Determination of Giftii bio pesticide rate for the control of Fussarium head blight disease of wheat in Arsi area

Abstract

The average national yieldof wheat is about 2.8 t/ha. However, poor yields are partially attributed by losses from Fusarium head blight (FHB), *SeptoriaSpp*, and rust diseases three main biotic threats to wheat productivity in Ethiopia and around the world. These losses are made worse by climate change, and a sizable amount of wheat which makes up 9% of the country's total cereal production is imported annually to make up the difference. In order to control FHB in wheat-potential areas in 2022 and 2023, the trial seeks to ascertain the proper rate of new product (GBP). Fertilizer application, weed control, and planting at the suggested seed rate were all part of the trial. Plant surfaces were treated with a mixture of test bio pesticides and a check fungicide and tap water. Grain yield, HLW, and TKW were measured, and bleached spikes were used to gauge the severity of the disease. In Kulumsa, Fusarium head blight (FHB) was shown to be more severe over the course of two years in the trial field. The productivity of sensitive cultivars Boru demonstrated higher yield with various treatments of G_BP and standard check Nativo 300Sc compared to untreated plots. The study also looked at the effect of G_BP on other agronomic variables. In terms of grain yield, weight of thousand kernels, and floor contents of Boru, the results indicate that 1liter/hectar of G_BP bio pesticides are comparable to standard check Nativo 300Sc. At 5% degree of freedom, however, they differ considerably from the untreated plot and are not significant from standard check.

Key words:Biotic, Threat, Severity, Sensitive, Standard

1. Introduction

Wheat is one of the most significant staple grains in the world (Rodríguez-kábana and Canullo, 1992).The primary source of calories and plant-based protein in human diets, With over 220 million hectares planted each year under a variety of meteorological circumstances and agro-ecological amplitudes, it is currently the most commonly grown cereal in the world, with an annual production of roughly 670 million tons (Shiferaw *et al*., 2013).

With a production of 750 million tons (MT) on roughly 220 million hectares, wheat is regarded as one of the most significant crops for food security globally, according to Tadesse *et al*. (2019). It is the most crucial crop for maintaining food security and ranks first among the world's produced cereal crops (>200 mha annually), according to Shiferaw *et al*. (2020). The development of the agricultural sector in general and the food security situation of farm households in particular are greatly aided by this key cereal crop (Anteneh and Asrat 2020). More than one-third of the world's population relies on bread wheat (Triticum aestivum L.) as a staple diet, making it the most popular cereal grain worldwide (Mitiku and Eshete, 2016).

Ethiopia produces over 1.8 × 106 hectares of bread (*Triticum aestivum* L.) and durum (*Triticum turgidum* L. var. durum) wheat, mostly as highland rain-fed crops, making it the greatest producer of wheat in sub-Saharan Africa (CSA, 2020). In order to cut wheat imports from 1.7 million metric tons in 2019 to zero by 2023, Ethiopia's Ministry of Agriculture and Natural Resources has planned to boost wheat production from 2.7 metric tons per hectare in 2019 to 4 metric tons per hectare by 2023 (Diriba and Ababa, 2019). "Wheat belts" are regions that produce a lot of bread wheat, such the Bale, Arsi, and Shewa zones of Oromia regional state (Mume*et al*., 2019). Unlike durum wheat, which is mostly grown on vertisols with poor drainage, bread wheat is grown on better-drained soils and at slightly higher elevations (>2400 m a l) (Tadesse *et al*., 2019).

