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Effects of Different Application Rates of Pesticides and Chemical Fertilizers on Wheat Stripe Rust and Wheat Yield

Chengdong WANG[1], Xi CHEN[1], Lei LU[2]

1. Bijie Economic Crop Workstation, Bijie 551700, China; 2. Bijie Agricultural Product Quality Inspection and Testing Center, Bijie 551700, China

Abstract [**Objectives**] The paper was to investigate the effects of different application rates of pesticides and fertilizers on wheat stripe rust and wheat yield. [**Methods**] Two-factor split block design was adopted. [**Results**] Different application rates of pesticides and chemical fertilizers would affect the incidence of wheat stripe rust, and further affect the yield of wheat. Triadimefon had no significant effect on wheat yield, and potassium sulfate compound fertilizer had significant effect on wheat yield, while their interaction had no significant effect on wheat yield. There were significant differences in wheat yield among the 15 treatment combinations, which may be due to the fact that the application rate of potassium sulfate compound fertilizer had extremely significant effect on wheat yield. [**Conclusions**] Under the wheat/green manure/maize zonal rotation system in Bijie, the sowing width of wheat is guaranteed to be 0.5 m under the 1.65 m zonal cropping system, and the sowing rate of wheat is arranged according to the basic seedling of 1.2 million plants/hm^2. In the early stage of wheat stripe rust, 15% triadimefon WP can be sprayed evenly at the dose of 1 050 g/hm^2 by a high-power sprayer in a sunny day.

Key words Wheat; Qianmai 22; Triadimefon; Potassium sulfate compound fertilizer; Disease index; Yield

1 Introduction

Wheat is a major grain crop in Bijie City. Qianmai 22 is a new wheat variety selected and bred by Guizhou Drought Grain Sorghum Research Institute, and it has been popularized in large area in Bijie City. However, due to the severe incidence of wheat stripe rust in recent years, there is a lack of supporting cultivation and management technology of pesticide and fertilizer application in production. The test was conducted in 2021 – 2022. With Qianmai 22 as the experimental material, this paper studied the effects of different doses of triadimefon and different amounts of potassium sulfate compound fertilizer on wheat stripe rust and wheat yield, aiming to extract the supporting cultivation and management technical basis of pesticide and fertilizer application for stable and high yield of wheat in Bijie City.

2 Materials and methods

2.1 General situation of experimental site The experiment was conducted in the contracted land of Wang Jing, a farmer of Pingdi Group, Datian Community, Liuquhe Town, Hezhang County, at an altitude of 1 610 m. The field was featured by sandy soil and medium fertility, with corn as the preceding crop.

2.2 Materials The wheat variety Qianmai 22 was provided by Guizhou Drought Grain Sorghum Research Institute. The fertilizer was potassium sulfate compound fertilizer ($N/P_2O_5/K_2O$ = 15/15/15), and the pesticide was 15% triadimefon WP, all purchased from Hezhang Yanzi Agricultural Materials Co., Ltd.

2.3 Experimental design A two-factor split block design was adopted in the experiment. Three spraying doses of the main treatment pesticide (N) were designed as follows: N1 = 300 g/hm^2, N2 = 1 050 g/hm^2, N3 = 1 800 g/hm^2; five basic application levels of the secondary treatment potassium sulfate compound fertilizer (H) were set as follows: H1 = 105 kg/hm^2, H2 = 180 kg/hm^2, H3 = 255 kg/hm^2, H4 = 330 kg/hm^2, H5 = 405 kg/hm^2. There were 15 treatment combinations and 3 repetitions. All plots were randomly arranged, with a total of 45 plots. The plot was 4.5 m long and 3.3 m wide, covering an area of 14.85 m^2. An interval of 0.5 m was retained between repetitions and in the surrounding. The green manure planting belt will be planted with 2 rows of corn in the following year.

