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Evaluation of Four Quinoa Cultivars to the Infection by Downy Mildew under Middle Egypt Conditions

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Quinoa (*Chenopodium quinoa* Willd), recently introduced to Egypt, is a promising plant with its ability to grow in various stress conditions, and its importance in human nutrition. A potential constraint for quinoa production is downy mildew disease (*Peronospora farinose* f.sp. *chenopodii* Byford), which recorded for the first time in Egypt during 2015. Four quinoa cvs. (white Egyptian, American, Rainbow, Black) were cultivated under Middle Egypt climate at two different locations: Fayoum (Aboxa, Ibshawai center), and Bani-Sweif (Sids Research Station) governorates, Egypt during 2015/16 and 2016/17 growing seasons. Each cv. was cultivated in six plots (12 m^2 area) /location, which contains 200 plant /cv. per plot. Half of the experimental plots were treated with metalaxyl and mancozeb fungicides controlling the disease. Disease incidence and severity of downy mildew (using three leaves method and percentage scales) were assessed four times yearly with 21 days interval, which began at 28 days old. Black cv.the most susceptible one was totally infected being 100 and 93% disease incidence at Bani-Sweif and Fayoum, respectively followed by Egyptian and American cvs., being 80 and 54% disease incidence at Bani-Sweif and 71 and 49 disease incidence at Fayoum, respectively. While, Rainbow cv. wasthe lowest susceptible one, being 38 and 29 disease incidence at Bani-Sweif and Fayoum, respectively. The severity of the disease was in the same trend of disease incidence. Seed yield loss caused by downy mildew disease infection ranged from 95% in black cv. to 87% in rainbow one. Fayoum climate condition is higher significant unfavorable conditions than Bani-Sweif one for downy mildew dispersal for the evaluated cvs.. A further work must be performed for the disease management.

Keywords: *Downy mildew, Quinoa, Rainbow and White-Egyptian.*

Quinoa (*Chenopodium quinoa* Willd.) is an andean crop, has recently gained worldwide attention because of its ability to grow in various stress conditions like soil salinity, acidity, drought, frost, etc. (Jacobsen *et al.*, 2005; Bhargava *et al.*, 2007; Adolf *et al.,*2012 and Ruiz *et al*, 2014). The common use of quinoa is for the nutritional purposes (flour, soap, breakfast and alcohol) (Bhargava *et al.*, 2006).Repo-Carrasco-Valencia *et al.* (2010) reported that quinoa grains have a high quality protein *i.e.*, sulfur rich amino acids 14.8 to 15.7%, oil with essential fatty acids as linoleic acid and g-linolenic acids and natural antioxidants (atocopherol and g-tocopherol), along with a wide range of minerals and vitamins (Kumar *et al.*, 2006). Besides this, quinoa saponins have immense industrial importance in the preparation of soaps, detergents, and shampoos, in fire extinguishers (Johnson and Ward, 1993).Mujica (1994) reported that quinoa medicinal uses in inflammation, as analgesic and as a disinfectant of the urinary tract. Recently, quinoa's saponin has nutritional and pharmacological benefits (Hirose *et al.,* 2010). In addition it has a role in plant defense system, saponins possess various biological and pharmacological properties, including hemolytic, cytotoxic, immune modulatory, anti-inflammatory and antitumor impact. (Demir and Kilinc, 2016). These reports can open new avenues for its use as a medicinal crop (Bhargava *et al.*, 2006 and Demir and Kilinc, 2016).

Different cultivars of quinoa are known for their adaptability to agro-ecological zones, ranging from sea level to an altitude of over 4000 m (Jacobsen *et al.,* 2003) and offer a great scope for agricultural diversification from sub-tropical to temperate regions. Due to these characteristics, the crop has already been introduced and successfully established in Europe and Africa (Jacobsen *et al.,* 2003). Quinoa is introduced to Egypt recently (Ruiz *et al.*, 2014) as the Egyptian winter climate favors quinoa good production. Downy mildew is firstly recorded in Egypt (El-Assiuty *et al.*, 2014), which is a potential constraint for its production. The disease is mainly caused by *Peronospora farinose* f.sp. *chenopdii* Byford. (Danielsen and Lübeckm 2010; Ruiz *et al*, 2014 and Mhada *et al.,* 2015). Quinoa is influenced by field condition, the microclimate humidity and the distribution of the spore hotspots across the experiment field (Mhada *et al.,* 2015).

The objectives of this study are: (i) Identifying the causal organism of downy mildew of quinoa under middle Egypt climate, (ii) Estimation the incidence, severity of the disease and area under disease progress curves, and (iii) Determination the yield loss under natural infection by downy mildew for four quinoa cvs.with different agro-ecological climates.

Materials and Methods

The experimental trails were conducted during 2015/2016 and 2016/2017 growing seasons under middle Egypt climate conditions at two different locations of Fayoum (Aboxa-Ibshawai town) and Bani-Sweif (Sids Research Station) governorates, Egypt. The disease was assessed for four different quinoa cvs. (white Egyptian, American, rainbow, Black). Each cv.was cultivated in six plots /location, which contained 200 plant/cv. (Kumar *et al.*, 2006) per plot. Plots were 4 m length and 3 m width, with row spacing of 40 cm and 15 cm between plants. Three seeds were set at every point in each plot. Seeds were sowed in October each season and location. Seedlings were thinned to one seedling/ hill.

