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Participatory Demonstration and Evaluation of Optimum Fungicide Spray Frequency and Timing for Rust Management on Bread Wheat Production in West Arsi and Bale Zones, Southeastern Ethiopia

Ayalew Sida* and Bayeta Gadissa

Oromia Agricultural Research Institute, Sinana Agricultural Research Center, P.O.BOX. 208, Robe, Bale, Oromia, Ethiopia

*Corresponding author: ayalew.sida@yahoo.com

ABSTRACT

The study was carried out in West Arsi and Bale Zones of Oromia National Regional State Southeastern Ethiopia. To execute the trial, Dodola and Adaba districts were selected from West Arsi Zone while Agarfa and Sinana districts were considered from Bale Zone in which a total of 14 trial farmers were employed. The trial has three plots viz. research managed plot, farmers managed plot and the control plot. Similar agronomic recommendations were applied for all plots. Different frequency and timing of fungicide spray were applied using susceptible variety of bread wheat namely Ogolcho as a test crop. The trial was carried out using FRG approach. Data such as date of first spray, interval of spray, frequency of spray, production costs, and number of stakeholders participated during training and field days were recorded. Descriptive statistics were used to analyze quantitative data. Awareness creation was carried out in which 134 and 165 stake holders were participated on training and mini field days, respectively. The result of descriptive statistics revealed that average frequency of research managed plot was 2.29 while that of farmers' managed plot was 3.86. Similarly, the mean time of first spray after the date of planting for research managed plot was started on 35.57 days and 42.57 days attributed for mean time of first spray for farmers' managed plot. The ANOVA test depicted that research managed plot gave relatively high yield of 43.35 qt/ha followed by farmers managed plot which gave 30.84 qt/ha. The yield difference is statistically significant at less than 5% level of significance. The profitability analysis indicated that farmer who sprays two times keeping the right time could get extra net benefit of 42,269.00 ETB than who frequently spray without keeping the recommendations. Based on the finding, two times spray is effective applying the recommendations properly.

Key Words: Awareness Creation, Bread wheat, Frequency, FRG Approach, Fungicide, Timing

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INTRODUCTION

Bread wheat (Triticum aestivum L.) is one of the most staple food crops in the world and is one of the most important cereal crop produced in Ethiopia. Recently, wheat in general has become one of the most important cereal crops (strategic crop) in terms of production and food security in the country (Tolesa, 2014). Wheat is largely grown in the mid and highland areas of Ethiopia spanning at altitudes of 1500 to 3000 m above sea level (m.a.s.l). However, it is mainly grown between1800 to 2500 m.a.s.l in Bale, Arsi, West Arsi and Shoa zones of Oromia National Regional State (SARC Profile, 2015).

In Ethiopia, out of the total grain crop area, 1,747,939.31 ha of land was covered by wheat (CSA, 2019). In Bale Zone, 149,115.72 ha of land was covered by wheat during main production season (Bona season) and 5,226,944.66 quintals of grain was produced with the productivity of 35.05 qt/ha. Similarly in West Arsi Zone 132,859.80 ha of land was covered by wheat by which 4,642,444.24 quintal was gained with the average productivity of 34.94 qt/ha (CSA, 2022).

Despite its importance as food and industrial crop, wheat production and productivity around the globe is hampered by a number of factors including biotic and abiotic stresses as well as low adoption of new agricultural technologies (Tesfaye *et al*., 2001). Wheat rust is among the biotic factors affecting wheat production in Ethiopia generally, and Bale and West Arsi Zones particularly. Similarly, the evidence shows that, farmers are not using recommended fungicide spay frequency and timing for the management of wheat disease.

Hence, it was initiated to demonstrate and evaluate fungicides spray frequency and timing on bread wheat under farmers' condition.

