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EFFECT OF SALICYLIC ACID AND OXALIC ACID ON THE RESISTANCE TO WHEAT RUST DISEASE (*BASIDIOMYCETES, UREDINALES, PUCCINIA*)

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Abstract

Wheat rust pathogens belong to genus *Puccinia*, family *Pucciniaceae*, order *Uredinales* and class *Basidiomycetes.* During epiphytosis, the fungus causes significant damage to crops, disrupts assimilation processes in plants and reduces photosynthesis. Spring soft wheat Arai variety was tested for rust resistance. In this study, we used different concentrations of salicylic acid and oxalic acid. We treated the wheat seeds and seedlings with different concentrated acids. In the context of the artificial epidemic, during the rooting, dulling and germination stages of wheat development, we were infected with spores of yellow rust (*Puccinia striiformis f.sp. tritici*), brown rust (*Ruccinia tritici Erikss*) and stem rust (*Puccinia graminis Pers. F. Sp. Tritici*). We tested the effect of different concentrations of salicylic acid and oxalic acid on wheat rust disease.. The results of the study showed that the seeds were found to be moderately resistant to yellow rust of wheat treated with concentrated acid 0.25 mM SA + 0.1 mM OA (1) and 0.25 mM SA + 0.2 mM OA (3). 0.5 mM SA + 0.2 mM OA (2) was immunocompromised to brown rust when treated with concentrated acid spray. In organic agriculture, the chemical control of deafness in wheat leads to environmental pollution, in addition is not economically viable and a realistic way to combat it. Therefore, we need to look for effective ways for disease control. The data obtained in the study allow to fight against yellow rust and brown rust of wheat.

Keywords: wheat; pathogen; leaf rust; Resistant; yellow rust; population; stem rust.

Introduction

Central Asia, including Kazakhstan, is an important player in regional and global food security, producing most of the crop sold in the region, and the total area where wheat grows in Kazakhstan is more than 85% of total crop production[1]. One of the biggest challenges facing the world today is to match the rapidly growing demand for food with the increase in production, while ensuring that this production is carried out within the limits of sustainable and limited agricultural land. According to the FAO, the population will reach 9 billion by 2050[2]. Many organisms, such as bacteria, oomycetes, fungi, viruses and nematodes, can damage crops. Various fungal infections, which cause many diseases, decrease the yield. For example, infection of several fungal pathogens results in necrotic lesions on leaves and stems, which leads to leaf aging and reduced grain size; These pathogens include rust infections caused by *Puccinia* species [2-5].

The most common method of controlling plant diseases is the regular application of chemical pesticides to plants in order to eliminate or limit the phenotypes of the disease. However, long-term use of chemical pesticides are has side effects, it is becoming clear day by day. For example, many pesticides can cause acute and chronic human poisoning. They also contaminate beneficial pollinating insects, soil and water systems, and cause serious damage to ecosystems by affecting non-target organisms [6-8].

As a result of the direct and indirect effects of the applying of chemical pesticides to control plant diseases, warned the necessity of re-focusing on finding alternative ways to control pathogens. Crop rotation has played an important role in the management of phytosanitary conditions, which is aimed at preventing the accumulation of soil-specific pathogens in some families of plants by changing the host [10, 11]. However, while crop rotation is not economically effective, so that crop rotation is not always an economically suitable strategy for farmers . In addition to crop rotation, the introduction of genes of resistance to plant varieties (eg, R genes) into modern varieties through breeding programs [12-14]. However, in some cases this can be difficult, and in some cultures there are few or no resistant varieties [12]. In addition, pathogens can quickly overcome the resistance mechanisms of the host plant, especially if the resistance is encoded by a single gene. For example, rice varieties resistant to *M. oryzae* will be ineffective in 2-3 years [6].

Plants have developed several layers of protective reactions against the attack of microorganisms that threaten their survival. One of these responses is systemic acquired resistance, which is induced by certain pathogens or by abiotic, physical, or chemical agents called elicitors[15]. can be an additional way of protection. Chemical activation of plant disease resistance can be an additional way for farmers protecting from plant disease damage.

Elicitors are chemical compounds that activate and / or enhance the plant defense mechanisms, by affecting physiological processes, crop growth and productivity of plants [16, 17]. Furthermore, elicitors affect the metabolic activity of plants by producing phenolic compounds and regulating the activity of antioxidant enzymes, as a result the plant growth are improved[18-20].

Inducers do not directly kill pathogenic microorganisms, but promote plant growth and strengthen the plant's immune system, resulting in resistance to a wide range of diseases and stress [21].

The most commonly used chemical inducers are salicylic acid (SA) and oxalic acid (OA), which mimic the systemic effects of local infection [22, 23].

