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YIELD MAXIMIZATION AND CHOCOLATE SPOT CONTROL OF SOME FABA BEAN CULTIVARS BY ANTIOXIDANTS

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ABSTRACT

Two field experiments were conducted at the experimental farm of Tag El-Ezz Agric. Res. station, Dakahlia during 2004/2005 and 2005/2006 seasons to study the effect of three antioxidant substances (hydroquinone, citric acid and benzoic acid at concentrations of 5, 10 and 15mM) on growth, yield and yield components of three faba bean cultivars (Sakha 1, Giza 3 and Giza 2) as well as the severity of chocolate spot disease caused by *Botrytis fabae*. Generally, the application of benzoic acid at any concentration showed priority and proved to be the best and most effective in reducing disease severity on all tested cultivars. Hydroquinone came in the second order as compared to control treatment. Citric acid showed the lowest effect in this respect.

The foliar application of antioxidants on faba bean cultivars significantly increased growth and yield components which could be summarized as follows: 1) Sakha 1 cultivar surpassed Giza 3 and Giza 2 in number of branches, number of pods and seed weight plant^{-1}, 100-seed weight and seed yield, but Giza 3 cultivar surpassed Sakha 1 and Giza 2 in plant height and straw yield in the two seasons, 2) Citric acid gave the highly significant increase in number of pods & seed weight plant^{-1} and seed yield in both seasons, 3) Using 15mM of antioxidant substances gave higher significant increase in number of branches, pods and seed weight plant^{-1}, 100-seed weight and seed yield compared with control and 4) The interaction between faba bean cultivars and antioxidants had a significant effect on plant height in both seasons and on the 100-seed weight and seed yield in the first and second seasons. Sakha 1 with citric acid was more effective in this respect.

INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the most important food legume crops in many parts of the world. In Egypt, seeds represent a primary source of protein and carbohydrates, which inter in constitution of different popular delicious Egyptian foods. In addition, straw yield is used for animal feeding. Moreover, root nodulation of faba bean improves soil fertility by nitrogen fixation process (Mauromicale *et al.*, 2005). In 2005, the total cultivated area in Egypt reached 261,800 feddan with an average production of 350,000 Metric tonns (FAO, 2005).

Chocolate spot disease caused by *Botrytis fabae* Sardina, is widespread disease, occurring in almost all regions where faba bean is grown (Liang *et al.*, 1993 and Koike, 1998) including Egypt (Mahmoud, 1985 and Abo El-Hawa *et al.*, 1993). The disease results in harmful effects on growth, most physiological activities and yield (Khaled *et al.*, 1995).

Attempts in the past to identify useful and safe chemicals for controlling the diseases with no toxicity to plants, animals and consumers as

antioxidants (free radical scavengers) were the objective of investigations. Recently, plant production inputs involves the use of antioxidants which may play a role in the regulation of plant development, flowering, and chilling of disease resistance (Toal and Jones, 1999; Ziadi *et al.*, 2001; Dmitrier *et al.*, 2003 and Achuo *et al.*, 2004), so many antioxidants like salicylic, benzoic, citric and oxalic acids beside ribavirin (Rashad, 2005 and El-Abbasi and Mikhail, 2006) were used.

The plant protection mechanisms of these chemicals not only depend on the site of penetration (local protection) but also systemic protection could be achieved (Goodman *et al.*, 1986 and Galal *et al.*, 1997). Antioxidants may also affect on growth parameters, chlorophyll content, and plant growth, accumulation of antifungal compounds and increasing activity of oxidative enzymes (Siegrist *et al.*, 1997; Hammerschmidt *et al.*, 2001; Ziadi *et al.*, 2001; Malolepsza and Urbanek, 2002; Fariduddin *et al.*, 2003 and Morsy, 2005).

The present investigation aimed to evaluate benzoic acid, citric acid and hydroquinone as antioxidant chemicals on some faba bean cultivars (*i.e.*, Sakha 1, Giza 2 and Giza 3) under field conditions against chocolate spot disease, in an effort to reduce or at least retard its development and to lessen its eventual impact.

MATERIALS AND METHODS

Antioxidants:

Hydroquinone, citric acid and benzoic acid (ADWIC Co., Egypt)] were the antioxidants selected for this investigation. Each antioxidant was dissolved in water or ethanol to obtain the desired concentrations (5, 10 and 15mM).

