard and untreated checks in complete randomized design 10m across three locations. The treatments were planted in plots having 10m* 10m long with spacing of 0.2m intra row and 1 m between plots. Plots were sown in 150 kg ha- DAP and urea fertilizers were added rely on the commended rate to the area. Weeds were managed by hand weeding. To protect the yellow and stem rust diseases pressure, a foliar fungicide Nativo 75WG was sprayed equally on all treatments. The seeds of fungicide treated treatments were seed dressed 24hrs prior to planting as per companies recommendation.

2.3 Treatment Fungicides

The fungicide Proceed Plus™ MD with active ingredients of insecticides clothianidin and systemic fungicides of Prothioconazole (1.47%) + Tebuconazole (0.29%) + Metalaxyl (0.59%) was prior registered for the control/or suppression of the loose smut and covered smut diseases in wheat and barley but now intended for re-evaluation while Celest top312.5FS fungicide with active ingredients of Thiamethoxam (262.5 g/lt) + Fludioxonil (25 g/lt) +Difenoconazole (25 g/lt) was intended for verification purpose to control loose smut of wheat using susceptible wheat cultivar kubsa. Treatments were applied with a rate of 0.004 and 0.002 liter of fungicides per kilograms of wheat seed to Proceed plus and CelestTop 312.5FS respectively.

2.4 Diseases Assessment

In the field, the treatments were examined, and infection levels recorded as percentage plant contagion. Every plant with one or more diseased heads (totally or partly smutted) is noted as infected (Jones, 1990). Diseased ears were recorded at flowering by counting all infected heads per plot was then converted to percentages smutted based on estimates of the total number of heads existent per unit area from sampling a 1 m length of row in every alternate plot in each trial. Grain harvests were recorded at each site by collecting plants put in 5*5 m quadrants and then converted to hectares.

2.5 Data Analysis

Analysis of Variance (ANOVA) was computed by using SAS GLM Procedure (SAS version 9.00, Inst. 2002) and means contrasts for the significantly different variables were made among treatments with Least Significant Differences (LSD) test at 0.05 levels of significance.

3. RESULTS AND DISCUSSION

3.1 Disease Epidemics

In the growing season, loose smut infected seeds were employed and weather condition was favorable to develop wheat loose smut disease, so that diseases pressure was sufficient to evaluate and verify the intended fungicides across all the three locations.

As it is witnessed from Table 1 and Fig. 1, test fungicide, Celesttop312.5FS and standard check Proceed plus significantly reduced loose smut disease severity to the lowest level (100%) possible over the nil application. However, there was no statistically significant difference between the test and check fungicides in reducing loose smut disease severity.

Of the three treatments, fungicide dressed treatments (proceed plus and Celest Top) resulted in up to 100% control of loose smut regardless of their locations. On contrary, smut diseases severity was observed with a little difference in levels where maximum percent diseases severity (12.1%) was recorded at Meraro followed by Wonjigora and Kulumsa with percentage severities of 11.6% and 10.5% respectively.

Previously, scholars like Husnain et al. [10] evaluated six fungicides viz Dividend Star, Raxil Ultra, Score, Crest, Topsin-M and Hombre were found equally effective as seed treatment for loose smut disease control but lower difference on yield variation. Similarly Gad et al. [11] had evaluated fungicides Premis® 25% FS (Triticonazole), Sumi-8® 2%WP (Diniconazole), Dividend Extreme® 11.5% FS (Difenoconazole + Mefenoxam), Raxil® 2% DS (Tebuconazole) and tested fungicides were greatly effective in regulating the disease and gave more than 98% disease declining with high grain yield increment.

In addition, Sharma' et al. [12], has examined two fungicides viz. fluzamide (Pulsor 2 F) and carboxin (Vitavax 75 wr) for control of loose smut of wheat and result shown that both fungicides completely eliminated the loose-smut infection,

From visual field observation and data analysis (Table 1), it is apparent that the test fungicide, Celesttop312.5FS showed equivalent level of efficacy on loose smut diseases severity reduction compared to the standard check, Proceed plus. Therefore, both fungicides Celesttop312.5FS and Proceed plus can be recommended for the control of loose smut diseases.

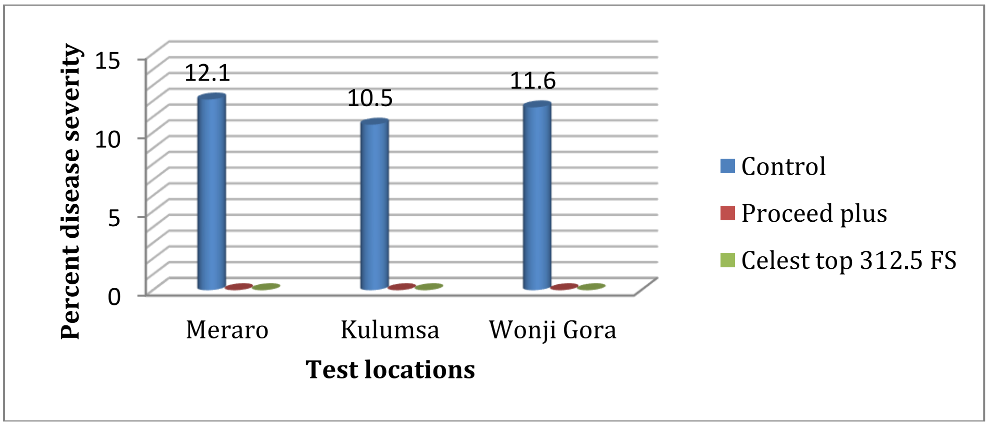

Fig. 1. Mean percentage heads of wheat affected by loose smut after seed treatment with fungicides along with untreated control at three sites in Arsi during 2023 main growing season