Two weeks after sowing, half of each cv. cultivated plots were sprayed with metalaxyl (Vacomil 35% WP at the rate of 250g/100 Lwater) systemic fungicide. Three weeks later mancozeb (Anadol 80% WP at the rate of 200g/100L water) contact fungicide applications were begun. The mancozeb treatment consisted of three applications spaced one week apart, followed by another Vacomil treatment. The last application was given one month before the beginning of harvest. The other three plots (untreated with fungicides) were used for disease assessment.

Soil and climate:

The two experimental locations have almost the same soil, which was characterized as clay-to-clay loam. The climate at Fayoum location during the quinoa growing periods (2015/2016 and 2016/2017) was assessed using world weather online database (https://www.worldweatheronline.com) respectively, the diurnal temperature have ranged from 13-24, 13-26 °C minimum temp. and 21-31, 20-35°C maximum temp, relative humidity 35-56 and 29-60% and total precipitation 7.9 and 29.58 mm. While, Bani-Sweif location climate during the same periods respectively, the diurnal temperature have ranged from 12-32, 12-26 °C minimum temp and 21-32, 20-36°C maximum temp, relative humidity 32-56 and 26-48% and total precipitation 4.9 and 18.62 mm.

Disease assessment :

Downy mildew was assessed four times yearly with interval of 21 days, which began at 28 days after planting. Disease percentage and severity were calculated using the following formulae:

$$\%\ Disease\ Incidence = \frac{number\ of\ diseased\ plants}{total\ number\ of\ inspected\ plants} \times 100$$

(Mhada *et al*., 2015) **1**

$$\%\ Disease\ Severity = \frac{\sum(rating\ no. \times no.\ of\ plant\ in\ each\ rating)}{Total\ no\ of\ plants\ \times highest\ rating} \times 100$$

(Abd-Elmoity and Ali, 2016) **2**

Area under disease progress curve (AUDPC) was calculated as follows:

$$AUDPC = \sum_{i}^{n-1} \left[\frac{(y_i + y_{i+1})}{2} \times (t_{i+1} - t_i)\right]$$

(Mhada *et al.,* 2015) **3**

Where n =The number of evaluations, y =Severity or incidence and t the number of days after sowing where at each evaluation. ti = Time (days); yi = Disease severity at the day i.

Disease severity was assessed according to 0-5 scale (Mhada *et al.,* 2015). A linear relationship is illustrated between disease severity and yield (Abd-Elmoity and Ali, 2016)

Harvest:

Seed yield was estimated for the four centeral rows. The number of the harvested plants in each plot was counted. Harvest was done when the plants were matured and seed yield per feddan was calculated

Statistical analysis:

The effect of downy mildew disease on the yield of cvs.band AUDPC were analyzed by ANOVA (Snedecor and Cochran, 1990).The correlation between yield and AUDPC is analyzed with correlation analysis (InfoStat-Statistical Software, version 2018, Universidad Nacional de Córdoba, Argentina. URL http://www.infostat.com.ar).

Results

Identification of the causal agent:

Symptoms of downy mildew on quinoa plants were initially observed on the lower leaves of the plant in the form of pale (different color depending on the cv.) necrotic spots on the upper surface and correspondingly grayish black conidiophores bear conidiospores of the pathogen on the lower surface (Figs. 1 and 2). The symptomatic tissues were utilized for identification and description of the pathogen. The pathogen was identified as *Peronospora farinosa* f.sp. *chenopodii* Byford based on morphological keys. The light microscopy revealed the presence of straight conidiophoresor slightly curved. These conidiophores were dichotomously at acute angles. Branches of the terminals were short, straight or slightly curved and pointed bearing a single broadly oval conidium (11.5–15.5×19–25.6µ).

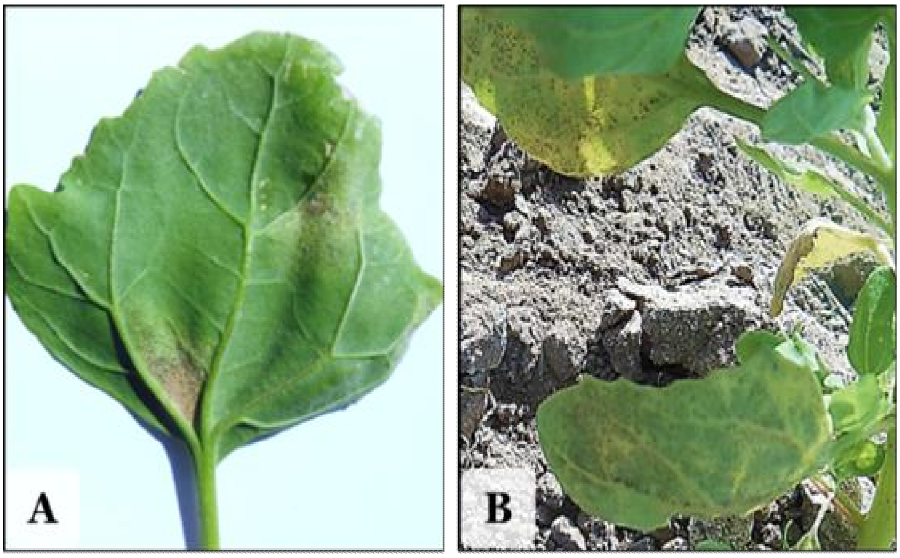

Fig. 1. Downey mildew symptoms on quinoa leaves collected A: from Fayoum governorate, B: from Bani-Sweif governorate