Field applications of the antioxidant substances against the chocolate spot disease:

Two field experiments were carried out at the experimental farm of Tag El-Ezz, Agricultural Res. Station, Dakhlia, Egypt during the two successive winter seasons of 2004/2005 and 2005/2006, to study the effect of various antioxidant chemicals *i.e.*, hydroquinone, citric acid and benzoic acid at concentrations of 5,10 and 15mM as foliar treatments on faba bean cultivars (Sakha 1, Giza 3 as a resistance cultivars and the susceptible cultivar Giza 2) against chocolate spot disease caused by *Botrytis faba*. Seeds were obtained from The Central Administration for Certification, Ministry of Agriculture, Egypt.

Sowing (10^{th} November for both seasons) was done after the summer crop rice. Thirty plots, each of 3.5X1.5m were used. The plots were ploughed well, and weeds removed, soil was leveled and nitrogen fertilizer (Urea 46%) was added at the rate of 15kg per feddan with the first irrigation. Phosphorus (15.5% P_2O_5, superphosphate) was added at the rate of 100kg per feddan after soil during soil preparation.

Split-split plot design with four replicates was allocated. The main plots were devoted of the three faba bean cultivars (Sakha 1, Giza 3 and Giza 2). The sub-plots were occupied by the three chemical substances (*i.e.*,

hydroquinone, citric acid and benzoic acid), while the sub-sub plots were assigned to the concentrations. The plants developed from each assigned treatment were sprayed twice, 20 and 50 days after sowing with the defined antioxidant. Plants sprayed with tap water only served as control.

Disease assessment:

The disease severity was estimated after 45 and 75 days of sowing according to the standard scale of Gondran (1977) as follows: 1=healthy plants; 2=small spots; 3=increasing spots number and spreading; 4=coalesce spots together and about ¼ of leaf surface is necrotic; 5=half of leaf surface is necrotic and 6=leaves death and fall.

$$\text{Disease severity} = \frac{\sum (\text{Number of the infected plants} \times \text{Numerical grade})}{\text{Higher degree in the category} \times \text{Total number of the tested plants}}$$

Studied characters:

At harvest, ten plants were randomly chosen from each plot to determine the following characteristics:

1. Plant height (cm); measured from the soil surface to the top of the plant,
2. Number of branches plant^{-1}.
3. Number of pods plant^{-1}.
4. Seed weight plant^{-1} (g).
5. Weight of 100-seed (g).
6. Seed yield (ardab fed.$^{-1}$); weight of seed harvested from each plot and converted to ardab fed.$^{-1}$ (ardab=155kg).
7. Straw yield (tonns fed.$^{-1}$); it was calculated by subtracting seed yield from the total yield for each plot and converted to tonns per Feddan.

The experiments were carried out in clay loam soil after rice harvested. The physical and chemical properties of the experimental soil are summarized in Table (1).

Table (1): Mechanical and Chemical analysis of the farm soil at Tag El-Ezz research station.

Analysis	Value	Analysis	Value
Mechanical analysis		**Soluble cations (mg/100g soil)**	
Course sand (%)	2.70	Na^{+}	13.5
Fine sand (%)	8.00	K^{+}	0.25
Silt (%)	39.80	Ca^{++}	13.10
Clay %	49.50	Mg^{++}	7.17
Soil texture	Silty clay	**Soluble anions (mg/100g soil)**	
Organic carbon (%)	2.25	HCO_3^{-}	0.54
Total Nitrogen (%)	0.10	CL^{-}	18.58
C/N ratio	20.10	CO_3^{-}	3.42
Chemical analysis			
EC (m moh/cm^2)		5.1	
pH		7.2	

Statistical analysis

Obtained data for each season was made separately and subjected to the statistical analysis as the usual technique of analysis of variance (ANOVA) of the split-split plot design (Gomez and Gomez, 1984). The treatment means were compared using Least Significant Difference (L.S.D.) at 0.5 % and 0.1% levels of significance outlined by Waller and Duncan (1969).

RESULTS AND DISCUSSION

In the last decades the interest for improving the production of agronomic plants as well as, increase their resistance to phytopathogens has greatly stimulated research aimed at the identification of molecules that can neutralize harmful oxygen radicals (antioxidants) and activation of plant defense mechanisms (De Gara, 2003). Antioxidants are promising agents for controlling seed, soil and foliar-fungal diseases (Elad, 1992 and Galal *et al.*, 1997). Several reports showed also the antioxidants effectiveness in improving plant development, productivity and other plant traits (Raskin *et al.*, 1989; Elad, 1992; and Rashad, 2005). However, some antioxidants compounds are from divers groups of plant phenolics (Raskin, 1992), that play an important role in regulation of plant growth, and development (Harborne, 1980). The next result came in line with the previous aims.