Exogenous use of salicylic acid and other chemicals, including: polyacrylic acid, acetyl salicylic acid, 2, 6-dichloroisonicotinic acid, methyl salicylate, jasmine acid and jasmine methyl ester, benzodiadiazole derivatives, DL-B-aminobutyric acid and our acid affects the accumulation of proteins and the reduction of several different diseases in many cultures [25].

Treatment of tomato seeds with 1 mM SA solution protects tomato plants from bacterial wilting in greenhouse and field conditions 26]. Spraying wheat plants with 200 mg/l concentrations of oxalic acid induced significant increases in shoot length, number of tillers/plant and dry weight of shoot [27]. Oxalic acid (1 mM) when applied as foliar spray to rice plants induced resistance to challenge infection with *R. solani*[28].

The purpose of the research is studying the effects of chemical inducers, namely,salicylic acid and oxalic acid, on the development and spread of rust disease of wheat.

Materials and methods

The study was conducted in the experimental field of the Kazakh Research Institute of Agriculture and Plant Growing, Almalybak village, Almaty region. Experiment was conducted in randomized complete block design. The research objects are spring wheat Arai, Salicylic acid (SA), oxalic acid (OA). Local populations of yellow rust (*Puccinia striiformis f.sp. tritici*), leaf rust (*Ruccinia tritici Erikss*) and stem rust (*Puccinia graminis Pers. F. Sp. Tritici*) were used as infection material. Wheat seeds and leaves were processed at different concentrations of salicylic acid (SA) and oxalic acid (OA) (Enbridge PharmTech, China). While the SA levels were 0 (control), 0.25 and 0.5 mM, the OA levels were 0 (control), 0.1 and 0.2 mM, respectively which applied via foliar fertilization vs. seed treatment. Wheat seeds were washed twice with sterile distilled water. Seed treatment: seeds were soaked in acid solution for 6 hours then grown in the field; foliar treatment: acid solutions were sprayed on 11-day-old seedlings, and after 24 hours *Puccinia recondita f. sp. tritici, Puccinia striiformis f. sp. tritici,* and *Puccinia graminis f. sp.* *Urodinospores* of *Tritici* pathogens were soaked in a 0.01% solution of Twin 80 and sprayed on wheat germ. R.A. Phytopathological assessment of rust disease was performed by McIntosh et al., 1995 [29]. According to this method, "R"- Resistant, "MR"- Moderately Resistant, "MS"- Moderately Susceptible, "S"- Susceptible.

Results

We studied the effects of salicylic acid (SA) and oxalic acid (OA) on rust. Wheat was infected with yellow rust during the growing stage, leaf and stem rust during the maturation stage(artificially). In the first stage of the study, the seeds and seedlings were treated with different concentrations of acid. The assessment of rust was conducted 3 times.

The following two tables provide a rust disease assessment of the Arai variety (yellow rust, leaf rust and stem rust) (Table – 1,2).

1 – Table Indications for rust infection when wheat seeds were treated with different concentrations of acids.

Acid concentration	Phytopathological assessment of the disease (Seed treatment)								
	Yellow rust			Leaf rust			Stem rust		
	I	II	III	I	II	III	I	II	III
0,25 мM SA	30MS	40S	50S	30MS	60MS	80S	0	20MS	30MS
0,5 мM SA	5MR	10MR	10MR	30MS	50S	70S	0	30MS	70S
0,1 мM OA	0	5MR	10MR	30MS	70S	80S	5MR	70S	80S
0,2 мM OA	5MR	5MR	10MR	30MS	60S	70S	5MR	30MS	70S
0,25 мM SA+0.1 мM OA	0	5MR	10MR	70S	70S	80S	20MS	30MS	70S
0,25 мM SA+0.2 мM OA	0	5MR	10MR	50S	80S	80S	30MS	50MS	70S
0,5 мM SA+0.1 мM OA	5MR	20MS	20MS	70S	70S	70S	50MS	50MS	50MS
0,5 мM SA+0.2 мM OA	20MS	30MS	30MS	40MS	70S	90S	20MS	20MS	40MS
Control	50MS	50S	70S	30MS	70S	90S	5MR	40MS	50S

When seeds were treated with salicylic acid (0.25 mM SA), spring soft wheat Arai was susceptible to yellow rust and leaf rust with 50S, 80S, respectively,and to stem rust was moderately susceptible with 30MS, When seeds treated with salicylic acid 0.5 mM and oxalic acid 0.1 mM OA and 0.2 mM OA Arai showed as moderately resistant to yellow rust with scale10MR, meanwhile, susceptible to leaf rust and stem rust between 70-80S. Seeds treated with salicylic acid and oxalic acid at a concentration 0.25 mM SA + 0.1 mM OA and 0.25 mM SA + 0.2 mM OA, respectively , were moderately resistant to wheat yellow rust with10MR. Brown and stem rust was found to be susceptible between 70-80S.