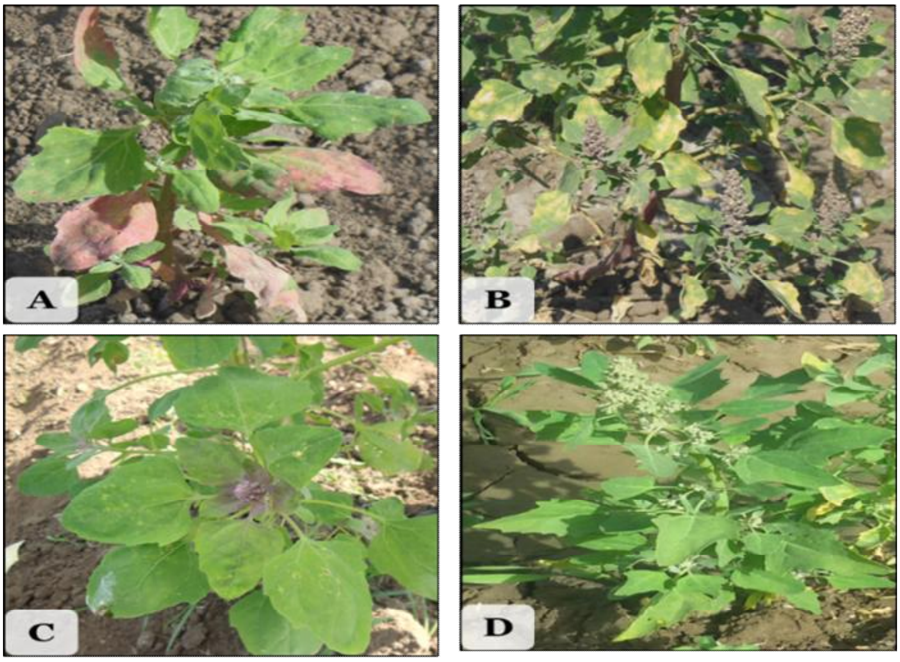

Fig. 2. Downey mildew symptoms on quinoa plants of A: black, B: Rainbow C: American, D: white Egyptian cultivars.

Disease incidence:

The four tested quinoa cvs. showed different downy mildew disease incidence, where Rainbow cv. had the lowest disease incidence being 29.15 and 38.15 % at Bani-Sweif and Fayoum governorates, respectively, followed by American cv. which had 48.6 and 53.8% at Bani-Sweif and Fayoum governorates, respectively (Table 1 and Fig. 3). Whereas, white Egyptian cv. had the highest disease incidence (75%). Black cv. was totally infected at Fayoum governorate, while at Bani-Sweif , the infected quinoa plants were 93.3 %.

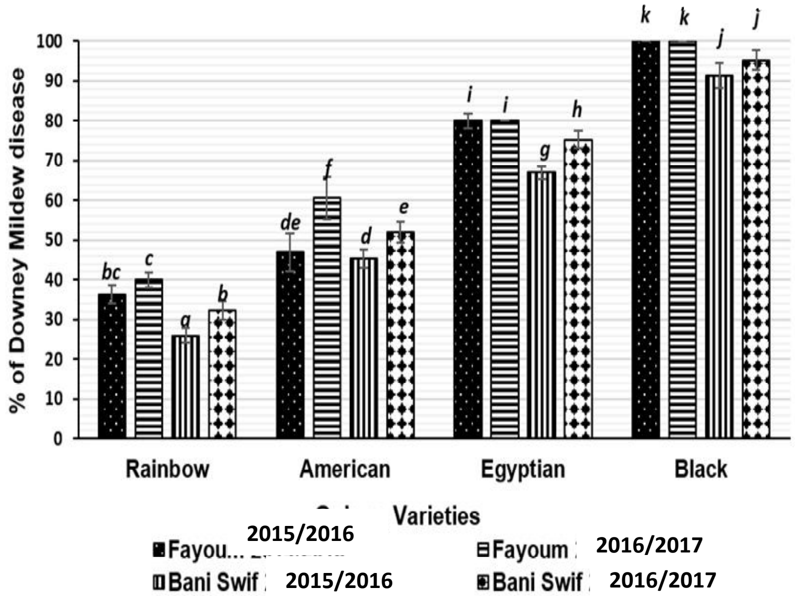

Fig. 3. Percentages of disease incidence of quinoa downy mildew on white Egyptian, American, Rainbow and Black cvs. The letters above error bars represent the significance according to L.S.D. of the means (P<0.05).

Disease severity:

The four studied cvs. showed significant differences in downy mildew disease severity, at the two-locations at the season 2015/2016. Whereas, these quinoa cvs. could be ordering according to their downy mildew disease severity in an ascending order; Rainbow, American, white Egyptian and Black cv. respectively (Fig. 4). The 2nd year of study had indicated significant differences between studied varieties. (Fig. 4). Rainbow quinoa cv. showed resistant to the disease compared with the other cvs., where only 3.0 and 2.6% disease severity were recorded at Fayoum and Bani-Sweif governorates, respectively. Moreover, white Egyptian cv. was significantly affected by downy mildew than Rainbow cv., where had 4.3 % disease severity, followed by the American cv. with disease severity of 9 %.However, the Black cv. was the most significant sensitive cv. (32 and 22.8 % average of disease severity at Fayoum and Bani-Sweif, respectively).

