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RESPONSE OF EGYPTIAN WHEAT CULTIVARS TO KERNEL BLACK POINT DISEASE ALONGSIDE GRAIN YIELD

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A B S T R A C T

During two successive growing seasons, survey of kernel black-point disease in seventeen Egyptian wheat cultivars recorded the disease as a rate of infection ranged from 1.75% to 64.07% and as disease indices ranged from 0.29% to 19.48% in mean of both seasons. The most susceptible wheat cultivars were Sakha 8 and Sakha 93 reached 64%, 63% kernel infection, and 17.13%, 19.5% disease index, respectively. The minimum incidence of black-point was observed on the cultivars Sohag 3 (1.75% kernel infection, 0.29% disease index), Beni-Suef 3 (2.67% kernel infection, 0.49% disease index), Giza 165 (3.34% kernel infection, 0.59% disease index) and Beni-Suef 1 (10.09% kernel infection, 2.30% disease index). The bread wheat cultivars (Sakha 8, 61, 69, 93, 94, Gemmiza 5, 7, 9 and 10), cultivated at the Northern Governorates locating in the Nile-Delta were observed as more susceptible to the black-point disease than the durum wheat cultivars (Sids 1, Sohag 3, Beni-Suef 1, 3, Giza 164, 165, 168 and 170) cultivated at the Middle and Southern Governorates of Egypt. The durum wheat cultivars, Sohag 3, Beni-Suef 1, 3, and Giza 165 with the minimum incidence of black-point, may be useful as a germplasm resource for black point resistance.

Keywords: Wheat, Kernel black point, Disease incidence, Cultivar response, Germplasm resource, Grain yield.

INTRODUCTION

Wheat is one of the most important winter cereal crops in Egypt in terms of the planted area and crop production. The area grown in Egypt was estimated by 1.418 million hectares, yielding 8.36 million ton of wheat grains (USDA, 2015). Kernel black-point disease has become one of the most serious problems of common (*Triticum aestivum* L.) and durum (*T. turgidum* L. ssp. *durum* (Desf.) Husn.) wheat, causing great losses in both yield and quality of grains (Bhandari *et al*., 2003 and Fernandez & Conner, 2011).The significance of the disease is that it cause common root rot, seedling blight, leaf spot, head blight and black-point diseases of wheat (Kumar *et al*., 2002).Grain losses due to the disease ranged from 24 to 27% in susceptible cultivars (Bhandari *et al.*, 2003). In addition, toxin contents were recorded in the infected grains (Snijders & Perkowski, 1990; Fernandez & Conner, 2011and Amatulli *et al*., 2013). Black point lowers the quality particularly of the durum wheat grains due to black specks that cannot be separated from semolina and end up in the pasta. Blackened kernels are considered damaged, and less than 2% damaged kernels are required for a grade of US No 1. (Davis & Jackson, 2002).

Kernel black point can be caused by several species of fungi, but usually by *Alternaria alternate, Cochliobolus sativus* and *Fusarium graminearum* (Huguelet & Kiesling, 1973; El-Khalifeh *et al*., 2002; Karwasra *et al*., 2006; Fernandez & Conner, 2011; Pathak & Zaidi, 2013; Srivastava *et al*., 2014 and El-Gremi *et al*., 2016). The fungi from black point cause a darkening of the kernel and a characteristic black area on the germ end of the kernel. Black point is favored by high humidity and rain between flowering and soft dough. High levels of nitrogen fertilization, excessive late season irrigation, and lodging can predispose the crop to black point (Conner *et al*. 1992).

The variability of microbial pathogens leads to different control methods including plant breeding for disease resistance, treating with synthetic chemical pesticides as well as physical processing. Gilbert *et*

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al.(2005) reported that temperatures of 30 and 50 degrees were ineffective in reducing fungus in wheat grains and the temperature of 90ºC killed both fungus and embryo. Fungicide application to protect the seed head during grain fill is usually not economical. Fungicides can be applied only up to 30 to 45 days before harvest, and thus applications during susceptible kernel development stages would infringe on the pre-harvest application interval. When applied at the end of flowering, the fungicides were not consistently effective in reducing black point incidence (Conner & Kuzyk, 1988). Although, plant breeding for disease-resistant varieties of wheat has more constraints due to uncontrollable factors dependent on pathogens itself as well as the ambient environmental conditions (Duveiller & Gilchrist, 1994), but it is considered the most economic and effective means to disease management (Fernandez & Conner, 2011).

