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RESEARCH ARTICLE

The Effect of Wheat Mixtures on the Powdery Mildew Disease and Some Yield Components

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Abstract

Mixtures composed of five wheat cultivars, Jingshuang 16, Jing 411, Jingdong 8, Lunxuan 987, and Baofeng 104, with different levels of resistance against powdery mildew were tested for their potential containment of the disease development in the field and for the influence on grain yield and the content of crude protein in the years 2007 and 2010. The plots were inoculated artificially with mixed isolates collected in the fields and propagated in the greenhouse and the disease was scored in 7 d interval during the two growing seasons. It was indicated that certain combinations, e.g., Jingdong 8: Lunxuan 987, Jingdong 8:Baofeng 104, and Jing 411:Jingdong 8:Baofeng 104, showed positive efficacy on the mildew. The cultivar combinations tested in 2007 showed increase of grain yield, while most of the combinations tested in 2010 did not show the increase. The differences of the increases or decreases were not statistically significant except combinations Jing 411:Jingdong 8:Baofeng104, Jingshuang16:Jingdong8:Lunxuang 987 and Jingshuang 16:Jingdong 8:Lunxuan 987: Baofeng 104, which showed the decrease of the grain yield. The mixtures did not show influence on the content of crude protein in grain. More cultivar combinations need to be tested.

Key words: wheat powdery mildew, cultivar mixture, AUDPC, yield, crude protein

INTRODUCTION

There has been over 60 years for the studies on the use of intra-species diversity against plant diseases (Mundt 2002; Finckh 2008). Many reports display that diversified crop planting reduces the severity of plant diseases and increased crop yield (Mundt *et al*. 1994; Munck 1997; Newton *et al*. 1997; Zhu *et al*. 2000; Bowden *et al*. 2001; Mille *et al*. 2006). Besides, much attention was paid to diversified cropping as well as increasingly concerning about the environment to sustain or even increase crop yield with few fungicide sprays.

Growing cultivar mixture is a way of diversified cropping. There are several advantages for the mixures. Different sources of cultivars can be composed without the use of recurrent parents. It is simpler to handle and the competition among component cultivars is easier to be coordinated. The environmental pressure can be buffered and the component cultivars can be selected directly from existing cultivars (Wolfe and Barrett 1980;

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Wolfe 1985; Finckh and Mundt 1992). Hence, the use of mixtures is relatively wider in production.

A number of mechanisms are proposed for the mixtures to reduce the diseases: dilution of inocula, physical barrier and induced resistance (Shen *et al*. 1990; Wolfe 1992; Mew *et al*. 2001; Liu *et al*. 2002). The mixed wheat cultivars can increase the complexity of a pathogen and hence the competition among pathogen populations (Zhou 1997). Researches revealed that the genetic diversity of pathogen population is more abundant when compared to the pure stands (Browning and Frey 1981; Muller *et al*. 1996). The disease was reduced along with the increase of the pathogen diversity (Dileone and Mundt 1994). Other studies displayed that mixtures can control effectively several cereal diseases, such as powdery mildew, rusts and rice blast (Zhu *et al*. 2000; Mundt 2002; Fang *et al*. 2004; Guo *et al*. 2007).

Wheat powdery mildew caused by *Blumeria graminis* (DC) Speer f. sp. *tritici* Emend Marchal has become one of the most important wheat diseases in China due to the extension of cultivars carrying Pm8 derived from rye. The informal data showed that over 90% cultivars estimated carried Pm8 by the end of the 1990s (Yang Z M 1998, personal communication). The occurrence of wheat mildew was 5.9-9.4 million ha in 2001-2006 in China and the estimated grain loss was 260-320 thousand tonnes (http://www.ppq.gov.cn/nongqing_xiaomai.asp). The utilization of resistance is the most economical and effective way of decreasing the loss caused by the disease. However, the existing breeding programmes pay more attention to the use of single or fewer major gene(s). The growing of cultivars carrying a sole resistance gene in large areas causes directional selection in pathogen populations and the virulence that can overcome the cognate resistance gene will increase in frequency. The disease will prevail when the conditions favour the pathogen and cause great loss. For example, wheat powdery mildew prevailed in an area of 12 million ha for two consecutive years in 1990 and 1991. The recorded grain loss was 1 438 and 770 million kg, respectively (Shao and Liu 1996). Although cultivars carrying other effective resistance genes, such as *Pm21*, *Pm4a*, *Pm4b*, *Pm2*, *Pm6*, etc., have been integrated into commercial cultivars in recent 10 years, cultivars carrying Pm8 are still the main genes used in large areas. The prevalence of the disease has been suppressed by spraying triazole fungicides. The resistance to triazoles, esp. triademinal, has been detected for more than 10 years. The risk of new prevalence isolates still exists. The present paper reports the results of the field trial of wheat mixtures in Langfang, Hebei Province, China, when inoculated with mildew pathogen. The control efficacy and the effect of the mixtures on yield and the content of crude protein are discussed.

RESULTS

AUDPC of the disease

Area under disease progress curves (AUDPCs) of 7 treatments were calculated and the expected and the observed values were compared (Table 1). The result indicated that among the 4 mixtures, combination of Baofeng 104:Lunxuan 987 showed positive efficacy, i.e., 61.74%. Other mixtures showed negative control. The variance analysis shows that there was no significant difference between the expected and the observed values for all of the treatments.

The observed and the expected values were compared for the AUDPC. The result was listed in Table 2. The data indicated that 70% of the mixtures showed the smaller AUDPC than the theoretical value. The highest control efficacy was 17.73% and lowest -13.5%.

Table 1 Comparison of the AUDPC in different mixtures in 2007[1)]

Mixture component	AUDPC (observed)	AUDPC (expected)	Relative control (%)
Baofeng 104:Jing 411	264.79 a	209.05 a	-26.67
Baofeng 104:Lunxuan 987	16.88 a	44.12 a	61.74
Lunxuan 987:Jing 411	418.45 a	296.13 a	-41.3
Baofeng 104:Lunxuan 987:Jing 411	295.80 a	252.59 a	-17.11
Jing 411	625.99	-	-
Lunxuan 987	131.57	-	-
Baofeng 104	0.79	-	-

[1)] The data are the mean of three replicates. The letter indicates the significance at 5% between the observed and the expected value. The same as below.