Table 1. Relation of four quinoa cvs.to natural infection by downy mildew at Fayoum and Bani-Sweif governorates during 2015/2016 and 2016/2017growing seasons

Cvs.	Governorate					
	Fayoum			Bani-Sweif		
	Season		Mean	Season		Mean
	2015/2016	2016/2017		2015/2016	2016/2017	
Rainbow	36.3*bc*	40.0*c*	38.2	26.0*a*	32.3*b*	29.2
American	47.0*de*	60.6*f*	53.8	45.3*d*	52.0*e*	48.6
Egyptian	80.0*i*	80.0*i*	80.0	67.0*h*	75.3*g*	71.2
Black	100.0*k*	100.0*k*	100.0	91.3*j*	95.3*j*	93.3
L.S.D. for: Location , year = 1.53710; Cv.s , location * year =2.17379; Cv.*location, Cv.*season = 3.07420; Cv.*Season*Location = 4.34758						

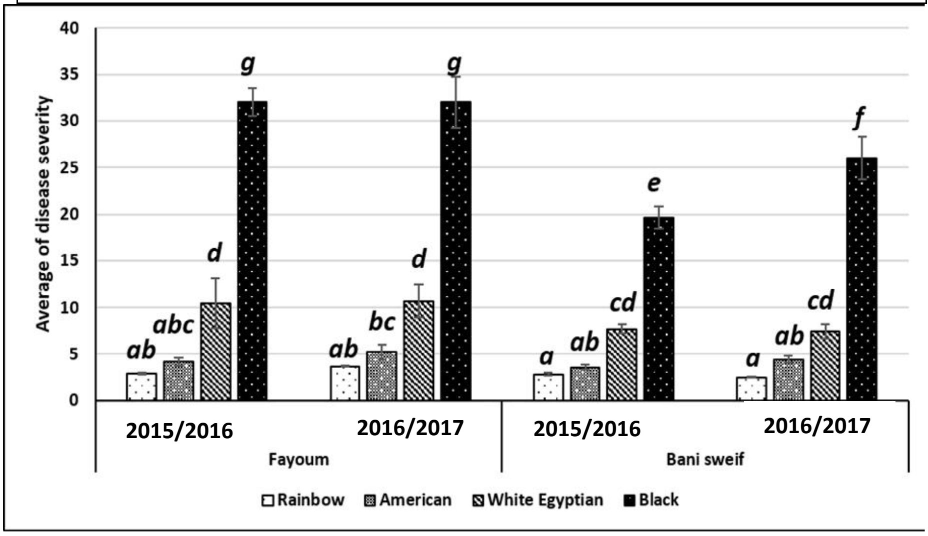

Fig. 4. Severity of quinoa downy mildew disease on four cvs.
The letters above error bars represent the significance according to L.S.D. of the means (P<0.05).

Area under disease progress curves for downy mildew of quinoa (AUDPC):

Disease progress curves for the four cvs. had different values (Figs. 5 and 6, Table 2). Both of Rainbow and American cvs had the same AUDPC curves trends with disease severity increments during the 28, 49 and 70 days after sowing, followed by decrement of disease severity at 90 days after sowing with respect to their values at both examined locations. While, the Black and white Egyptian cvs had disease severity values with a limited range (Table 2), which was clear in the almost linear AUDPC curves (Figs. 5 and 6,).

Table 2. Effect of the infection by quinoa downy mildew on four cvs.; A: Rainbow, B: American, C: White Egyptian, D: Black, under climate of Fayoum and Bani-Sweif governorates

Cvs.	Governorate	Season	Disease severity (days)			
			28	49	70	91
Rainbow	Fayoum	2015/2016	1.96*ab*	2.77*c*	4.97*c*	1.76*a*
		2016/2017	2.27*bc*	3.64*e*	5.52*b*	3.22*c*
	Bani-Sweif	2015/2016	1.58*a*	2.19*b*	4.03*d*	3.33*c*
		2016/2017	1.52*a*	1.94*a*	3.78*a*	2.63*b*
Americn	Fayoum	2015/2016	3.67*bc*	4.68 *f*	5.05*c*	3.34*c*
		2016/2017	4.68*d*	5.33*g*	6.05*e*	4.74*e*
	Bani-Sweif	2015/2016	2.18*b*	3.12*e*	5.04*c*	3.86*d*
		2016/2017	2.77*c*	4.70 *f*	5.49*d*	4.76*e*
Egyptian	Fayoum	2015/2016	8.84*f*	10.62*j*	12.08*g*	10.37 *h*
		2016/2017	8.89*f*	10.15*i*	12.03*g*	11.61*i*
	Bani-Sweif	2015/2016	6.24*e*	7.24*h*	8.70*f*	8.50*g*
		2016/2017	6.39*e*	7.33*h*	8.55*f*	7.50*f*
Black	Fayoum	2015/2016	31.19*i*	32.06*m*	33.56*k*	31.45*l*
		2016/2017	30.91*i*	32.18*m*	33.23*j*	31.73*m*
	Bani-Sweif	2015/2016	17.94*g*	19.26*k*	20.65 *h*	20.45*j*
		2016/2017	25.02*h*	26.59*l*	27.42 *l*	24.98*k*

* Days after sowing.

L.S.D. for:	**28 days**	**49 days**	**70 days**	**91 days**
Location, Season	0.017809	0.06311	0.059979	0.05702
Cvs , Location * Season	0.25186	0.8925	0.08455	0.08063
Cv.*Location, Cv.*Season	0.35619	0.12622	0.11957	0.11403
Cv.*Season*Location	0.50373	0.17850	0.16910	0.16127