1. Disease severity of faba bean as influenced by antioxidants

The present data (Table 2) of the two growing seasons reveled that, antioxidants applications as foliar spray on faba bean plants significantly reduced variably chocolate spot severity caused by *B. fabae* compared with the control treatment. The foliar application of 5 and 10mM of the tested antioxidants on the faba bean cultivars *i.e.*, Sakha 1, Giza 2 and Giza 3, after 45 days of cultivation revealed that, benzoic acid significantly reduced disease severity (DS) of chocolate spot disease. Hydroquinone was found to be in the second rank after benzoic acid but on Sakha 1 and Giza 2 only. Much more reduction in DS on Sakha 1, Giza 2 and Giza 3 cultivars was recorded when 15mM of benzoic acid, hydroquinone and citric acid (64.4, 33.46 and 49.26%; 53.5, 33.46 and 28%; and 32, 24.8 and 7%, respectively reduction) were applied. On the other hand, citric acid on Giza 3 cultivar did not show any significant differences as compared to control.

At 75 day of cultivation, the application of benzoic acid at 5, 10 and 15mM showed priority and proved to be the best and most effective in reducing DS on all tested cultivars compared with hydroquinone and citric acid. On the other hand, the application of 5mM citric acid on Giza 3 increased DS over the control. Generally, DS decreased with increasing the concentration of the antioxidant. Our results are supported by many authors against *Botrytis cinera* and *B. fabae*, where they found that significant reduction of chocolate spot disease severity of faba bean and beneficial changes were obtained after antioxidants application, where, new unknown proteins with molecular weights from 20 to 91k. Dalton in pre-treated plants were induced (Elad (1992; Ismail *et al.*, 2004 and El-Abbasi & Mikhail, 2006).

These results may be referred to conversion of benzoic acid (as precursor) into salicylic acid in the plant cells (Yalpani *et al.*, 1993). The activity of which is induced by either pathogen infection or exogenous benzoic acid application, which leads to the accumulation of salicylic acid (Leon *et al.*, 1993 and Yalpani *et al.*, 1993). A pioneering study demonstrated that the application of exogenous salicylic acid or its derivatives (*e.g.*, benzoic acid) induces synthesis of pathogenesis related proteins and partial resistance to pathogens (De Gara, 2003).

2. Field evaluation of the antioxidant substances against the chocolate spot disease:

2.1. Faba bean cultivars performance:

The results in Tables (3 and 4) show significant differences among faba bean cultivars with respect to all studied parameters in the two growing seasons. Sakha 1 and Giza 3 were taller than Giza 2, while Giza 3 cultivar was the best in straw yield fed.$^{-1}$ compared to the other faba bean cultivars. Data revealed that Sakha 1 cultivar was the high in No. of branches, No. of pods and seed weight plant^{-1}, 100-seed weight and yield ardab fed.$^{-1}$. These differences in seed yield might be due to the variation in genotypes of the studied varieties. Similar results were recorded by El-Bana and Soliman (1994), El-Kaddoussi (1996) and Mohamed & Abbas (2005) reported that, Giza 3 surpassed Giza 2 in seed weight plant^{-1}, 100-seed weight and seed yield ardeb fad.$^{-1}$ but Giza 3 surpassed in Sakha 1 and Giza 2 in plant height and straw yield.

2.2. Antioxidant substances:

The results in Table (3 and 4) show the effect of three substances used as antioxidant chemicals on growth and yield of faba bean cultivars in the two seasons. Results of statistical analysis revealed that the tested chemicals had significant effects on plant height, number of branches plant.$^{-1}$, number of pods plant^{-1},100 seed weight and seed yield in both seasons. While number of branches plant^{-1}, seed weight plant^{-1} and straw yield recorded significant increase in only one season. For seed yield, citric acid recorded 4% and 10% increase in the first season and 9% and 11% in the second season compared with hydroquinone and benzoic acid, respectively.