Although well-managed fields employing disease-free cultivars can achieve yields >5 t/ha in the highlands, the national mean yield is at 2.8 t/ha (CSA, 2020). Rust diseases, septoria, and FHB, which have long been among the main biotic threats to wheat production globally, are partially to blame for low mean yields (Wan *et al*., 2013).There is no bread wheat types introduced to market with complete resistant or immunity against FHB. This is partly due to resistant to FHB is complex and quantitatively inherited characteristic controlled by numerous genes and altered by environment factors (Bai and Shaner 1994).Worldwide great efforts are conducted to arrive with resistant wheat genotypes for breeding reasons to obtain resistance and Fhb3 resistant gene were reported to be effective for fusarium diseases (Qi *et al*., 2008).Climate change, a widespread issue that has imposed numerous problems on modern agriculture in general and wheat production in particular, exacerbates the loss of crop yield and quality (Ahmed *et al*., 2020). A sizable amount of wheat is imported annually to fill the national deficit, which represents 9% of the country's total grain production, because the existing supply of wheat cannot keep up with demand (Diriba, 2020).

Fusarium diseasesis one of the most damaging diseases affecting wheat and small grains globally. Mycotoxins generated by Fusarium pathogens jeopardize the safety of food and feed, and yield and quality losses can be catastrophic (McMullen *et al*., 2012).

During anthesis, a complicated and crucial stage of reproductive growth, Fusarium fungus spread and infect wheat heads through open florets (Kang *et al*., 2000). According to Brown *et al*. (2010), the fungus are biotrophic during infection, but necrotrophic intracellular colonization follows biotrophic growth after host cell death is triggered. The switch from biotrophy to necrotrophy may be triggered by the production of the trichothecene toxin deoxynivalenol (DON), which is specifically induced during colonization [Maclean *et al*., 2008, Bönnighausen*et al*., 2019].

Light to moderate rainfall for as little as two or three days can promote illness. The ideal temperature range for infection is 75°F to 85°F (24°C to 29°C); but, infection will happen at lower temperatures under extended periods of high moisture and humidity. Other wheat heads may become infected by the extra spores produced by the original infection on the wheat head. In uneven wheat stands with late flowering tillers, this secondary infection can be particularly troublesome. Infection will continue as long as climatic conditions are suitable, and wheat plants are at sensitive growth phases.

The timing of application, spray coverage, and disease pressure all affect how well a fungicide suppresses FHB. Nowadays, a number of fungicides are approved for use against wheat FHB, and their levels of protection differ. According to research, early blooming is the best time to apply fungicides in the triazole class (Feekes 10.5.1). If circumstances that promote disease growth persist after Feekes 10.5.1 and circumstances preclude an application at Feekes 10.5.1, fungicide treatments may still be effective after early blossoming.

Therefore, In 2022 and 2023 GC cropping season the trial was laid out to determine the appropriate rate of new product (GBP) for the control of Fusarium head blight diseases of wheat in wheat potential areas of the country.

2. Methodology used

2.1 Experimental materials used

The trial was carried out at Kulumsa research center in Arsi zone Southeastern Ethiopia. Bread wheat variety Boru was planted at recommended seed rate by row planting method on five plots of 1.2 m x 2m (2.4m^2). The treatments were arranged in RCBD design with three replications.The recommended fertilizer rate was applied during planting. Weeds were managed by hand weeding. A check fungicide Nativo 300Sc at the rate of 0.75 l/ha and a test bio pesticides of different rate, 1.5 l/ha of G_BP/50% above company recommendation, 0.5 l/ha of G_BP/50% below company recommendation and company recommendation 1l/ha were mixed with tap water at the rate of 200 l/ha using knapsack sprayer and sprayed on the plant surfaces starting from the diseases occurrence (Early heading) every two week at different growth stage on the three of the plots of 2.4m^2 at each location and replication. The standard check Nativo 300Sc at recommended rate applied at each location and replication. The leftover one plot at each replication was received no fungicide spray check treatment. Disease Severity (DS) was determined as the proportion of bleached spikes with in randomly thrown quadrants. In each fields severity was rated on scale of 0 to 9, where: 1=no symptoms, 2=<5%, 3=5-15%, 4=16-25%, 5=26-45%, 6=46-65%, 7=66-85%, 8=86-95%, 9=96-100% Miedaner, *et al*., (1996). The grain yield, HLW and TKW also recorded following the standard procedures. The agronomic traits were analyzed using R-Software package.