2.4 Experimental process Wheat seeds were sown on October 28, 2021. According to the basic traits of Qianmai 22 (germination rate 85%, 1 000-grain weight 45 g, seedling emergence rate 80%), the seeding rate of wheat was calculated at the basic seedlings of 1.2 million plants/hm^2, and quantitative seeds were broadcasted evenly to each plot. When sowing wheat, potassium sulfate compound fertilizer was applied quantitatively to the plots as the base fertilizer according to the amount of each treatment. In the early stage of wheat stripe rust, high-power sprayer was used to spray according to the dose of each treatment on February 23, 2022. On May 3, 2022 (milk ripe stage), 180 apical leaves were randomly selected from each plot to grade wheat stripe rust. Wheat was harvested on May 30, 2022, and 10 panicles were randomly selected from each plot to count the grain number per panicle. After harvesting and threshing and weighing in each plot, 1 kg of seeds were weighed and loaded into yarn mesh bags. After drying, the dry weight of seeds was weighed and converted into drying rate, and 1 000-grain weight was measured. In the course of the experiment, the basic seedlings, total number of stem tillers and effective panicles in a fixed band of wheat were also investigated in each plot.

2.5 Experimental records The experimental items recorded included wheat growth dynamics, incidence of stripe rust disease, theoretical yield, actual yield and other related traits.

3 Results and analysis

3.1 Growth dynamics of wheat As shown in Table 1, the

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E-mail: 583152273@qq.com

number of basic seedlings ranged from 1 119 000 to 1 168 500 plants/hm^2; N3H5 had the lowest basic seedlings of 1 119 900 plants/hm^2, while N2H2 and N2H3 had the highest basic seedlings of 1 168 500 plants/hm^2. The total number of stem tillers ranged from 2 689 500 to 2 824 500 tillers/hm^2; N3H5 had the lowest number of 2 689 500 tillers/hm^2, and N2H2 had the highest number of 2 824 500 tillers/hm^2. The number of effective panicles ranged from 1 518 000 to 1 842 000 panicles/hm^2; N1H5 had the lowest number of 1 518 000 panicles/hm^2, while N2H2 had the highest number of 1 842 000 panicles/hm^2. The tiller number ranged from 1 542 000 to 1 657 500 tillers/hm^2; N1H4 had the lowest number of 1 542 000 tillers/hm^2, while N1H2 had the highest number of 1 657 500 tillers/hm^2. The tillering rate ranged from 133.83% to 142.45%; N1H5 had the lowest tillering rate of 133.83%, while N1H2 had the highest tillering rate of 142.45%. The panicle bearing tiller rate ranged from 24.23% to 41.67%; N1H1 had the lowest rate of 24.23%, while N2H2 had the highest rate of 41.67%.

Table 1 Investigation of wheat growth dynamics ($n=3$)

Treatment combination	Number of basic seedlings $\times 10^4$ plants/hm^2	Number of stem tillers $\times 10^4$ tillers/hm^2	Number of effective panicles $\times 10^4$ panicles /hm^2	Tiller number $\times 10^4$ tillers/hm^2	Tillering rate // %	Panicle bearing tiller rate // %
N1H1	115.65	272.55	153.75	156.90	135.56	24.23
N1H2	116.40	282.15	180.45	165.75	142.45	38.63
N1H3	115.65	272.70	177.30	157.05	135.84	39.28
N1H4	115.35	270.15	163.65	154.80	134.28	31.24
N1H5	115.35	269.85	151.80	154.35	133.83	23.56
N2H1	115.05	275.10	154.95	160.20	139.30	24.96
N2H2	116.85	282.45	184.20	165.45	141.53	41.67
N2H3	116.85	277.35	181.95	160.50	137.41	40.57
N2H4	115.65	272.25	174.45	156.45	135.25	37.54
N2H5	114.90	269.25	168.60	154.20	134.19	34.83
N3H1	112.65	270.75	157.65	158.10	140.31	28.50
N3H2	117.00	282.30	183.30	165.30	141.27	40.08
N3H3	114.75	275.40	178.65	160.65	140.02	39.85
N3H4	113.25	271.20	174.75	157.95	139.32	38.89
N3H5	111.90	268.95	165.45	157.05	140.39	34.09

3.2 Effects of different application rates of pesticides and fertilizers on the incidence of wheat stripe rust As shown in Table 2, in the case of a major outbreak of wheat stripe rust in 2022, the incidence of wheat stripe rust in each treatment combination was as follows: the prevalence rate was 97.78% in N2H1 and N3H2, and 98.89% in N2H4 and N2H5, while that in the remaining treatment combinations was 100%. The severity ranged from 5.14% to 12.49%; the severity in N1H3 was the highest and that in N2H2 was the lowest. The disease index ranged from 15.08 to 22.92, with N3H1 being the highest and N2H2 the lowest. According to the disease index of wheat stripe rust, N2H2 (disease index 15.08) had the mildest incidence, followed by N1H2 (disease index 15.17) and N3H2 (disease index 16.17).