In the next stage of the study, 20 days after sowing, we sprayed seedlings with different concentrations of acid on the wheat leaves and infected with spores of yellow, leaf and steam rust during period of the tillering, booting and earing.

The leaves of the Arai variety were sprayed with different concentrations of acids. Based on the results in the table, we conclude that most of the samples are susceptible to rust disesae.

2– Table Indications for rust infection of wheat leaves when treated with different concentrations of acids.

Acid concentration	Phytopathological assessment of the disease (Foliar spray)								
	Yellow rust			Leaf rust			Stem rust		
	I	II	III	I	II	III	I	II	III
0,25 мM SA	0	0	0	70S	80S	80S	70S	80S	80S
0,5 мM SA	0	0	0	50MS	60S	70S	50MS	60S	70S
0,1 мM OA	0	0	0	50MS	70S	70S	60S	70S	70S
0,2 мM OA	0	0	0	70S	70S	80S	70S	70S	70S
0,25 мM SA+0.1 мM OA	0	0	0	70S	70S	80S	60S	70S	70S
0,25 мM SA+0.2 мM OA	0	0	0	50MS	50S	60S	50MS	50MS	50MS
0,5 мM SA+0.1 мM OA	0	0	0	70S	70S	80S	70S	70S	80S
0,5 мM SA+0.2 мM OA	0	0	0	0	0	50MS	30MS	50MS	50S
Control	0	0	0	70S	70S	90S	90S	90S	90S

There were no signs of yellow rust among wheat seedlings which treated with acids, the incidence rate was "0". In addition, the control variant was not infected. Therefore, this result reveals the inaccuracy of the experiment, it can be concluded that in the conditions of artificial infection environment is not properly infected with yellow rust spores. Wheat treated with 0.25 mM SA acid were susceptible to leaf rust and steam rust at 80S. Meanwhile wheat treated with 0.5 mM SA and 0.1 mM OA acids showed susceptible to leaf rust and stem rust at scale 70S. Wheat treated with 0.2 mM OA and 0.25 mM SA + 0.1 mM OA was susceptible to leaf rust with 80S and stem rust with 70S. Wheat treated with 0.25 mM SA + 0.2 mM OA showed intolerance to leaf rust with 60S. The subject was found to be moderately susceptible to stem rust, the incidence was 50MS. Wheat treated with 0.5 mM SA + 0.1 mM OA was susceptible to leaf rust and steam rust between 70-80S. Wheat treated with 0.5 mM SA + 0.2 mM OA (2) was found to be suseptible to stem rust with 50S.

Discussion

Kazakhstan is producer of high quality wheat in the world. The main problem in spring wheat production are fungal diseases. Rust is the most common, most harmful disease of cereals [30.31,32]. Chemical control is ineffective for rust disease, The resistance of brown rust populations of Almaty region to wheat varieties grown in Kazakhstan has been tested, but the effect of chemical inducers on the development and spread of the disease has not been studied [33,34]. Several studies have reported that SA application reduces bacterial wilt in tomato plants and suppressed *Botrytis cinerea* infections lesions on *Arabidopsis thaliana* under both greenhouse and field conditions [35]. Foliar fertilization of 1 mM OA significantly induced resistance of rice plants to infections associated with *R. solani[36]*. In our study, Arai was moderately susceptible to yellow rust and stem rust with 20-50MS, while susceptible to leaf rust with scale 70-90S at 0.5 mM SA + 0.1 mM OA and 0.5 mM SA + 0.2 mM OA concentration in seed treatment, meanwhile, signs of leaf rust were not observed on the leaves of wheat, thus, they were immune to the leaf rust disease. Therefore, it can be concluded that wheat are resistant to leaf rust when leaves treated with 0.5 mM SA + 0.2 mM OA.

Conclusions

In conclusion, spring soft wheat Arai was considered to be immune to leaf rust when foliar sprayed with 0.5 mM SA + 0.2 mM OA. samples which seeds were soaked with 0.25 mM SA + 0.1 mM OA and 0.25 mM SA + 0.2 mM OA were found to be moderately resistant to yellow rust.