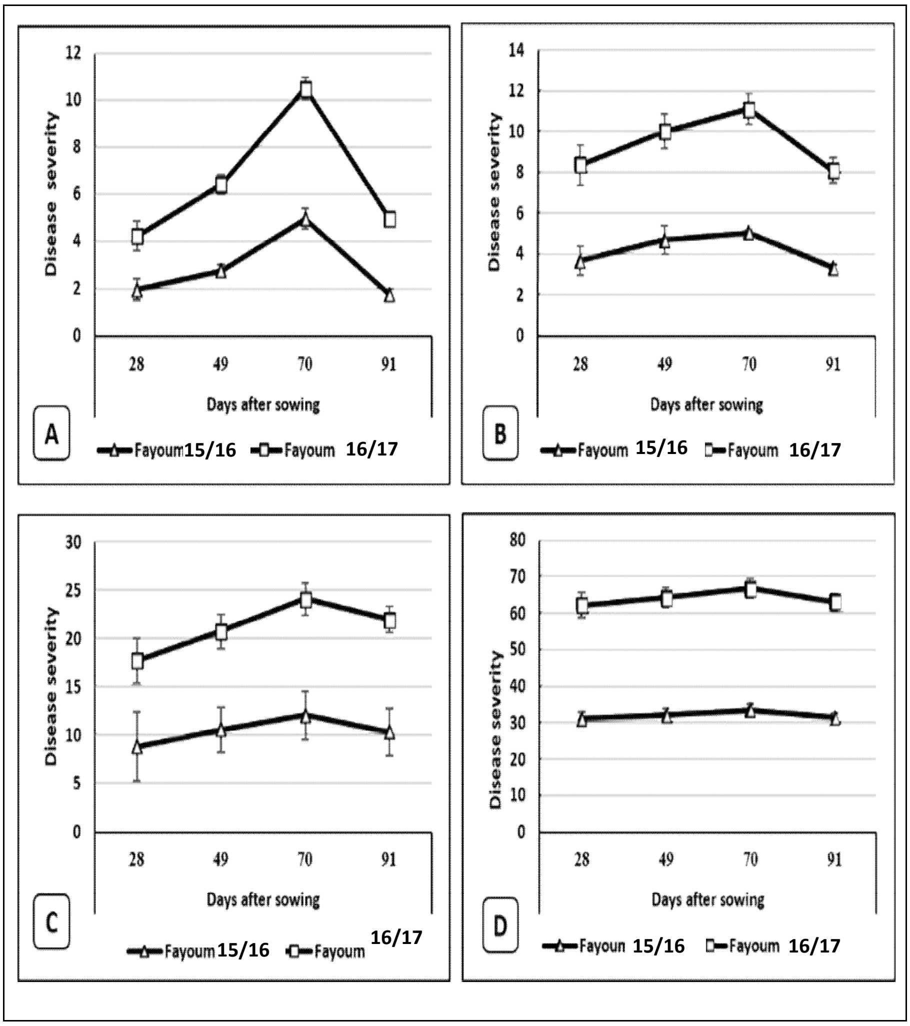

Fig. 5. Effect of the infection by quinoa downy mildew on fourcvs.; A: Rainbow, B: American, C: White Egyptian, D: Black, under Fayoum governorate climate

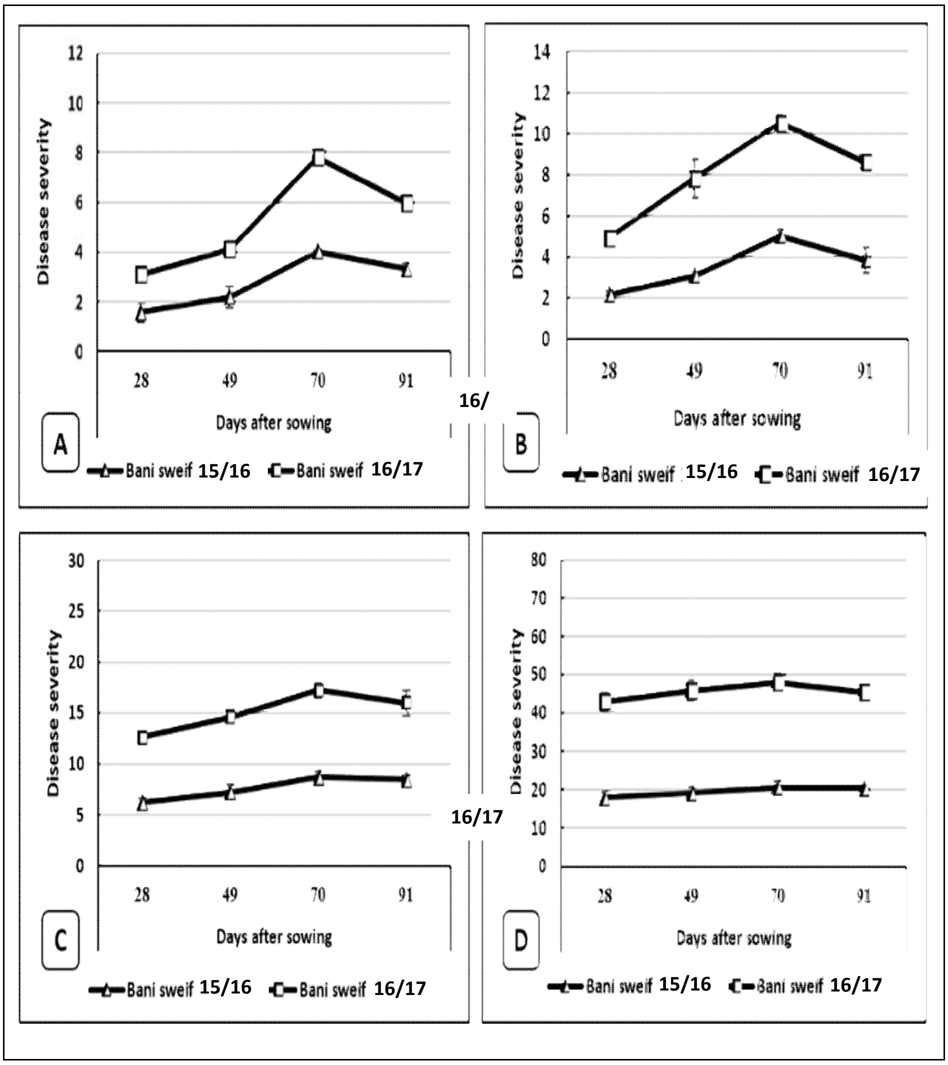

Fig. 6. Effect of the infection by quinoa downy mildew on four cvs.; A: Rainbow, B: American, C: White Egyptian, D: Black, under Bani-Sweif governorate climate.