Objectives

- To enhance awareness on fungicides spray frequency and timing for the management of wheat rust among farmers
- To evaluate yield performance and profitability of optimum frequency and timing of fungicide spray
- To collect farmers' feedback on fungicide spray frequency and timing

MATERIALS AND METHODS

Description of the study Area

Dodola district is located in the West Arsi Zone of the Oromia State; this town has a latitude and longitude of 06°59′N 39°11′E, with an elevation ranging from 2362 to 2493 meters above sea level. The land use and land cover of Dodola district shows that 28.3% is arable or cultivable (5.1% of the total was part of state farms), 17.4% pasture, 48.9% forest (including 696.76 square kilometers of natural vegetation and 12.24 of man-made forest), and the remaining 5.4% is considered swampy, mountainous or otherwise unusable.

Adaba district is also located in West Arsi Zone of Oromia Region with the geographical location of 39°36′ – 40°00′E and 6°00′ – 7°10′N. A survey of the land in this woreda shows that 16.9% is arable or cultivable, 23.3% pasture, 52.2% forest, and the remaining 7.6% is considered swampy, mountainous or otherwise unusable.

Sinana and Agarfa districts are located in Bale Zone of Oromia Regional State. The districts are found at a distance of 465 km and 430 km, respectively to the southeast from Addis Ababa

Sinana district is potential district which is suitable for crop production and the district is mainly characterized by highland agro-ecology (90%) while the rest (10%) accounts for midland agro-ecology. Concerning land use land cover status of Sinana district, 63% is used for crop production while 11.78% is grazing land, 7.5% covered with forest and about 0.07% barren/degraded land and 17.65% of land occupied with others (for construction, rivers, gorges and others).

Agarfa district consists of a total land area of 1343 km^2 (134,300 hectares) and out of which 45% is arable land, 30% is grazing land, 12% is forest, 5% is covered by barren/degraded area, and 8% is occupied by rivers, mountains, different constructions. It is estimated that 13,760 (13.2%) are urban dwellers and 90,852 (86.8%) are rural dwellers. More than 95% of the population is engaged in agriculture. The agro-ecological zones of the district are highland (83%), midland (11%) and lowland (6%). The altitude ranges from 1250m to 3855m a.s.l.