The present work mainly aimed to survey the black point naturally infection on Egyptian wheat grains of commercially cultivated cultivars and its impact on grain yield.

MATERIALS AND METHODS

Survey of the kernel black-point disease on Egyptian wheat cultivars: The hand-harvested grains of seventeen wheat cultivars (Sakha 8, Sakha 61, Sakha 69, Sakha 93, Sakha 94; Gemmiza 5, Gemmiza 7, Gemmiza 9, Gemmiza 10; Giza 164, Giza 165, Giza 168, Giza 170; Sids 1; Sohag 3; Beni Suef 1, Beni Suef 3) cultivated at the Northern, Middle and Southern Governorates of Egypt during two successive growing seasons were sampled for kernel black-point investigation. The collected samples were kept in paper envelops and preserved in refrigerator until need. Disease incidence on grains was recorded as kernel infection (%) and disease index according to Raemaekers (1988). Samples of 200 grains-each were classified in 5 categories: no infection (0); black tip (1); embryo area discolored (2); infection over embryo and part of endosperm (4); extensive damage and shriveling (6), and the disease index was calculated using the formula adopted by Raemaekers (1988) as following;

$$Disease\ Index = \frac{(a \times b) + (b \times 1) + (c \times 2) + (d \times 4) + (e \times 6)}{12}$$

Where a, b, c, d and e refer to numbers of the harvested grains of each category, respectively. Each cultivar was represented by three random samples.

Grain yield estimation: This investigation was carried out in order to determine the effect of black point naturally infection on grain yield. Naturally infected plants of the most sensitive cultivar was investigated for grain yield parameters and compared with protected plants grown at the Experimental Farm of Sakha Agricultural Research Station, Agric. Res. Center of Egypt. The protected plants were treated with the liquid fungicide Sumi-8 (5% diniconazol, Sumitomo, Japan) at the concentration of 0.35 ml/L. Disease incidence was recorded as kernel infection (%) and disease index according to Raemaekers (1988) previously mentioned. Each cultivar was represented by three random samples. Three grain yield parameters *i.e.* number and weight of kernels/spike and 1000-kernels weight were used in the investigation. Data were subjected to analysis of variance using IRRI Stat Computer Program. Means were compared using Duncan multiple range test (DMRT) (Duncan, 1954).

RESULTS

Response of Egyptian wheat cultivars to kernel black point: During two successive growing seasons, survey of the black point of wheat grains were successfully achieved on 17 Egyptian cultivars, including 9 breed wheat cultivars cultivated at the Northern Governorates (Kafr-Elshiekh and Garbiya) and 8 durum wheat cultivars cultivated at the Middle and Southern Governorates (Giza, Beni-Suef and Sohag). Data presented in Table (1) showed a range of kernel black point infection levels of 17 surveyed wheat cultivars. The most susceptible wheat cultivars were Sakha 8 and Sakha 93 where the calculated means of both seasons reached 64%, 63% kernel infection, and 17.13%, 19.5% disease index, respectively. On the other hand, the minimum incidence of black-point was observed on the varieties Sohag 3 (1.75% kernel infection, 0.29% disease index), Beni-Suef 3 (2.67% kernel infection, 0.49% disease index), Giza 165 (3.34% kernel infection, 0.59% disease index) and Beni-Suef 1 (10.09% kernel infection, 2.30% disease index). Remaining surveyed wheat cultivars showed moderate range of disease incidence as kernel infection or disease index records.