Table 2 Investigation and statistics of the incidence of wheat stripe rust

Treatment combination	Level // %									Incidence				
	0	1	5	10	20	40	60	80	100	Number of leaves investigated individual	Number of diseased leaves individual	Prevalence rate // %	Severity // %	Disease index
N1H1	0	0	58	50	36	24	12	0	0	180	180	100	8.86	20.42
N1H2	0	54	52	32	18	16	8	0	0	180	180	100	5.87	15.17
N1H3	0	38	28	28	22	26	24	14	0	180	180	100	12.49	19.33
N1H4	0	22	32	44	34	30	18	0	0	180	180	100	9.95	19.75
N1H5	0	12	22	52	56	26	12	0	0	180	180	100	9.78	22.08
N2H1	4	30	46	38	44	4	4	10	0	180	176	97.78	7.56	18.58
N2H2	0	62	50	34	14	14	4	2	0	180	180	100	5.14	15.08
N2H3	0	38	48	38	36	8	6	4	2	180	180	100	7.16	17.75
N2H4	2	22	40	36	26	30	8	16	0	180	178	98.89	11.28	21.50
N2H5	2	22	40	36	26	30	8	16	0	180	178	98.89	11.28	21.50
N3H1	0	14	40	44	32	30	10	10	0	180	180	100	10.82	22.92
N3H2	4	60	30	44	30	6	6	0	0	180	176	97.78	5.26	16.17
N3H3	0	46	46	56	18	8	6	0	0	180	180	100	5.66	16.92
N3H4	0	50	26	38	34	28	4	0	0	180	180	100	7.22	18.83
N3H5	0	18	46	46	22	34	10	4	0	180	180	100	9.52	21.17

3.3 Effects of different application rates of pesticides and fertilizers on wheat yield

3.3.1 Effects on theoretical yield of wheat. As shown in Table 3, the theoretical yield of wheat ranged from 2 808.90 to 3 633.90 kg/hm^2. N2H2 had the highest theoretical yield of 3 633.90 kg/hm^2, followed by N3H2 (3 613.50 kg/hm^2) and N1H2 (3 610.95 kg/hm^2).

3.3.2 Effect on actual yield of wheat. As shown in Table 4, the actual yield ranged from 2 708.42 to 3 436.06 kg/hm^2. N2H2 had the highest actual yield (3 436.06 g/hm^2), followed by N1H2 (3 415.85 kg/hm^2) and N3H2 (3 348.47 kg/hm^2). ANOVA results demonstrated that there was no significant difference among different groups ($F = 3.63 < F_{0.05} = 4.46$), proving that the experiment had small error and the experimental results were reliable. As for pesticides, $F = 3.29 < F_{0.05} = 4.46$, indicating that the three treatments of pesticides had no significant difference in wheat yield. As for fertilizers, $F = 280.28 > F_{0.01} = 4.22$, indicating that the five fertilizer treatments had significant differences in wheat yield. As for pesticide × fertilizer, $F = 1.886 < F_{0.05} = 2.36$, indicating that the interaction of pesticides and fertilizers had no significant effect on wheat yield. The significance analysis showed that N2 was the best pesticide, which had no significant difference with N1 and N3; H2 was the best fertilizer, which was significantly better than H3, H4, H5 and H1; H3 fertilizer was the second best, and it was significantly better than H4, H5 and H1; H4 fertilizer was superior to H5 and H1; H5 fertilizer was better than H1, but there was no significant difference.