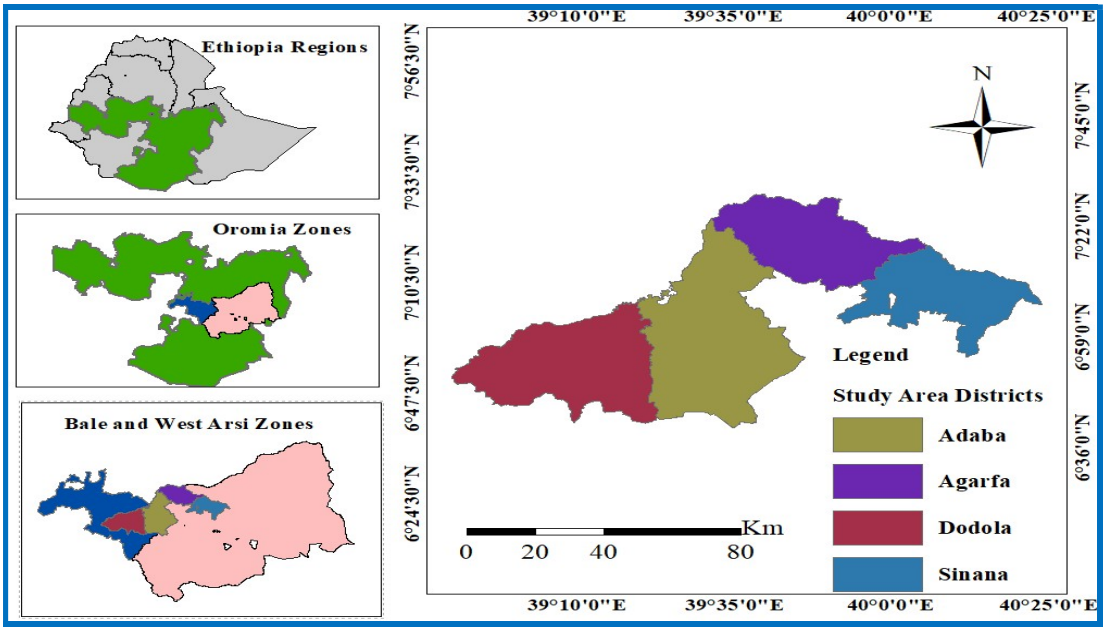

Figure 1: Map of the study area

Site and farmer selection

Sinana and Agarfa districts of Bale zone as well as Dodola and Adaba districts of West Arsi Zone were selected purposively as demonstration sites based on the existing wide use of fungicide. Moreover, two (2) representative kebeles were selected from each district and a total of seven (7) kebeles were used for this demonstration activity in 2021/22 and 2022/23 during main season of production. A total of 14 trial farmers used for the activity implementation.

Farmers Research Groups (FRGs) were established in each kebele by enhancing the participation of FRG farmers and the concerned stakeholders. Accordingly, in each kebele one (1) FRG consists of 15-20 members was established by taking into consideration the concept of gender participation (Table 1). From each FRG, two representative hosting farmers were selected based on willingness and past commitment history in managing the trial in which each farmer's field was taken as replication of the trial.

Table 1. List of FRG members by gender

District	Kebele	Adult men	Adult Women	Young men	Young women	Total
Dodola	Ketchema	13	3	3	1	20
Adaba	Ejersa	13	2	3	-	18
Sinana	Robe Area	10	3	2	-	15
	Selka	14	2	3	-	19
Agarfa	Ali	11	4	3	2	20
	Elanni	10	2	3	1	16
	Total	71	16	17	4	108

Field design and materials

Simple plot demonstration on 10m x 10m size of land was allotted for each treatment by using the recommended wheat production packages. This activity has three plots: research managed plot; farmer managed plot and control plots. Susceptible variety (Ogolcho) was used for all plots. Rexiduo and Nativo fungicides were used in 1st and 2nd years, respectively for research managed plot.

Technology demonstration and evaluation approaches

Farmers were encouraged to participate in the process of demonstration activities as well as on different extension events organized at each site. Training was given for farmers and agricultural experts (DAs, supervisors and SMSs) in order to build knowledge and skills of the participants toward the appropriate time of spray and the recommended frequency. Similarly, mini-field days were also organized at representative sites during demonstration (at maturity stage of the crop) to enhance the active participation of farmers in the process with researchers and other relevant stakeholders. At each district, before leading the participants to Focused Group Discussion (FGD**)**, brief orientation was given to them on the objectives of technology evaluation and selection in research process. Then, the evaluators were grouped in to small manageable groups by selecting and having one group leader and secretary, oriented to set their own criteria and finally, reported the evaluation result through their respective group leader.

Types of data and methods of data collection

Data such as time of spray for research managed plot and farmer managed plot, frequency of spray for research managed plot and farmer managed plot and data for yield performance were recorded. Besides, input costs (fertilizers, seeds, labor, fungicides, herbicides, transportation and harvesting costs), local market price of the out puts at harvesting time for each treatment were collected. Number of farmers participated on training, field visit and mini-field day was recorded by gender disaggregation. Farmers' feedback about the time of spray and frequency of spray was assessed using key informant interview and Focus group discussion (FGD) methods of data collection.

Methods of Data analysis

Descriptive statistics such as mean and standard deviation were used to analyze the quantitative data. One may ANOVA was used to compute the yield difference among the three treatments. Economic data was analyzed using Benefit-cost ratio. Narration was used to summarize the farmers' feedback about the appropriate time, recommended rate of fungicide and water, and optimum frequency of fungicide application.

RESULT AND DISCUSSION

Time of Spray and Frequency

The aim of this activity is to demonstrate the proper time of fungicide spray and the optimum frequency of spray for farmers. The average frequency of research managed plot was 2.29 with minimum and maximum frequency of 2 and 3, respectively. On the other hand, the mean frequency of fungicide spray for farmer's managed plot is 3.86 with minimum and maximum frequency of 3 and 5, respectively.