Table 1. Evaluation of fungicides efficacy against loose smut diseases severity, yield and yield components of bread wheat in Arsi during 2023 main cropping season

Treatments		Rate (l/Kg)	Loose smut severity (%)	Grain yield (Qt/ha)	TKW (g)	HLW
Common name	Trade name					
Prothioconazole (1.47%) +Tebuconazole (0.29%) +Metalaxyl (0.59%)	ProceedPlus TM MD	0.004	0[a]	43.53[a]	38.92[a]	73.91[a]
Thiamethoxam (262.5 g/lt) + Fludioxonil (25 g/lt) +Difenoconazole (25 g/lt)	Celest top312.5FS	0.002	0[a]	42.82[a]	40.99[a]	74.57[a]
	Nil	0	11.4[b]	40.46[a]	37.78[a]	70.21[b]
Mean			3.8	42.27	39.23	72.9
CV (%)			11.8	4.23	5.12	4.52
LSD(0.05)			7.82	4.33	5.12	5.43

TKW = Thousand Kernel Weight, HLW = Hectoliter Weight, LSD = Least significant difference among treatment means (p ≤ 5%), CV= Coefficient of variation, Means with the same letter within a column are not significantly different

Table 2. Yield and related attribute values of fungicide treated and control checks across locations in 2023 growing season in Arsi highlands

Treatments	Locations								
	Meraro			Kulumsa			Wonji Gora		
	Grain yield	TKW	HLW	Grain yield	TKW	HLW	Grain yield	TKW	HLW
Control	40.46	38.99	70.01	41.02	38.11	70.43	42.07	37.21	70.93
Proceed plus	42.37	40.12	74.11	42.99	38.12	73.67	43.15	38.52	73.97
Celest top 312.5	41.98	40.99	74.57	42.87	39.21	73.44	43.53	38.91	74.03

3.2 Yield and Related Attributes

The statistical analysis showed that there was no significant difference between the test fungicide and the standard check fungicide in grain yield, thousand kernel weight and hectoliter weight (Table 1). Even though there was no statistically significant difference in grain yield between test fungicide CelestTop 312.5FS and standard check fungicide (Proceed plus), relatively superior grain yield was obtained from Celesttop312.5FS treated treatment but the difference is insignificant to differentiate the effect of the chemicals. Conversely, despite there was no significant difference in thousand seed weight and hectoliter weight between test fungicide (Celesttop312.5FS) and standard check fungicide(Proceed plus) quite higher thousand seed weight and hectoliter weight was obtained from CelestTop312.5FS.

However, there is highly significant difference in hectoliter weight between fungicide treatments (test and check fungicides) and nil application (untreated plot). Nevertheless, there is no significant difference among Celesttop312.5FS, Proceed plus, and untreated plots in grain yield and thousand seed weight.

In Rajasthan of India Bhatnagar et.al. (1978) demonstrated six fungicides (Dividend Star, Raxil Ultra, Score, Crest, Topsin-M and Hombre) were found equally effective as seed treatment for disease control but high incidence of loose smut on wheat and this disease caused 39-78 % loss on untreated plots.

Both Celest Top 312.5FS and Proceed plus were almost equally effective in reducing loose smut incidence (severity) but a significant difference with untreated control across locations [13,14].

At Meraro, grain yield were 41.98Qt/ha, 42.37Qt/ha and 40.46Qt/ha to proceed plus, Celest top 312.5FS and untreated check plots in their order (result presented in Table 1). At Kulumsa grain yield of 42.99 Qt/ha, 42.87 Qt/ha and 41.02 were recorded to proceed plus, Celest top 312.5FS and untreated check respectively. Whereas, 43.15Qt/ha, 43.53Qt/ha and 42.07 Qt/ha grain yield were recorded to proceed plus, Celest top 312.5FS and untreated control plots of Wonji-gora respectively [15,16].

The result of present investigation disclosed that numerically there was close to similar results between the fungicide intended to test (Celest top312.5 FS) and the standard check fungicide (Proceed plus) in grain yield, thousand kernel weight and hectoliter weight (Table 1). On contrary, test and standard check fungicides had significant yield and related attributes advantage over unsprayed plot.

4. CONCLUSION AND RECOMMENDATION

CelestTop312.5FS did not differ from the standard check fungicide (Proceed plus) in controlling loose smut diseases. Similarly, celestTop312.5FS provided very close to equal grain yield, thousand kernel weight and hectoliter weight with Proceed plus treated treatments across locations. Moreover, these fungicides reduced loose smut diseases severity to the lowest level possible and revealed grain yield advantage better than the nil (untreated check). After all assessment and evaluation result, the newly verified fungicide is found to be very effective in controlling loose smut diseases of wheat. Thus, CelestTop312.5 FS at a rate of 200ml fungicide with 1 to 2 liters of water as wetting agent for 100 Kg of wheat seed is recommended for registration for the control of loose smut diseases of wheat as sole or integrated disease management options on wheat. Moreover, proceed Plus™ MD is valuated and suggested for producers for managing loose smut of wheat.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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