2.3. The antioxidant concentrations:

The results in Tables (3 and 4) show that the antioxidant concentrations had significant effect on growth, yield, and yield components of faba bean in both seasons. Results of statistical analysis for the obtained data revealed that the concentration (15mM) surpassed the other concentrations and control on the plant height, number of branches, number of pods and seed weight plant^{-1}, 100-seed weight, seed yield and straw yield fed.$^{-1}$ in both seasons. The increment as result of using 15mM, in the seed yield were 4, 11 and 43% in the first season and 6, 15 and 43% in the second season over 10mM, 5mM and control, respectively. This increase in seed yield may be due to increase in vegetative growth and yield components *i.e.*, plant height, number of branches plant^{-1} and 100 seed weight which affected by the application of studied chemicals, that help plants to tolerate the fungal infection.

Table 2: Effect of spraying faba bean plants with different antioxidants on disease severity of chocolate spot disease caused by *Botrytis fabae*.

Substrate	Conc. (mM)	Varieties: Sakha 1				Giza 2				Giza 3			
		1st season		2nd season		1st season		2nd season		1st season		2nd season	
		45 day	75 day	45 day	75 day	45 day	75 day	45 day	75 day	45 day	75 day	45 day	75 day
		Disease severity (infection Index) %											
Hydroquinone	5	3.8cdefg	3.8def	3.53efg	3.5ghi	3.8cdefg	3.4fg	3.96de	3.3hij	4.8abc	4.4cde	4.73abc	4.3ef
	10	3.8cdefg	3.4fg	3.33fg	3.3hij	3.8cdefg	3.0fgh	3.73ef	3.0jk	4.6abcd	3.8def	4.6bc	3.73gh
	15	2.8gh	2.4hij	2.26hi	2.3lm	3.4efgh	2.8ghi	3.3fg	2.73kl	3.4efgh	2.8ghi	3.4efg	2.73kl
Citric acid	5	5.2a	4.6bcd	5.0ab	4.73cde	5.0ab	3.6efg	4.96abc	3.5ghi	5.4a	5.8a	5.2a	5.73a
	10	4.4abcde	3.8def	4.5bcd	3.86fg	4.4abcde	3.4fg	4.4cd	3.3hij	5.0ab	4.8bc	4.96abc	4.53de
	15	3.4efgh	3.2fgh	3.3fg	3.1ijk	3.8cdefg	3.0fgh	3.73ef	3.0ijk	4.4abcde	3.8def	4.4cd	3.73gh
Benzoic acid	5	3.2fgh	3.0fgh	3.3fg	2.96jk	4.0bcdef	3.2fgh	3.96de	3.3hij	3.8cdefg	3.4fg	3.73ef	3.4ghij
	10	3.0fgh	2.4hij	3.0g	2.4l	3.8cdefg	2.0ij	3.5efg	1.86mn	3.4efgh	2.8ghi	3.73ef	2.73kl
	15	1.6i	1.0K	1.73i	0.86o	3.6defg	1.6jk	3.3fg	1.53n	2.4hi	1.8jk	2.4h	1.73n
Control		4.8abc	5.2abc	4.86abc	5.0bc	5.0ab	5.4ab	4.96abc	5.5ab	4.8abc	5.4ab	4.73abc	4.96cd

Values of means within a column followed by the same letter(s) are not significantly different at P=0.05.

Table (3): Mean values of plant height, number of branches, pods and seed weight plant^{-1} for faba bean cultivars as affected by different antioxidant treatments during 2004/2005 and 2005/2006 seasons.

Character / Treatment	Plant height (cm)		No. of branches Plant^{-1}		No. of pods plant^{-1}		Seed weight Plant^{-1} (gm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
A. Cultivars								
Sakha 1	106.14	107.27	3.704	4.188	18.0	20.333	21.329	26.23
Giza 3	114.77	124.17	3.179	3.563	16.708	18.458	20.705	23.09
Giza 2	96.08	96.83	3.304	3.563	18.235	20.333	19.959	21.65
F. test	**	**	**	**	**	**	*	**
L.S.D. 5%	6.35	7.05	0.15	0.27	0.62	1.02	0.95	0.745
1%	9.63	10.68	0.23	0.41	0.93	1.55	-	0.893
B. Substrate								
Hydroquinone	97.84	100.73	3.400	3.771	17.173	19.021	20.705	24.32
Citric acid	122.95	118.88	3.621	3.859	18.483	22.979	21.358	24.43
Benzoic acid	106.29	108.67	3.167	3.688	15.746	17.354	19.942	22.23
F. test	**	**	**	N.S.	**	**	N.S.	*
L.S.D. 5%	4.53	4.24	0.22	-	1.05	2.57	-	1.35
1%	6.00	5.63	0.30	-	1.39	3.41	-	-
C. Concentrations								
5mM	106.98	108.89	3.52	3.64	18.26	20.81	21.677	23.09
10mM	107.98	112.94	3.62	4.11	18.00	20.67	28.113	24.64
15mM	113.19	121.14	3.68	4.25	19.09	22.19	28.113	25.11
Check (0mM)	95.34	94.92	2.76	3.08	13.58	15.47	16.049	21.79
F. test	**	**	**	**	**	**	**	**
L.S.D. 5%	2.88	3.06	0.19	0.38	1.29	1.76	1.64	1.69
1%	4.55	4.83	0.30	0.66	2.03	2.78	2.58	2.01
Interaction								
AXB	**	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
AXC	**	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
BXC	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
AXBXC	**	N.S.	N.S.	N.S.	*	N.S.	N.S.	**