The obtained data of the two locations (Fayoum and Bani-Sweif governorates) reviewed that the Black cv. was the most susceptible one (Fig. 7, Table 3) and the Rainbow, American and white Egyptian ones were the most resistant. A significant difference in AUDPC was found between Black cv. and the other three cvs.. No significant difference in AUDPC was observed between Rainbow and American cvs. (Fig. 7).

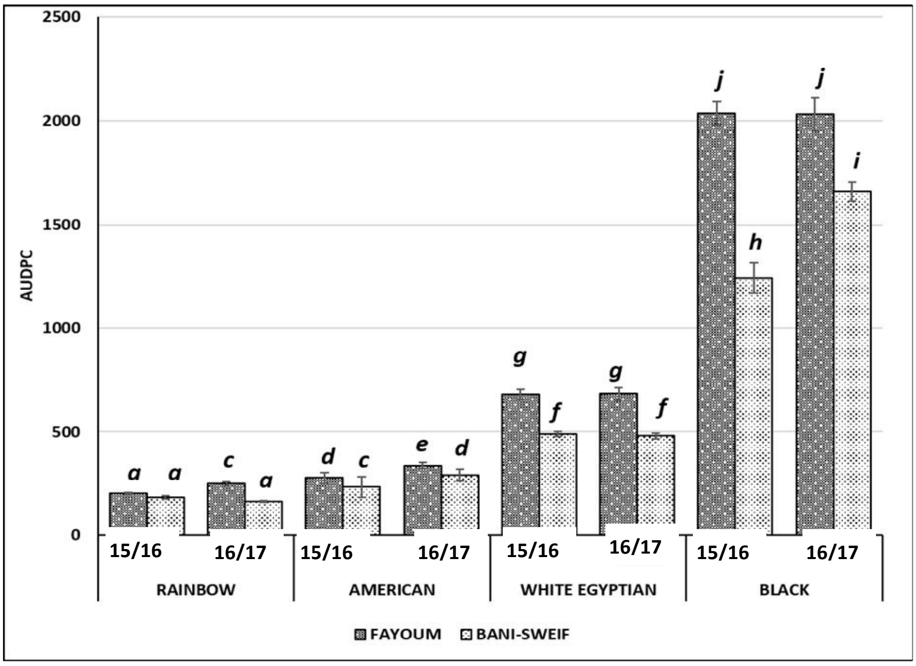

Fig: 7. AUDPC values of quinoa cvs. at Fayoum and Bani-Sweif governorates during 2015/2016, 2016/2017 growing seasons. The error bars represent LSD of the means, means with common letters are not statistically different (P<0.05).

Table 3. AUDPC values of quinoa cvs. at Fayoum and Bani-Sweif governorates during 2015/2016, 2016/2017 growing seasons

Cvs.	Governorate					
	Fayoum			Bani-Sweif		
	Season		Mean	Season		Mean
	2015/ 2016	2016/ 2017		2015/ 2016	2016/ 2017	
Rainbow	201.43*a*	249.90*c*	225.665	182.14*a*	163.66*a*	172.9
American	277.87*d*	337.93*e*	307.9	234.75*c*	292.99*d*	263.87
Egyptian	678.41*g*	681.24*g*	679.83	489.37*f*	479.47*f*	484.42
Black	2035.71*j*	2031.16*j*	2033.44	1241.35*h*	1659.14*i*	1450.25

LSD for: Location , year = 6.86871; Cv.s , location * year = 9.71853;

Cv.*location, Cv.*season = 13.75933; Cv.*Season*Location = 19.51787

The yield losses of four quinoa cvs. due to the infection by downy mildew:

There was a linear correlation between the harvested yield and the disease severity. In addition, all the cvs. had a strong reverse correlation between the yield and the disease severity during the two seasons at both study locations (Fig. 8).

This adverse correlation between downy mildew severity and yield emphases the seed yield losses of all the investigated cvs. (Fig. 8). Whereas, the quinoa seed yield loss ranged from 87 to 95 % in all the tested cvs. with reference to the fungicide treated ones (Table 4). Rainbow and American cvs. had the significant low disease severity (Fig. 4) with significant high seed yield (Table 4). While, downy mildew decreased seed yield at Fayoum up to 95% in case of Black cv., which had the significant lowest (1.12 and 0.90 ton/feddan during the seasons 2015/2016 and 2016/2017, respectively), and Bani-Sweif (1.31 and 1.05 ton/feddan during the two seasons, respectively) combined to the significant highest disease severity (Table 4). Whereas, all the tested cvs showed high yield of quinoa seeds with downy mildew control regime (Table 4).