Generally, the bread wheat cultivars (Sakha 8, 61, 69, 93, 94, Gemmiza 5, 7, 9 and 10) cultivated at the Northern Governorates were observed as more susceptible to the black-point disease than the durum wheat cultivars (Sids 1, Sohag 3, Beni-Suef 1, 3, Giza 164, 165, 168 and 170) cultivated at the Middle and Southern Governorates. This fact was proved throughout the obtained data coincident along with the two growing seasons with significant differences.

Table 1. Response of Egyptian wheat cultivars to kernel black-point disease at different Governorates of Egypt during two successive growing seasons.

Governorate	Cultivar	First season		Second season		Mean of seasons	
		%kernel infection	Disease index	%kernel infection	Disease index	%kernel infection	Disease index
Kafr-Elsheikh	Sakha 8	60.33 g	16.03 g	67.83 i	18.22 h	64.07 h	17.13 g
	Sakha 61	24.33 d	6.36 e	33.50 g	11.64 f	28.92 de	8.84 de
	Sakha 69	37.17 f	8.50 f	55.50 k	12.26 f	46.34 g	10.38 ef
	Sakha 93	56.33 g	17.86 h	69.67 m	21.09 i	63.00 h	19.48 g
	Sakha 94	40.33 f	9.61 f	45.67 i	12.85 f	43.00 g	11.23 ef
Giza	Giza 164	16.00 c	3.97 c	18.83 d	5.65 c	17.42 bc	4.81 bc
	Giza 165	2.17 a	0.35 a	4.50 b	0.83 a	3.34 a	0.59 a
	Giza 168	16.33 c	4.50 cd	19.50 d	5.77 c	17.92 bc	5.14 bc
	Giza 170	35.17 f	9.11 f	46.33 i	14.60 g	40.75 fg	11.86 ef
Gharbia	Gemmiza 5	23.67 d	6.83 e	24.67 e	6.51 cd	24.17 cd	6.67 cd
	Gemmiza 7	27.33 de	5.94 de	33.50 g	7.23 de	28.84 de	6.59 cd
	Gemmiza 9	39.33 f	9.95 f	52.83 j	14.16 g	46.08 g	12.06 f
	Gemmiza 10	27.50 de	8.97 f	30.33 f	11.60 f	28.92 de	10.29 ef
Beni-Suef	Sids 1	29.83 e	5.86 de	36.17 h	8.01 e	33.00 ef	6.94 cd
	Beni-Suef 1	9.67 b	2.42 b	10.50 c	2.18 b	10.09 ab	2.30 ab
	Beni-Suef 3	2.33 a	0.47 a	3.00 ab	0.50 a	2.67 a	0.49 a
Sohag	Sohag 3	1.50 a	0.25 a	2.00 a	0.35 a	1.75 a	0.29 a

Means followed by a common letter in the same column are not significantly different at the 5% level by DMRT.

Grain yield estimation: Data in Table (2) represent three grain-yield parameters (number and weight of kernels/spike and weight of 1000 kernels) of naturally infected wheat (Sakha 93) compared to protected plants. The protected plants showed lower kernel infection (%) and disease index than the infected plants with significant differences. All the grain yield parameters were adversely affected by infection with black point. Naturally infected wheat with black-point significantly decreased the number of kernels/spike to 46.93, the weight of kernels/spike to 1.91g and the weight of 1000 kernels to 40.65g compared with protected plants with fungicide Sumi-8 (66.87%, 3.12 and 46.63g, respectively). As indicator to grain yield loss, the grains resulted from the naturally infected plants significantly reduced the 1000 kernels weight by 12.82% compared to protected plants.

Table 2. The grain-yield parameters alongside disease incidence of the naturally black point infected wheat (Sakha 93) compared to the protected plants with fungicide (Sumi-8).

