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Research Article

Economic Returns of Foliar Fungicides Application to Control Yellow Rust in Bread Wheat Cultivars in Arsi high lands of Ethiopia

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Abstract

Wheat yellow rust caused by Puccinic Striiformis f. sp tritici is the most widespread and destructive disease of wheat, especially in the highlands of Ethiopia. Application of foliar fungicides are important mechanisms to control wheat yellow rust disease. The activity was conducted at two experimental sites Meraro and Bekoji in 2018 main cropping season, in order to determine net returns of wheat yields from the application of fungicides. The aim of the study was to know net reruns obtained from the application of propiconazole and Thiophanate-methyl 310g/l +Epoxiconazole 187g/l fungicides with twice application frequency in four bread wheat cultivars with different resistance level, being susceptible, moderately susceptible, moderately resistant and resistant including Kubsa, Danda'a, Lemu and Wane against wheat yellow rust respectively in 2018. The positive net returns at Meraro, 12.66, 11.4, 8.39 and 7.65, and at Bekoji 12.14, 11.4, 7.92 and 5.18 on Kubsa, Lemu, Danda'a and Wane (susceptible, moderately susceptible, moderately resistant and resistant bread wheat varieties by the twice application of RexDuo respectively. Maximum net return on fungicide application was obtained on the susceptible (Kubsa) variety $1164.98 ha^{-1} at Bekoji and $1215.13 ha^{-1} at Meraro and minimum net returns was observed on Wane (resistant) variety $ 5.18 ha^{-1} at Bekoji and 7.65 at Meraro experimental stations by the twice application of Rex®Duo. Epoxiconazole +Thiiophanate-methyl applied treatments were resulted the highest returns at the rate of 0.5l ha−1, but low net returns were observed on propiconazole applied treatments at a rate of 0.5l ha−1 at both location. From the study lower economic return at Bekoji was obtained due to dry climatic conditions which resulted in low rust severity as compared to Meraro obtained higher profitability to higher altitude with cooler climate, lower temperature, heavy dew and intermittent rains. This indicated that conducive climatic conditions to yellow rust disease development during the growing season, cultivar resistance, fungicide application frequency, plant growth stage, fungicide and fungicide application costs and the price of wheat determines the net return in fungicide application of wheat. The results from this study indicated that foliar fungicide applications to bread wheat cultivars can be profitable in twice application with sensitive to semi sensitive(moderately susceptible to susceptible)varieties; however, net loss can result if fungicides are frequently applied in with low disease severity or resistant varieties rather than sensitive and semi sensitive varieties.

Keywords: Strip rust; Bread wheat; Cultivar, Net return; Fungicide application

Introduction

Rusts caused by obligate pathogens of wheat are yellow rust (*Puccinia striiformis* f. sp. *tritici)*, stem rust (*Puccinia graminis* f.sp. tritici) and leaf rust (*Puccinia recondite* f.sp. *tritici*) which infect the foliage, stem and sometimes the spikes lost more than $5bilion in each year .They have the capacity to develop into widespread epidemics and complex life cycles that involve alternate hosts and several spore stages resulting in yield losses of 30-50% sensitive and semi sensitive cultivars and 57-97% on [1-8]. Wheat stripe rust, caused by *Puccinia striiformis* is one of the most widespread, destructive and an emerging serious disease, especially in cool climates, present in almost all the wheat growing areas and a formidable threat to global wheat production [2-6]. In Ethiopia Arsi, Bale and North shoa areas, are wheat mono cropping and the most prevalent to yellow rust disease epidemics which causes 57 to 97% of yield losses in sensitive and semi sensitive bread wheat cultivars [7,8] Application of foliar fungicides are important mechanisms to control wheat yellow rust and reduce yield losses. According to [9], [6] findings comparatively better yields were obtained on sprayed treatments rather than unsprayed treatments under experimental condition. During the fungicide application; conduciveness of

environment to rust, varietal resistance, effectiveness and timing of fungicide application to be taken into consideration in reducing the disease severity and rate of epidemic development. Large scale commercial and government-run wheat farms have generally chosen to plant rust-susceptible wheat varieties because they have a greater yield potential of 20%-25% and 36.6% -51.1% than rust-resistant varieties [5 and 8]. Wheat grown in a higher-yield potential (highland) environment may be more likely to produce a yield response.