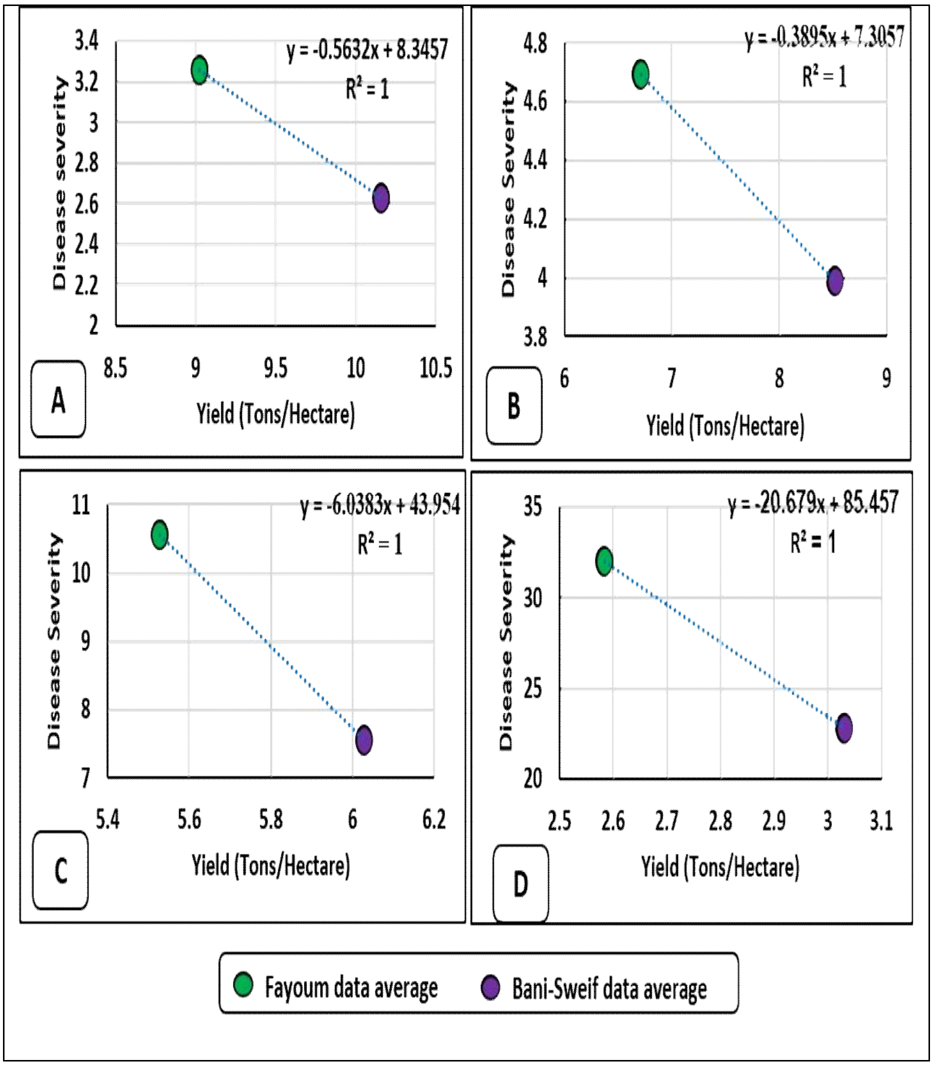

Fig. 8. Correlation between downy mildew disease severity of four quinoa cvs. and the yield average during the two seasons at Fayoum and Bani-Sweif governorates on the A: Rainbow, B: American, C: White Egyptian, D: Black.

Table 4. Effect of spraying two fungicides on the produced seed yield of four quinoa cvs. Under the natural infection of downey mildew, field experiments at Fayoum and Bani-Sweif governorates during 2015/2016 and 2016/2017 growing seasons

Location	Season	Seed yield (ton/feddan)[1] of cvs.											
		Rainbow			American			White Egyptian			Black		
		Treated[2]	Untreated	% loss	Treated[2]	Untreated	% loss	Treated[2]	Untreated	% loss	Treated[2]	Untreated	% loss
Fayoum	2015 2016	2966*o*	375*f*	87.36	2716*j*	275*cde*	89.87	2904*mn*	229*bc*	92.11	2331*h*	112*a*	95.20
	2016 2017	2819*kl*	203*b*	92.80	2849*klm*	250*bcd*	91.22	2892*mn*	200*b*	93.08	2409*i*	090*a*	96.26
	Average	2893	289	90.08	2783	263	90.55	2898	215	92.60	2370	101	95.73
Bani-sweif	2015/2016	2984*o*	449*g*	84.95	2796*k*	315*e*	88.73	2934*no*	330*ef*	88.75	2350*hi*	131*a*	94.43
	2016/2017	2974*o*	460*g*	84.53	2857*lm*	254*bcd*	91.11	2986*o*	304*de*	89.82	2311*h*	105*a*	95.46
	Average	2979	455	84.74	2827	285	89.92	2960	317	89.29	2331	118	94.94
Average		2936	372	87.41	2805	274	90.24	2929	266	90.94	2350	110	95.00

[1]The harvested area of each plot/cultivar was 12 m^2. The yield was converted into kg/feddan.

[2] The treated plots were sprayed with two fungicides mancozeb (Anadol 80% WP) and metalaxyl (Vacomil 35% WP) to control downy mildew

L.S.D. for: Location, year, fungicide treatment= 14.89159; Cv.s, location * year, cv.*fungicide treatment, fungicide treatment *location= 29.78319; Cv.*location* season, Cv.*season*fungicide treatment, Cv.*location*fungicide treatment = 42.11978; Cv.*Season*Location* fungicide treatment = 59.5663

Discussion

Extension of quinoa cultivation at new countries as Egypt, with different environmental conditions that differs from their origin one, could increase the extension of the spectrum of pests and diseases injurious to quinoa plants. This risk could be due to the exposure of introduced cultivars at other areas outside their traditional growing regions to new growing conditions; including climate and cultural practices (Dřímalková, 2003).