		Infected plants	Protected plants	Difference
Disease incidence	Kernel infection (%)	69.67	25.17	45.50**
	Disease index	21.09	11.64	9.45**
Grain yield parameter	No. of kernels/spike	46.93	66.87	19.94**
	Kernels weight/spike (g)	1.91	3.12	1.21**
	1000 kernels weight (g)	40.65	46.63	5.98**

SMD = 0.14

DISCUSSION

The importance of the grain black-point disease of wheat is that it cause common root rot, leaf spot, seedling blight, head blight and black-point diseases (Kumar *et al*., 2002). The deleterious effects of the black-point disease of wheat kernels include losses in yield quantity and quality. Grain losses due to the disease ranged from 24 to 27% in susceptible cultivars (Bhandari *et al.,* 2003) and high correlations were found between toxin contents and infected grains (Snijders & Perkowski, 1990; Fernandez & Conner, 2011 and Amatulli *et al*., 2013). Economical management, trade and market price of black-pointed wheat grains showed that the qualitative appearance of the grain, particularly the colour and luster, reduced the market price of wheat by 3.71 to 12.49% in infected seed lots compared with healthy seed lots (Solanki *et al*., 2006).

Variation in response of wheat cultivars to the kernel black-point disease was reported by many authors (Zishan *et al*., 2005, Beniwal *et al.*, 2005 and Wang *et al*., 2006). In the present study, the bread wheat cultivars (Sakha 8, Sakha 61, Sakha 69, Sakha 93, Sakha 94, Gemmiza 5, Gemmiza 7, Gemmiza 9, Gimmiza 10) were more susceptible to the black-point disease than the durum wheat cultivars (Sohag 3, Beni-Suef 1, Beni-Suef 3, Sids 1, Giza 164, Giza 165, Giza 168, Giza 170). The durum wheat cultivars, Sohag 3, Beni-Suef 1, 3, and Giza 165, which exhibited the minimum incidence of black-point, may be useful as a germplasm resource for black point resistance. This fact was in agreement with Davis and Jackson (2002) where they reported some differences in resistance to this disease occur in durum varieties, but no variety is known to be completely resistant to black point. Li*et al.*(2014) found that among the 403 wheat genotypes studied, 37.5% were classified as resistant (151 genotypes), 62.5% were classified as susceptible (252 genotypes) and 36 wheat genotypes were highly resistant to black point disease.

In addition, the environmental conditions, where cultivars are cultivated, play a great role in disease incidence (Beniwal *et al*., 2005 and Jain *et al*., 2012). Results obtained in the present study revealed that survey of the natural infection of the black-point disease on bread wheat cultivars cultivated at the Northern Governorates locating in the Nile Delta had higher percentage of infection and disease index than the durum wheat cultivated at the Middle and the Southern Governorates of Egypt. This may due to the high relative humidity at Northern areas providing ideal conditions for developing high levels of black-point in wheat cultivars. So, unlike results obtained by El-Khalifeh *et al*., 2002) who pointed out that durum wheat was more affected than bread wheat cultivars this could be explained when different environmental conditions of cultivation are considered. Similarly, none of 30 cultivars of durum wheat were resistant to the disease when they were tested at humid area in Italy (Cappelli *et al*., 1993). The average broad-sense heritability for black point disease resistance of 403 wheat genotypes was 58.6%, suggesting that black point was stronger affected by genetic factors compared to environmental factors (Li*et al.*, 2014).

The grain yield parameters are directly related to the severity of black-point disease (Malaker & Main, 2002). This relation was affirmed when number and weight of kernels/spike and weight of 1000 kernels were estimated. In the present study, as the higher black-point disease incidence as the lower crop-yield parameters were estimated. Naturally infected wheat (Sakha 93) with black-point significantly decreased the number of kernels/spike to 46.93, the weight of kernels/spike to 1.91g and the weight of 1000 kernels to 40.65g compared to protected plants. Qualitative parameters, which are out of the scope of this study, were also affected and lowered the price of wheat up to 12.5% (Solanki *et al*., 2006).

CONCLUSION

Our findings on the black point of wheat grains, including determination the response of commercially cultivated cultivars alongside grain yield provided information on germplasm resources for disease-resistant cultivars breeding as well as a reference for determining the suitable sowing environmental conditions in wheat production that are of great benefits for wheat breeders in selection process.

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