3. Results and discussion

The current experiments were set up in areas where the aforementioned weather conditions suitable to disease development and susceptible wheat cultivar were grown. Cultivars that were considered resistant to other diseases and remained in production and available in farmer's field were susceptible to Fussarium head blight disease at the moment due to the sporadic nature in an area, Arsi zone. A variety of biotic and abiotic stresses threaten Ethiopian wheat production, with fusarium head blight diseases being the most difficult to manage and affecting wheat production in areas with high elevation and favorable weather conditions. In this sense, resistant cultivars by themselves are unable to withstand the current state of affairs in our nation. This well-known statement has become a thing of the past because of the Fussarium problem in some places, particularly in Arsi, West Arsi, and Bale, which were regarded as the wheat belt and made Ethiopia the bread basket of East Africa up until this point. It is essential to support our cultivars systematically with chemical pesticides and other products, such as biopesticides, at the right amount, rate, and time of application in order to maintain consistent wheat production and support the genetic constituents of the wheat cultivars' resistance behavior.

3.1. Impacts of G_BP to fusarium diseases at Kulumsa over years

Figure 1 below shows how yellow rust responds to novel biopesticides used to manage yellow rust in several hotspot locations in Arsi. The findings show that the last time fusarium head blight was severe.

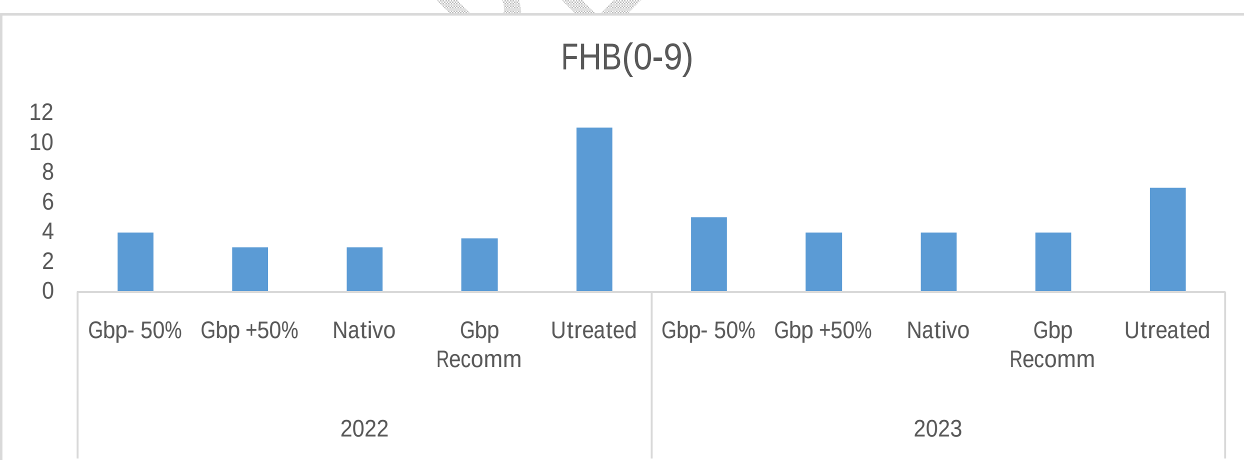

Figure 1. Response of fusarium head blight to different rates of G_BP

As previously mentioned, for the two years in a row on the trial field, FHB was higher in Kulumsa. According to the field response, the 1 l/ha and 1.5 l/ha of G_BP product are superior to the 50%-/0.5 l/ha of G_BP products and untreated plots, and they are comparable to standard check Nativo 300Sc at field conditions throughout the year.

3.2. Impacts of G_BP to different agronomic traits

The strain from diseases has a significant impact on the productivity and output of several commodities. Primarily if sensitive wheat cultivars and favorable climatic conditions were sown in regions where FHB is a prevalent issue.