Although, downy mildew is one of the limiting diseases for quinoa (*C. quinoa*) plants (Choi *et al*., 2010, and Abd-Elmoity and Ali, 2016), there is an argument about the causal agent of downy mildew disease. Most studies (Yerkes and Shaw1959 and Abd-Elmoity and Ali, 2016) are in agreement with our finding, which indicated that the downy mildew pathogen is identified as *Peronospora farinose* f.sp. *chenopodii*. While, certain studies (Choi *et al*., 2010) indicated that, the quinoa downy mildew pathogen is *Peronospora variabilis*.

Quinoa cultivars have different resistance levels to downy mildew, differed from highly susceptible (Black cv.) to moderately susceptible (Rainbow, white Egyptian and American cvs.). Danielsen and Ames, (2000) and Ochoa *et al*. (1999), reported that there is a wide range of downy mildew resistance levels among different quinoa cultivars. This could be due to the resistant gene expression and its interaction with climate conditions as temperature and humidity levels, in addition to the variance of downy mildew isolates virulence up to locations (Danielsen and Ames, 2000). This explains the significant differences between the two studied loci and seasons even with their almost similar climate. The obtained data illustrated higher favorable climate conditions for disease incidence at Fayoum governorate rather than Bani-Sweif one. Moreover, the second growing season of study has positive significant disease incidence increment rather than the first season that could be due to the increment of the relative humidity and rainfall accumulation during the 2nd year of study regarding the first one (according to world weather online database).

Certain studies have used the AUDPCs as indicators for the relationship between yield loss and quantitative resistance in the plants, especially in the field (Danielsen and Ames, 2000). Mhada *et al*., (2015) significantly separate quinoa cultivars regarding level of resistance into five groups with reference to AUDPC. Therefore, the Black cv. could be classified as highly sensitive one. While, Rainbow and American ones could be considered as the resistant cvs. and the white Egyptian cv. considered as moderately susceptible with respect to AUDPC values.

Danielsen and Ames (2000) and Danielsen *et al*.(2003) illustrated that the most significant disease, affecting quinoa cultivation in South America, is downy mildew as recorded by reducing the yield up to 33 - 58%, and even up to 99%, in some cvs., which this is fulfill with our findings, where the loss ranged from 87 to 95%. In addition, the negative correlation between disease severity and quinoa seed production in the four tested cultivars.

Both Rainbow and American cvs. could be recommended to be cultivated in middle Egypt combined with downy mildew control procedures. The main research task recently is to ensure food production security under low-input regimes. Moreover, the salinization of soil and water is the primary cause of crop loss worldwide (Ruiz *et al.*, 2014). There is a need for rely on plants as quinoa to re-vegetate and remediate of salt affected lands. Further research should be conducted to assess the safe control procedures for limiting downy mildew hazard.

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تقييم إصابة أربعة أصناف من الكينوا بمرض البياض الزغبي تحت ظروف مصر الوسطى

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دخل نبات الكينوا (*Chenopodium quinoa* Willd) مؤخراً الى مصر كنبات له القدرة على تحمل الظروف البيئية المختلفة حيث انه نبات طبي ويستخدم في التغذية البشرية. من اهم مشاكل انتاج الكينوا هو مرض البياض الزغبي المتسبب عن الفطر *Peronospora farinose* f.sp. *chenopdii* والذي سجل لأول مرة في مصر عام ٢٠١٤. تم زراعة اربعة أصناف من الكينوا (مصري– أمريكي– رينبو –إسود) تحت ظروف مناخ مصر الوسطى بموقعين مختلفين: الفيوم (أبوكسا، مركز إبشواي)، بنى سويف (محطة بحوث سدس) خلال الموسمين ٢٠١٥ / ٢٠١٦ و ٢٠١٦/٢٠١٧. تم زراعه ستة قطع تجريبية (مساحة ١٢ م٢)/صنف/موقع،بمعدل ٢٠٠ نبات / صنف/ قطعة تجريبية. تم معاملة نصف عدد القطع التجريبية بمبيدين (مانكوزيب وميتالاكسيل) لمكافحة المرض.تم تقييم نسبة حدوث المرض باستخدام طريقة ثلاث أوراق أربع مرات سنويًا مع فاصل زمني مدته ٢١ يومًا، بدأ من عمر ٢٨ يومًا. اثبتت التجارب ان الصنف الأسود هو الأكثرعرضه للإصابة بالبياض الزغبي حيث سجل ١٠٠ و٩٣% ببنى سويف والفيوم على التوالي، ثم الصنف المصري والأمريكي والذي سجل ٨٠ و٥٤% ببني سويف، ٧١ و٤٩% بالفيوم.في حين كان صنف الرينبو أقل الأصناف عرضه للإصابة حيث سجل ٣٨و٢٩% ببنى سويف والفيوم على التوالي. كانت شدة المرض في نفس الاتجاه لحدوث المرض. وأوضحت النتائج أن الإصابة بمرض البياض الزغبي تسببت بنسبة فقد في محصول الحبوب الناتج بنسب تراوحت من ٩٥% بالصنف الأسود إلى ٨٧% بصنف رينبو.وعليه يتضح أن الظروف البيئية بالفيوم مواتية بدرجة أعلى من حالة بني سويف لانتشار إصابة الكينوا بالبياض الزغبي على نبات الكينوا. ولذا وجب عمل دراسة مستقبلية لمكافحة المرض.