Timely application of fungicides effectively prevents yield losses and further spread of the disease to the wheat production regions, and potentially huge nationwide yield loss was avoided through use of fungicides [10]. Fungicide prices influence the decision of spraying or not spraying. However, when the disease severity is low, crop yield is usually not impacted. The benefit from fungicide applications in crop production is reflected in the returns of up to three times the cost involved [11]. There is a misconception that fungicides are used to get a "yield bump" but most crop scientists agree that fungicides simply protect yield potential. When disease severity has the potential to reduce crop yields, then fungicide applications may help to protect the crop from potential losses. On the other hand, if disease severity is low and there is minimal yield loss, then applying a fungicide will not result in either a yield or economic advantage [12]. In the considerable studies researchers emphasized that there are a number of factors that farmers should consider before making a fungicide spray decision, including yield potential, wheat price, fungicide cost, and disease pressure. Although many farmers and private wheat growers spray as soon as the rust occurred without considering economic threshold level of the disease and positive net return on the economic yield of wheat. The main objective of this research was to determine the profitability of wheat yield using fungicides against yellow rust in susceptible, moderately susceptible, moderately varieties and comparing with commercial relatively resistant wheat varieties.

Materials and Methods

The study was undertaken at Kulumsa Agricultural Research Center, sub-stations Bekoji and Meraro, in Arsi highlands of South Eastern Ethiopia during 2018 main cropping season. The experiment was conducted at Meraro and Bekoji experimental stations from the Kulumsa Agricultural Research Center substations during the main cropping season of 2018 at south eastern part of Ethiopia.

Treatments and Experimental design

The experiments were laid out in randomized complete block design (RCBD) in factorial arrangement with three replications. Four bread wheat cultivars which were selected based response of reaction being Kubsa susceptible (Sensitive), Danda'a Moderately susceptible (semi sensetive), Lemmu moderately resistant and Wane relatively resistant to wheat yellow rust and released from Kulumsa Agricultural Research Center, Ethiopia were used (Table 1). All the varieties were sown at the recommended rate of 100 kg seed ha-1 to six row plots of 2.5m length and 1.2m width with 20 cm inter-row spacing. The gaps between plots and replications were 1m and 1.5m, respectively. Spreader rows consisting of a mixture of highly susceptible bread wheat varieties of Morocco, Kubsa and PBW 343 were planted in each border row in order to ensure uniform spread of inocula and sufficient disease development. Experimental plots were fertilized with Diamonium phosphate (DAP) and Urea (41kgN/46kg P2O5ha^{-1}) just at planting and weeds and insect pests were controlled as management recommendations.

Table 1: Description of Materials (Wheat Cultivars) used for the experiment.

Variety	Year of release	Pedigree/Male	Selection History	Source	Response to stripe rust
Kubsa	1994	THELIN/WAXWING//PATOR/ 3/INQALAB91*2/ TUKURU 9Y-0B	ICW08-00270-4AP0AP-040SD4SD-OSD0KU-LOKULOKUL	ICARDA	S
Danda'a	2010	SHARP/3/PRL/SARA//TSI/VEE /LIRA//BOW/3/ BCN/KAUZ/6/H UBARA-5	ICW08-00261-4AP0AP-0AP-2KUL010DZOKUL	ICARDA	MS
Lemu	2016	PASTOR//HXL7573/2*BAU /3/SOKOLL/ WBLL1/4/SFI1//NS732/HER/3/SAADA	ICW08-00215	ICARDA	MR
			5AP0AP040SD4SD-OSD0KULOKULOKU		
Wane	2016	PASTOR//HXL7573/2*BAU/3/S OKOLL/ WBLL1/4SAFI1//NS73 2/HER/3/SAADA	ICW08-00214-7AP0AP-040SD7SD-0SDOKU-LOKULOKUL	ICARDA	R

S: Susceptible, MS: Moderately susceptible, MR: Moderately resistant, R: Resistant Source: Ethiopian crop registration directory of 2014, 2016.

Fungicide and application frequency

Wheat plots were sprayed with recently registered and widely used fungicides viz. Rex® Duo (Epoxiconazole + Thiophanate-methyl) and Tilt 250EC*(propiconazole) at 0.5lt product ha^{-1} in 250lha^{-1} water using Manual Knapsack Sprayer (Table 2). Foliar fungicides and its application costs were used to analysis profitability on the spraying of fungicides to four bread wheat cultivars (Table 3). The average price of bread wheat cultivars were calculated from data provided by the Ethiopian Agricultural and commodity Marketing Service and average local fungicide prices used were obtained by assessing local retailers and chemical manufacturers. Since knapsack fungicide application was agreed by contract between the grower and the commercial applicators so Adjuvant and surfactant, and machinery and machinery,

maintenance costs were omitted because of the wide variation in their uses and costs. Net return from fungicide application was calculated as follows: Rn = YiP− (Fc + Ac) Where, Rn is the net return from fungicide application ($ ha^{-1}); Yi is yield increase from fungicide application (kg ha^{-1}), obtained by subtracting the yield in the Control treatment from the yield in the fungicide treatments; P is the wheat price ($ kg^{-1}); Fc is the fungicide cost ($ ha^{-1}) and Ac is the fungicide application cost ($ ha^{-1}).