2.4. Interaction effects:

The interaction between faba bean cultivars and antioxidant substances on plant height in the two seasons was shown in Table (5). The highest plant height was recoded by the application of citric acid with Giza 3 and Sakha 1 (127.26 and 119.60 cm, respectively) in the first season. In the second season, the highest plant height was given by citric acid (137.44) with Giza 3 and by citric acid (126.43 cm) with Sakha 1.

The interaction between faba bean cultivars and antioxidant substances on 100-seed weight and seed yield in the first season and second season was shown in Table (6). Citric acid recorded the highest weight of 100-seed with Sakha 1 and Giza 3 (72 gm, for both) in the first season. The highest in seed yield was recorded by citric acid (12.845 with Sakha 1 in the second season.

A pioneering study demonstrated that the application of exogenous salicylic acid or its derivatives (*e.g.*, benzoic acid) have appositive effect on mung beans development include increasing the pod number and yield (Singh and Kaur, 1980) as well as, stimulated adventitious root initiation and increasing the height and grain number of cheena millet (Kling and Meyer, 1983). Such result was obtained by application of benzoic acid on rice plants naturally infected by brown spot disease. Rice plot treated with benzoic acid

at 20mM maximizing number of filled grains panicle^{-1}, panicle weight, 1000 grain weight and grain yield fad.$^{-1}$ (Rashad, 2005).

Table (4): Mean values of 100-seed weight, seed and straw yield fad.$^{-1}$ for faba bean cultivars as affected by different antioxidant treatments during 2004/2005 and 2005/2006 seasons.

Characters / Treatment		100-seed weight (g)		Seed yield ardab fad.$^{-1}$		Straw yield ton fad.$^{-1}$	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
A. Cultivars							
Sakha 1		69.88	71.98	12.01	11.67	2.416	2.489
Giza 3		69.15	71.23	11.61	11.29	2.373	2.784
Giza 2		52.99	62.04	11.36	10.29	2.190	2.110
F. test		**	**	*	**	**	**
L.S.D.	5%	2.24	2.02	0.43	0.24	0.161	0.119
	1%	3.39	3.06	-	0.37	-	0.177
B. Substrate							
Hydroquinone		62.89	68.92	11.71	10.83	2.333	2.497
Citric acid		65.31	69.54	12.16	11.81	2.430	2.455
Benzoic acid		61.73	66.79	11.05	10.62	2.216	2.431
F. test		**	**	**	**	*	N.S.
L.S.D.	5%	1.49	1.22	0.57	0.433	0.159	-
	1%	1.98	1.62	0.76	0.57	-	-
C. Concentrations							
5mM		63.94	68.03	11.77	11.00	2.471	2.524
10mM		65.44	69.72	12.57	11.91	2.438	2.548
15mM		65.89	70.69	13.12	12.60	2.456	2.666
Check (0mM)		60.64	65.22	9.18	8.82	1.939	2.106
F. test		**	**	**	**	**	**
L.S.D.	5%	1.63	1.40	0.61	0.39	0.129	0.119
	1%	2.57	2.21	0.96	0.62	0.204	0.175
Interactions							
AXB		**	N.S.	*	N.S.	N.S.	*
AXC		N.S.	N.S.	N.S.	N.S.	N.S.	**
BXC		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
AXBXC		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table (5): Plant height as affected by the interaction between cultivars and antioxidant substances during 2004/2005 and 2005/2006 seasons.