3.2.1. Grain yield

Table 1 below shows that the vulnerable kinds' productivity in comparison to the untreated plot, Boru produced higher yields in all years under high disease pressure when treated with various G_BP and standard check Nativo 300Sc treatments. In comparison to the other treatments and the standard check Nativo 300Sc, the G_BP product rate 50% + (1.5l/ha) and the company-recommended G_Bp (1l/ha) demonstrated a greater yield with a mean grain yield of 51.03 Q/ha. At every year, the company's suggested G_BP rate,biopesticidedemonstrated superior yield, which is statistically equivalent to a standard check.

Table 1. Mean values of agronomic treatments

Trt	GYLD Q/ha	TKW	HLW
Nativo 300Sc/ standard Check	**55.733a**	**39.772a**	**69.953a**
50%+ G_BP(1.5li/hec)	**51.033ab**	**39.340 ab**	**70.693a**
company recommendation(1li/he)	**50.467ab**	**38.042ab**	**69.057ab**
50%- G_BP(0.5 li/hec)	**47.733bc**	**35.088bc**	**67.443bc**
Untreated Plot	**36.050c**	**32.832c**	**66.717c**
Mean	**48.203**	**37.015**	**68.773**
LSD (5%)	**11.3**	**4.5**	**2.3**
CV	**19.65**	**10.30**	**2.84**

In general, the G_BP, biopesticides with varying rates evaluated at various sites demonstrated yield advantages that were comparable to the standard check Nativo 300Sc and significantly superior than the untreated plots in every year.

3.2.2. TKW and HLW

The TKW and HLW of all treatments across all locations, as shown in table 1 above, are statistically significant, leading us to the conclusion that the G_BP bio pesticides are comparable to the standard check, Nativo 300Sc, in terms of both the floor contents of the Boru variety that received varying levels of G_BP product and the weight of thousands of kernels.

4. Discussion

Only by using an integrated strategy that include fungicide use, resistant cultivars, and production practices can minimize FHB diseases. Nonetheless, a more thorough comprehension of the host and pathogen resistance mechanisms is unquestionably required. Using some fungicides, such as chemical fungicides, botanicals, and biopesticides, can help reduce illnesses in wheat, but it does not ensure that the pathogen will be completely eradicated. The current result indicated that the appropriate rate of the existing biopesticides should be applied for the control of fusarium diseases, which was in agreement with the findings of Belachew Bekele and Wubit Dawit (2017). This means that appropriate, efficient, and environmentally friendly control measures must be applied to lessen such stresses. According to McMullen *et al*. (1999), there was a considerable difference in the grain yield between treated and untreated plots, which led to economic losses in wheat. Giftii biopesticides must be applied at flowering in order to reduce fusarium disease load and boost wheat yield, TKW, and HLW, which is consistent with research by Müllenborn*et al*. (2008).

5. Conclusion

One of the most important crops for global food security is wheat. FHB, septoria, and rust diseases have long been the primary biotic hazards to wheat production worldwide. Grain yield was much greater than the untreated control throughout the year. The foliar biopesticide G_BP, which was administered at a rate of 1 l/ha combined with 200 l/ha of water, enhanced yield, HLW, and TKW comparable to Nativo 300Sc in both years and greatly decreased the severity of the FHB under field conditions. Biopesticide-assisted disease control can boost crop output while posing no threat to beneficial insect pests.

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.

ACKNOWLEDGEMENT

The authors would like to gratefully acknowledge the Ethiopian Institute of Agricultural Research

(EIAR), and Giftii Foods and PLC for the financial support. Besides, we gratefully acknowledge Kulumsa Agricultural Research for hosting the trial.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