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САЛИЦИЛ ҚЫШҚЫЛЫ МЕН ҚЫМЫЗДЫҚ ҚЫШҚЫЛЫНЫҢ БИДАЙДЫҢ ТАТ (BASIDIOMYCETES, UREDINALES, PUCCINIA) АУРУЛАРЫНА ТӨЗІМДІЛІГІНЕ ӘСЕРІ

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Түйін

Дәнді дақылдардың тат ауруларының қоздырғыштары *Uredinales* қатарының Базидиомицеттер (*Basidiomycetes*) класына жататын *Puccinia spp*. Саңырауқұлағы эпифитотия кезінде егін түсіміне көп шығын келтіреді, өсімдіктердегі ассимилияциялық процестерді бұзып, фотосинтезді азайтады. Жаздық жұмсақ бидай Арай сортының тат ауруларына төзімділігін сыналды. Зерттеу жұмысында біз Салицил қышқылы мен қымыздық қышқылының әртүрлі концентрациясын қолдандық. Әртүрлі концентрлы қышқымен бидай себерден бұрын тқымды, бидай өсіп шыққаннан кейін жапырақтарын өңдедік. Жасанды індет аясында бидай даму кезеңдерінің түптену, түтіктену және масақтану кезеңдерінде тат ауруының сары тат *(Puccinia striiformis f.sp. tritici)*, қоңыр тат *(Puccinia tritici Erikss*) және сабақты тат *(Puccinia graminis*

Pers. f. sp. tritici) ауруының спорасымен залалдадық. Салицил қышқылы мен қымыздық қышқылының әр түрлі концентрациясын қолдана отырып тат ауруларына әсерін сынадық. Зерттеу нәтижесі көрсеткендей Тұқымды 0,25 мМ SA+0.1 мМ OA(1) және 0,25 мМ SA+0.2 мМ OA(3) концентрлі қышқылмен өңделген бидайдың сары тат ауруымен орташа төзімді деп анықталды. 0,5 мМ SA+0.2 мМ OA(2) концентрлі қышқылды жапыраққа шашу әдісімен өңделген жағдайда қоңыр татқа иммунды деп ерекшеленді. Органикалық ауылшаруашықта бидайдың саңырау құлақ ауруларымен химиялық жолмен күресу қоршаған ортаның ластануна алып келеді, экономикалық жағынан тимсіз әрі күресудің нақты жолы емес. Сондықтан аурумен күресудің тимді жолдарын іздестіруміз керек. Зерттеу жұмысында алынған мәліметтер бидайдың сары тат және қоңыр тат ауруымен күресуге мүмкіндік береді.

Кілт сөздер: бидай; патоген; қоңыр тат; төзімді; сары тат; популяция; сабақты тат.

ВЛИЯНИЕ САЛИЦИЛОВОЙ И ЩАВЕЛЕВОЙ КИСЛОТ НА УСТОЙЧИВОСТЬ ПШЕНИЦЫ К РЖАВЧИНЕ (*BASIDIOMYCETES, UREDINALES, PUCCINIA*)

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Аннотация

Возбудителями ржавчинных болезней злаков являются Puccinia spp, относящиеся к классу Basidiomycetes рода Uredinales. При эпифитозе гриб наносит значительный ущерб сельскохозяйственным культурам, нарушает ассимиляционные процессы в растениях и снижает фотосинтез. Испытан на устойчивость к ржавчине сорт яровой мягкой пшеницы Арай. В исследовании использовали различные концентрации салициловой и щавелевой кислот. Обрабатывали пшеницу различными концентрированными кислотами перед посевом и после появления всходов. В условиях искусственной эпидемии на стадиях укоренения, притупления и прорастания пшеницы нас заражали спорами желтой ржавчины (Puccinia striiformis f.sp. tritici), бурой ржавчины (Ruccinia tritici Erikss) и стеблевой ржавчины (Puccinia tritici Erikss). graminis (перс. F. Sp. Tritici). Мы проверили влияние на ржавчину, используя различные концентрации салициловой кислоты и щавелевой кислоты. Результаты исследования показали, что семена оказались умеренно устойчивыми к желтой ржавчине пшеницы, обработанной концентрированной кислотой 0,25 мМ СК + 0,1 мМ ОА (1) и 0,25 мМ СК + 0,2 мМ ОА (3). 0,5 мМ СК + 0,2 мМ ОА (2) приводили к ослаблению иммунитета к бурой ржавчине при обработке спреем концентрированной кислоты. В органическом сельском хозяйстве химическая борьба с глухотой пшеницы приводит к загрязнению окружающей среды, экономически нецелесообразна и не является реальным способом борьбы с ней. Поэтому нужно искать эффективные способы борьбы с болезнью. Данные, полученные в ходе исследования, позволяют вести борьбу с желтой и бурой ржавчиной пшеницы.

Ключевые слова: пшеница; возбудитель; бурая ржавчина; устойчивый; желтая ржавчина; популяция; стеблевая ржавчина.