Antioxidants		Plant height (cm)					
		1st season			2nd season		
		Sakha 1	Giza 3	Giza 2	Sakha 1	Giza 3	Giza 2
Hydroquinone		96.57	101.15	95.78	97.43	108.31	96.44
Citric acid		119.60	127.26	91.96	126.43	137.44	92.75
Benzoic acid		102.25	115.87	100.47	97.93	126.75	101.31
F. test		N.S.	**	N.S.	N.S.	**	N.S.
L.S.D.	5%		0.498			0.467	
	1%		1.074			1.008	

Table (6): 100- seeds weight and seed yield as affected by the interaction between cultivars and antioxidant substances during 2004/2005 and 2005/2006 seasons.

Antioxidants		100-seed weight (g)			Seed yield (Ton)		
		1st season			2nd season		
		Sakha 1	Giza 3	Giza 2	Sakha 1	Giza 3	Giza 2
Hydroquinone		72	63	53	10.56	11.098	11.490
Citric acid		67	72	52	12.845	12.858	11.322
Benzoic acid		70	70	52	12.514	11.371	11.267
F. test		N.S.	**	N.S.	N.S.	*	N.S.
L.S.D.	5%		2.632			1.011	
	1%		5.684				

This increment in plant production may attribute to the increased flower longevity and inhibits ethylene biosynthesis in plant cell suspension culture by blocking the conversion of 1-aminocyclopropane-1-carboxylic acid to ethylene (Leslie and Romani, 1986). A significant increase was also reported (Rashad, 2005) on photosynthetic pigments (chlorophyll a, b and carotenoids) as well as total carbohydrate and protein contents of the yielded grains of the treated rice plants with benzoic acid.

Such improvement in plant growth parameters, especially in a crop like faba bean in Egypt, is seriously needed since all parts of faba bean plants are hundred percent in use regardless fresh or dry. Moreover, some antioxidants are food grade. So, they are safe for use from an antifungal point of view. Their practical use in plants under field conditions is possible. Further studies are highly needed to elucidate the mode of action of antioxidants, either on plant host or on the pathogen.

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زيادة الإنتاجية ومقاومة التبقع الشيكولاتي لبعض أصناف الفول البلدي باستخدام مضادات الأكسدة

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بتاج العز - دقهلية خلال موسمي الزراعة ٢٠٠٤ /٢٠٠٥، ٢٠٠٥/٢٠٠٦ لدراسة تأثير ثلاثة مضادات أكسدة وهي الهيدروكينون ، حمض الستريك و حمض البنزويك مع ثلاث تركيزات من كل منها (٥ و ١٠ و ١٥ ملليمول) بالإضافة إلي الكنترول علي شدة الإصابة بمرض التبقع الشيكولاتي المتسبب عن الفطر *Botrytis fabae* وذلك علي ثلاث أصناف من الفول البلدي (سخا ١ و جيزة ٣ و جيزة ٢).

وبصفة عامة فقد سجلت التركيزات المختلفة من حمض البنزويك أعلي تأثير معنوي في خفض شدة الإصابة للمرض علي جميع الأصناف المستخدمة ، بينما جاء الهيدروكينون في المرتبة الثانية في التأثير مقارنه بالكنترول ، في حين جاء حمض الستريك بتركيز ١٥ ملليمول في المرتبة الأخيرة.

وفي هذه الدراسة أظهرت معاملات الرش بعد ٢٠ و ٥٠ يوم من الزراعة بمضادات الأكسدة علي المجموع الخضري لأصناف الفول البلدي تأثير معنويا علي نمو وإنتاجية المحصول والذي يمكن تلخيصه فيما يلي:-

١- تفوق الصنف سخا ١ علي الأصناف الأخرى في جميع صفات الدراسة ماعدا طول النبات، في حين تفوق الصنف جيزة ٣ في تلك الصفة على باقي الأصناف.

٢- أدى استخدام الرش بحمض الستريك إلي زيادة جميع الصفات المدروسة في كلا موسمي الزراعة.

٣- كان للتركيز ١٥ ملليمول تأثير معنوي علي جميع الصفات المدروسة مقارنه بالتركيزات الأخرى والكنترول

٤- أظهر التفاعل المشترك بين الأصناف ومضادات الأكسدة تأثيرا معنويا بين الصنف جيزة ٣ وحمض الستريك علي طول النبات في كلا موسمي الزراعة ، كما أظهر التفاعل تأثير معنويا بين الصنف سخا ١ وحمض الستريك على وزن الـ ١٠٠ بذرة و محصول البذور.

٥- هناك حاجة ماسة للسير في هذا الخط البحثي في مصر.