Concerning time of fungicide spray, the first spray was started to be sprayed after 5 % disease severity for research managed plot. Accordingly, in average, the first time of spray for research managed plot was started on 35.57 days after the date of planting with early and late time of fungicide spray of 33 and 38 days after planting, respectively. Similarly, the mean time of first spray for farmers' managed plot was 42.57 days after the date of planting with the early and late time of spray of 35 and 50 days after planting, respectively. The second spray was undertaken on the 21st day of the first spray for majority of the research managed plots. The same type of fungicide was used for different times for research managed plot within one cropping season. Accordingly, Rexiduo was applied for research managed plot during the first year while Nativo was applied for the second year of activity implementation. Farmers prefer to spray different fungicide at different stage. They assume that using the same fungicide can develop adaptability and failure to control.

Table 2. Result of descriptive statistics for time and frequency of fungicide spray

Parameters	N	Minimum	Maximum	Mean
Time of first spray for Researcher managed plot (number of days after planting)	14	33.00	38.00	35.57
Time of spray for farmer's plot (number of days after planting)	14	35.00	50.00	42.57

Frequency of spray for researcher managed plot	14	2.00	3.00	2.29
Frequency of spray for farmer managed plot	14	3.00	5.00	3.86
Valid N (listwise)	14			

Awareness Creation

Awareness was created for farmers through providing training and by organizing mini-field days in which farmers were enhanced to evaluate the three plots. Accordingly, mini field days were organized at different sites in which 136 farmers and 29 agricultural experts were involved. Awareness creation was focused on proper time of fungicide spray, optimum frequency of spray and the appropriate way of fungicide spray.

Table 3: Number of stakeholders participated on mini-field days

Locations	Farmers			Experts (DAs + SMSs)		
	Male	Female	Total	Male	Female	Total
Adaba	18	2	20	4	1	5
Dodola	18	2	20	5	0	5
Agarfa	53	3	56	8	3	11
Sinana	35	5	40	6	2	8
Total	124	12	136	23	6	29

Practical and theoretical training was also given for farmers and agricultural experts to enhance their awareness towards the right time of fungicide spray and the optimum frequency required to control rust in order to increase bread wheat production. A total of 108 farmers and 26 agricultural experts were participated on the practical and theoretical training in the two years of activity implementation.

Table 4: Participants of training for two years

District	Farmers			DAs			SMSs		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Dodola	18	3	21	2	1	3	2	0	2
Adaba	19	5	24	3	0	3	1	1	2
Sinana	26	1	27	4	2	6	1	1	2
Agarfa	34	2	36	3	3	6	2	0	2
Total	97	11	**108**	12	6	**18**	6	2	**8**

Yield Evaluation of Treatments

Yield performance evaluation was also carried out in which the research managed plot (two time spray) gave relatively high yield of 43.35 quintals per hectare with standard deviation of 15.18 (Table 4). The farmer managed plot (four times spray) gave mean yield of 30.84 quintals per hectare with the standard deviation of 19.21. The control plot gave mean yield of 7.87 quintals per hectare with poor quality of grain. The mean yield difference among the treatments is significant at less than 5% level of significance. Therefore, the high grain yield which was obtained from twice spray (research managed plot) was the result of proper time of spray supported by appropriate method of spray, use of recommended rate of fungicide and water. Hence, spraying many times without keeping the right time, without recommended rates of fungicide and water results to failure of rust control and finally for extra cost which in the long rung brings health problem on the individuals who engaged on fungicide spray and environmental effect as whole.

Table 5: Yield performance of treatments

Treatments	N	Mean	Std. Deviation	F-value
Research Managed	14	43.35	15.18	
Farmer managed	14	30.84	19.21	21.2**
Control	14	7.87	6.56	

**, stands for statistical significant level of less than 5%

Farmers' Feedback

During feedback assessment through group discussion, farmers raised that they sprayed their farm at least four times. Their major problems in case of fungicide application were; they usually use small amount of water (i.e. they use only 120 liters of water for a hectare while the recommendation is 250 liters). Similarly, they also use fungicides below or above the recommendations. They also fail to apply the right way of fungicide application. Their focus is to cover the large area within short time and labor cost. After the demonstration process farmers were glad to practically apply the fungicide as per the recommendations and the awareness they gained from demonstration. Therefore, the farmers were showed their commitment to apply two times keeping the right time and appropriate method of application.