Table 3 Theoretical yield of wheat ($n = 3$)

Treatment combination	Number of effective panicles // ×10^4 panicles/667 m^2	Grain number per panicle grain/panicle	1 000-grain weight // g	Theoretical yield kg/hm^2	Rank
N1H1	10.25	43.1	43.1	2 851.65	14
N1H2	12.03	44.9	44.6	3 610.95	3
N1H3	11.82	43.7	43.5	3 370.35	6
N1H4	10.91	43.2	43.2	3 056.40	9
N1H5	10.12	43.0	43.0	2 808.90	15
N2H1	10.33	43.0	43.4	2 893.95	13
N2H2	12.28	44.6	44.3	3 633.90	1
N2H3	12.13	43.6	43.5	3 456.15	4
N2H4	11.63	42.6	42.7	3 178.20	7
N2H5	11.24	42.3	42.4	3 023.85	10
N3H1	10.51	42.9	43.0	2 905.95	12
N3H2	12.22	44.2	44.6	3 613.50	2
N3H3	11.91	44.1	43.5	3 432.30	5
N3H4	11.65	42.9	42.9	3 218.55	8
N3H5	11.03	42.3	42.3	2 960.40	11

Table 4 Actual yield of wheat ($n = 3$)

Treatment combination	Plot yield // kg				Equivalent yield // kg/hm^2	Significance of difference	
	I	II	III	Average		0.05	0.01
N1H1	4.10	4.17	4.11	4.13	2 762.32	h	EF
N1H2	5.07	5.02	5.06	5.05	3 415.85	b	A
N1H3	4.69	4.6	4.64	4.64	3 159.83	d	BC
N1H4	4.24	4.33	4.33	4.30	2 856.65	fg	DE
N1H5	4.02	4.11	4.09	4.07	2 708.42	h	F
N2H1	4.16	4.12	4.09	4.12	2 802.75	h	EF
N2H2	5.10	5.33	5.15	5.19	3 436.06	a	A
N2H3	4.65	5.01	4.70	4.79	3 132.88	c	B
N2H4	4.26	4.48	4.44	4.39	2 870.12	ef	D
N2H5	4.03	4.18	4.28	4.16	2 715.16	gh	EF
N3H1	4.04	4.12	4.03	4.06	2 721.90	h	F
N3H2	4.97	4.95	5.09	5.00	3 348.47	b	A
N3H3	4.65	4.75	4.89	4.76	3 132.88	cd	B
N3H4	4.34	4.51	4.51	4.45	2 924.02	e	CD
N3H5	4.05	4.12	4.04	4.07	2 728.64	h	F

4 Conclusions and discussion

(i) The experimental results showed that in the case of severe incidence of wheat stripe rust, the spraying dose of pesticide N and the base application rate of fertilizer H had different effects on the incidence of wheat stripe rust. In the treatment combination of pesticide × fertilizer (NH), N2H2 had the lightest incidence, followed by N1H2 and N3H2.

(ii) The results showed that there was no significant difference in wheat yield among pesticides, pesticides × fertilizers, or different groups, but there were extremely significant differences in wheat yield among fertilizers. The extremely significant differences in wheat yield among 15 pesticide and fertilizer (NH) treatment combinations were caused by the application rate of fertilizers. N2H2 (3 436.06 g/hm^2) had higher yield than N1H2 (3 415.85 kg/hm^2) and N3H2 (3 348.47 kg/hm^2), but there was no significant difference between N1H2 and N3H2. The wheat yields of N2H2, N1H2 and N3H2 were significantly higher than those of the other 9 treatment combinations. (To page 15)

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(iii) Under the wheat/green manure/maize zonal rotation system in Bijie, the sowing width of wheat should be guaranteed to be 0.5 m under the 1.65 m zonal cropping system, and the sowing rate of wheat should be arranged according to the basic seedling of 1.2 million plants/hm^2. It is recommended to apply fertilizer precisely, and 180 kg/hm^2 potassium sulfate compound fertilizer ($N/P_2O_5/K_2O$ = 15/15/15) can be selected as the standard to apply the base fertilizer when sowing wheat. In the early stage of wheat stripe rust, 15% triadimefon WP can be sprayed evenly at the dose of 1 050 g/hm^2 by a high-power sprayer in a sunny day.

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