6. Reference

1. Bai GH, Shaner G. (1994). Scab of wheat: prospects and control. Plant Dis. 78:760–766.
2. Bai GH, Shaner G, Ohm H (2000) Inheritance of resistance to Fusarium graminearum in wheat. Theoretical and Applied Genetics 100: 1-8
3. Brown NA, Urban M, van de Meene AM, Hammond-Kosack KE. The infection biology of Fusarium graminearum: defining the pathways of spikelet to Buerstmayr et al. BMC Genomics (2021) 22:470 Page 14 of 17 spikelet colonisation in wheat ears. Fungal Biol. 2010; 114(7):555–71. https:// doi.org/10.1016/j.funbio.2010.04.006.
4. Bönnighausen J, Schauer N, Schäfer W, Bormann J (2019) Metabolic profiling of wheat rachis node infection by *Fusarium graminearum*-decoding deoxynivalenol-dependent susceptibility. New Phytol 221:459–469. 10.1111/nph.15377

5. Central Statistics Agency for Ethiopia. (2020). Agricultural sample survey of area and production of major crops.
6. Dagninet Asrat &Adugnaw Anteneh, (2020) A review, Status of food insecurity in dryland areas of Ethiopia: Cogent Food & Agriculture (2020), 6: 1853868.
7. Diriba, G., 2020. Agricultural and Rural Transformation in Ethiopia. Obstacles, Triggers and Reform Considerations. Policy Working Paper 01/2020. Addis Ababa, Ethiopia.
8. Dweba CC, Figlan S, Shimelis HA, Motaung TE, Sydenham S, Mwadzingeni L, Tsilo TJ. (2017). Fusarium head blight of wheat: Pathogenesis and control strategies. Crop protection. Jan 1;91:114-22.
9. Kang Z, Buchenauer H. Cytology and ultrastructure of the infection of wheat spikes by Fusarium culmorum. Mycol Res. 2000; 104(9):1083–93. https://doi.org/10.1017/S0953756200002495.
10. Maclean DJ, Schenk PM, Gardiner DM, et al. 2008.The Fusarium mycotoxin deoxynivalenol elicits hydrogen peroxide production, programmed cell death and defence responses in wheat. Mol Plant Pathol. ;9(4):435–45 https://doi.org/10.1111/j.1364-3 703.2008.00475.x
11. McMullen M, Bergstrom G, De Wolf E, Dill-Macky R, Hershman D, Shaner G, Van Sanford D (2012) A unified e□ort to fight an enemy of wheat and barley: Fusarium head blight. Plant Dis 96(12):1712–1728
12. McMullen, M.P. & Stack, R.W. 1999. Fusarium head blight (scab)of small grains. Bulletin no 804, Extension Service, North DakotaState University.
13. Miedaner, T., Gang, G., Geiger, H.H. (1996). Quantitative-genetic basis of aggressiveness of 42 isolates of Fusarium culmorum for winter rye head blight. Plant Disease (USA).
14. Mitiku, M., Eshete, Y. (2016). Assessment of wheat diseases in the south Omo zone of Ethiopia. Science Research, 4:183-186.
15. Mullenborn, C., U. Steiner and E.C. Oerke, 2007. Effect offungicides on Fusarium head scab and saprophytic fungi on wheat.15th International Symposium on Modern Fungicides andAntifungal Compounds, 6-10 May, Ramada Treff Hotel.

16. Qi LL, Pumphrey MO, Friebe B, Chen PD, Gill BS. Molecular cytogenetic characterization of alien introgressions with gene Fhb3 for resistance to Fusarium head blight disease of wheat. Theoretical and Applied Genetics. 2008 Nov; 117:1155-66.
17. Rodríguez-Kábana, R. and Canullo, G.H. (1992) — Cropping systems for the management of phytonematodes. *Phytoparasitica* **20**: 211–224.
18. Shiferaw, B., Smale, M., Braun, H. J., Duveiller, E., Reynolds, M., and Muricho, G. (2013). Crops that feed the world 10. Past successes and future challenges to the role played by wheat in global food security. *Food Secur*. 5, 291–317. doi: 10.1007/s12571-013-0263.
19. Tadesse, W., Bishaw, Z., Assefa, S. (2019). Wheat production and breeding in Sub-Saharan Africa: Challenges and opportunities in the face of climate change. International Journal of Climate Change Strategies and Management, 11:696-715.