Table 2: Description of Materials (foliar fungicides) used in the trials.

Common name	Trade name	Active ingredient	Application rate(liters ha-1)
Propiconazole	Tilt 250EC	250EC at 0.1% con.	0.5
Epoxiconazole + Thiophanate-methyl	Rex® Duo	Epoqsikonazol(187g/l),thiofn methyl(310g/l)	0.5

Table 3: Fungicides and application costs, and Wheat price.

	Fungicide Cost(FC) ($ha-1)	Fungicide application	FC + AC ($ha-1)	Wheat price ($ Qt-1)
Fungicides		(AC) Cost ($ha-1)		
Rex® Duo once	29.26	18.5	47.76	42.5
Rex® Duo twice	58.52	37	95.52	42.5
Tilt 250 EC* once	21.29	18.5	39.79	42.5
Tilt 250 EC* twice	42.58	37	79.58	42.5

Source: Survey data on BASF Ag Products, Bayer Crop Science, and Syngenta Crop Protection companies, 2017.

Results and Discussion

At Bekoji, profitability from the application of fungicides varied from 7ha^{-1}$ in Lemu variety treated with one application of Tilt to 1165$ha-1 in Kubsa variety that received twice application of Rex® Duo (Table 4). At Meraro, net return after fungicide application ranged from 88$ha-1 in Danda'a variety treated once with Tilt to 1215$ha-1 in Kubsa variety treated twice with Rex® Duo (Table 5). From the application of fungicides profitability of economic yield in bread wheat varieties at Bekoji and Meraro in experimental stations, similarly showed variability in net returns from location to location (Table 4 and 5).The lower profitability at Bekoji can be attributed to dry weather which resulted in low disease levels as compared to Meraro obtained higher profitability to higher elevation with cooler climate, lower temperature, heavy dew and intermittent rains. In Meraro, yellow rust on bread wheat is first observed ate early seedling stage with optimum urediniospores in mid belig or early mehar season (June to November). The positive net return can be strongly influenced by the Market price of wheat on applying fungicides to control wheat yellow rust. The expected yield increase of 2967 kg ha^{-1} representing 51.1% of the yield potential and a fungicide and application cost of $96 ha^{-1}, the net return was $1164.98 ha^{-1} at a wheat price of 0.425kg^{-1}$ compared to $497.7 ha^{-1} t at the same wheat price of 0.425kg^{-1}$. Therefore twice application of Rex® Duo or Tilt 250 EC immediately after appearance of rust disease on wheat varieties at 15 days interval are effective in controlling the disease and achieving higher economic return. The results indicated that lower economic return at Bekoji was obtained due to dry climatic conditions which resulted in low level of rust severity as compared to Meraro obtained maximum profitability to higher altitude with cooler climate, lower temperature, heavy dew and intermittent rains. This findings are convenient with work done by [13,14 and 15] indicated that conducive climatic conditions to yellow rust disease development during the growing season, cultivar resistance, fungicide application frequency, plant growth stage, fungicide and fungicide application costs and the price of wheat determines the net return in fungicide application of wheat. According to [16] findings doubling and tripling the grain price of bread wheat had the highest impact on the net return from fungicide application, followed by increasing fungicide cost. In conclusion, profitability is dependent on many factors, including weather conditions favorable to disease development, the level of disease intensity, efficacy of the fungicide applied in controlling each specific disease, fungicide and fungicide application costs and rates, fungicide application timing, cultivar resistance, cultural practices and the price of wheat.

Table 4: Effect foliar fungicides on wheat grain yield and net returns to wheat yellow rust at Bekoji experimental station.

Treatments		FC+AC	Yld	YI	YI	YiP	Rn	BCR
Cultivars	Fungicides	($ha-1)	(qtha-1)	(qtha-1)	%ha-1		($ha-1)	
Wane R	Tilt1	40	48.05	1.17	2.5	49.73	9.73	0.24
	Tilt2	80	59.22	12.34	26.32	524.45	444.45	5.56
	Rex1	48	51.08	4.2	8.96	178.5	130.5	2.72
	Rex2	96	60.85	13.97	29.8	593.73	497.73	5.18
	Untreated	0	46.88	0	0	0	0	-

Danda'a (MR)	Tilt1	40	27.53	1.15	4.36	48.88	8.88	0.22
	Tilt2	80	39.55	13.17	49.92	559.73	479.73	6
	Rex1	48	28.32	1.94	7.35	82.45	34.45	0.72
	Rex2	96	46.53	20.15	76.38	856.38	760.38	7.92
	Untreated	0	26.38	0	0	0	0	-
Lemu (MS)	Tilt1	40	30.48	1.1	3.74	46.75	6.75	0.17
	Tilt2	80	45.45	16.07	54.7	682.98	602.98	7.54
	Rex1	48	41.52	12.14	41.32	515.95	467.95	9.75
	Rex2	96	57.38	28	95.3	1190	1094	11.4
	Untreated	0	29.38	0	0	0	0	-
Kubsa (S)	Tilt1	40	9.48	6.75	247.25	286.88	246.88	6.17
	Tilt2	80	25.22	22.49	823.81	955.83	875.83	10.95
	Rex1	48	21.27	18.54	679.12	787.95	739.95	15.42
	Rex2	96	32.4	29.67	1086.8	1260.98	1164.98	12.14
	Untreated	0	2.73	0		0	0	-