Profitability Analysis

The result of profitability analysis illustrated in the Table 10 below shows that the researcher managed plot (twice spray) is economically profitable than the farmer managed plot (four times spray). The net benefit of 73,313.00 ETB was obtained per hectare in one production season from two times fungicide spray (researcher managed plot). Similarly, the net benefit obtained from farmers' managed plot (four times spray) was 31,044.00 ETB per hectare in one production season. Therefore, the farmer who sprays two times at the right time keeping the right method of fungicide spray by applying the recommended rate of fungicide and water could get the net benefit of 42,269.00 ETB than the farmer who frequently spray fungicide without keeping the right time, appropriate method of spray and the recommended rate of fungicide and water.

Table 6. Profitability analysis of the treatments for frequency of fungicide application

Parameters	**Treatments**	
	Researcher managed	**Farmer managed**
Yield obtained ($qtha^{-1}$)	43.35	30.84
Sale price (ETB/qt)	3,200.00	3,200.00
Total Revenue (Price * Qt)	138,720.00	98,688.00
Variable Costs		
Land preparation (tractor rent/ha.)	3500	3500
Cost of seed purchase/ha.	5800	5800
Cost of fertilizer (NPS and UREA)/ha.	7200	7200
Cost of Insecticide/ha.	850	850
Cost of herbicide/ha.	2200	2200
Cost of Fungicide/ha.	5000	10000
Cost of labor for insecticide spray/ha.	600	300
Cost of labor for herbicide spray/ha.	1200	600
Cost of labor for fungicide spray/ha.	600	1200
Cost of Labor for harvesting/ha.	6502.5	4626
Cost of grain cleaning/ha.	750	500
Cost of sack purchase/ha.	1204	868
Total Variable Costs (ETB/ha)	35,406.50	37,644.00
Fixed cost		
Fixed Cost of Land	30,000	30,000
Total cost (TVC + TFC)	65,407	67,644
Gross Margin (GM)=TR-TVC	103,313.50	61,044.00

Net Profit=TR-TC or GM-TFC	73,313.00	31,044.00
Benefit-cost Ratio=Total Revenue/Total Cost	2.12	1.46

CONCLUSION AND RECOMMENDATIONS

The study mainly focuses to enhance farmers' knowledge and skill towards the appropriate time and the economically feasible frequency of fungicide spray through practical demonstration. The study was implemented using three plots; research managed plot, farmers' managed plot and control plot (to see the yield loss incurred due to rust). During implementation, the average frequency of fungicide spray for researcher managed plot was 2.29 (two times) while that of the farmers' managed plot was 3.86 (four times). Practical and theoretical training was given for 108 farmers and 29 agricultural experts. Mini field days also organized at different locations in order to share the farmers' experience and to deliver the recommended rate, time and frequency of fungicide spray to control rust in which a total of 136 farmers and 29 agricultural experts were involved. Yield evaluation was also carried out among the treatments to identify the optimum frequency of fungicide spray and the appropriate time of application.

Yield and economic evaluation were carried out among the treatments in order to determine high yielder and economically feasible frequency of fungicide application. Accordingly, the research managed plot gave relatively high grain yield of 43.35 quintals per hectare followed by the farmers managed plot which gave 30.84 quintals per hectare. The yield difference is statistically significant at less than 5% significance level. The economic evaluation also depicted that research managed plot (two times spray) was also economically feasible with the net benefit of 42,269.00 ETB than the farmers managed plot in a single main production season.

Based on farmers' feedback, yield performance and profitability analysis two times spray is effective supported with recommended rate of fungicide and water, time and appropriate method of fungicide application.

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Conflicts of Interest

The authors declare no conflict of interest

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