Yld= Yield qt ha-1, Rn= net return from fungicide application ($ ha-1), P= wheat price ($ qt−1), FC =Fungicide cost ($ ha−1), AC = Fungicide application cost ($ ha−1), YI = Yield increase from fungicide application (qt ha-1 and %), Tilt1 = Once application of Tilt 250 EC*, Tilt2 =Twice application of Tilt 250 EC*, Rex1 = Once application of Rex® Duo, Rex2= Twice application of Rex® Duo once, BCR=Benefit Cost Ratio, MR=Moderately Resistant, R= Resistant, MS= Moderately Susceptible, S= Susceptible disease reaction.

Table 5: Effect foliar fungicides on wheat grain yield and net returns to wheat yellow rust at Meraro experimental station.

Treatments		FC+AC	Yld	YI	YI	YiP	Rn	BCR
Cultivars	Fungicides	($ha-1)	(qtha-1)	(qtha-1)	%ha-1		($ha-1)	
Wane R	Tilt1	40	33.35	3.7	0.45	157.25	117.25	2.93
	Tilt2	80	46.52	16.87	56.89	716.98	636.98	7.96
	Rex1	48	33.85	4.2	12.48	178.5	130.5	2.72
	Rex2	96	49.2	19.55	65.94	830.88	734.88	7.65
	Untreated	0	29.65	0	0	0	0	-
Danda'a (MS)	Tilt1	40	18.6	2.95	18.85	125.38	85.38	2.13
	Tilt2	80	26.58	10.93	69.84	464.53	384.53	4.81
	Rex1	48	21.6	5.95	38.02	252.88	204.88	4.27
	Rex2	96	36.85	21.2	135.5	901	805	8.39
	Untreated	0	15.65	0	0	0	0	-
Lemu (MR)	Tilt1	40	24.98	3.46	16.11	147.05	107.05	2.68
	Tilt2	80	36.65	15.13	70.33	643.03	563.03	7.04
	Rex1	48	31.8	10.28	47.79	436.9	388.9	8.1
	Rex2	96	49.43	27.91	129.7	1186.18	1090.18	11.4
	Untreated	0	21.52	0	0	0	0	-
Kubsa (S)	Tilt1	40	4.07	3	279.4	127.5	87.5	2.19
	Tilt2	80	21	19.93	1863	847.03	767.03	9.59
	Rex1	48	6.02	4.95	461.7	210.38	162.38	3.38
	Rex2	96	31.92	30.85	2883	1311.13	1215.13	12.66
	Untreated	0	1.07	0	0	0	0	-

Yld= Yield Qt ha−1, Rn= net return from fungicide application ($ ha-1), P= wheat price ($ qt−1), FC =Fungicide cost ($ ha−1), AC = Fungicide application cost ($ ha−1), Yi = Yield increase from fungicide application (qt ha−1), Tilt1 = Once application of Tilt 250 EC*, Tilt2 =Twice application of Tilt 250 EC*, Rex1 = Once application of Rex® Duo, Rex2= Twice application of Rex® Duo once, BCR=Benefit Cost Ratio.

Conclusion and Recommendation

Wheat yellow rust caused by *puccinia striiformis* f.sp.*tritici*, is the most widespread, destructive and formidable threat especially in cool climates, present in the highland wheat growing areas of Ethiopia. Now a day, possibility of producing new resistant variety is difficult due to complexity of yellow rust and continually evolvement of new races. In East Africa the current commercial wheat cultivars including recently released varieties are susceptible to the new races and not possible to grow a profitable yield of wheat without application of fungicides to the private sectors, farmers and government run wheat growers in Ethiopia. To obtained positive net returns, environmental factors, varietal response to rust, efficacy and timing of fungicide application, cost of fungicide, wheat price and agricultural practices should be taken into consideration. Our results and similar studies suggested that application of fungicide specifically diazoles like *Epoxiconazole + Thiophanate-methyl*, at hotspot areas to yellow rust province on sensitive(susceptible) and semi sensitive(intermediate) cultivar is beneficial and can constitute a significant part of stripe rust managing program. So research suggested to wheat growers to use effective fungicides on susceptible and intermediate varieties in the golden time of stripe rust occurrence, able to control wheat yellow rust to yield and net return increase.

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