EFFECT OF POTASSIUM SALTS ON ONION PURPLE BLOTCH INCIDENCE AND SOME PHYSIOLOGICAL AND YIELD PARAMETERS IN ONION SEED PLANTS

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ABSTRACT

Purple blotch disease is one of the most destructive diseases of onion in Egypt, which could cause 100% loss of onion seed production. The excessive use of chemical fungicide harms the environment and natural balance, leading to find another safe and effective alternative controlling onion purple blotch disease. Field experiments were conducted at Demo in El-Sultan Bahnas village, Fayoum County at El-Fayoum Governorate during the growing seasons 2017/2018 and 2018/2019 on onion for seed production. Plants were sprayed with four potassium salts; potassium silicate (K-silicate), potassium citrate (K-citrate), dipotassium phosphate (K_2HPO_4) and potassium carbonate (K_2CO_3). Two control treatments one with distilled water and the other with mancozeb 80%. K_2HPO_4 gave the best result in decreasing disease incidence or disease severity in leaves and flower stalks in respectively, followed by K_2CO_3 and K-silicate. While, the treatment of K_2CO_3 gave the highest inflorescences' fresh and dry weights followed by K_2HPO_4, then K-Citrate. The treatment of K_2HPO_4 generated the highest inflorescence and yield components compared to control treatment. K-silicate application exceeded the all other treatments and led to significant increases in free phenols and reduced sugars contents in onion leaves compared to control treatment. Examined Potassium salts in this study gave promised safe alternative control methods for onion purple blotch in onion seed production with reference to the chemical fungicide.

KEYWORDS: Onion seed, potassium, silicate, citrate, phosphate, carbonate, purple blotch

INTRODUCTION

Onion represents one of the most important and economic crops in Egypt. The economic importance of this crop appears in both local consumption and exportation purposes. Onion cultivated area was 189000 feddans and yielded 2863000 tons in 2017 **(CAPMAS 2020)**.

Purple blotch disease is one of the most destructive diseases of *Allium species* in Egypt. The disease is more severe for seed crops if comparison to bulb crops, sometimes causing 100% loss of onion seed production (**Quadri *et al.*, 1982, Gupta and Pathak, 1988 and Abdel-Rahim *et al.*, 2016**). The wide spread use of fungicides to control plant diseases led to an increase of health hazards due to their toxic residual and pollution effects. Therefore, using some other means of disease control instead of agrochemical is strongly encourage. Using safe mineral salts to control plant pathogenic fungi have received considerable attention as an alternative strategy (**El Rafai *et al*. 2003**)

Potassium is a major plant nutrient, which is essential for a variety of physiological processes i.e., photosynthesis, enzyme activation and contribution to maintenance of water status in plant tissues **(Marschner, 2012**). Certain researches were conducted explaining the effect of some potassium salts on disease control. As the mechanisms proposed by **Perrenoud (1990)** explaining dipotassium phosphate with its disease-suppressing effect by its direct effects; on pathogen multiplication, development and survival, and plant metabolism and, consequently, pathogen food supply. Moreover its influence on plant defense responses and stomata function, which affect the establishment and spread of the pathogen inside the plant phosphates manifest antifungal activity by induction of systemic acquired resistance (SAR).

While, the inhibitory effect of bicarbonate on fungi was explained by **Palmer *et al.,* (1997**) by reducing the fungal cell turgor pressure which resulted in collapse and shrinkage of hyphae and spores, and consequent inability of fungi to sporulation. This could be considered as alternative safe control with very low mammalian and environmental toxicity profile **(Jamar *et al.,* 2007; Youssef *et al.,* 2012** and **Anonymous (2016)**

Where, silicon plays role in growth improvement, photosynthesis increment, efficiency of transpiration and evaporation, increasing the strength of leaves and chlorophyll concentration per leaf area and product quality **(Hwang *et al.,* 2005 and Khalifa *et al.,* 2017**), in addition to the state of potassium silicate as one of the silicon fertilizers which contain 27% of silicon oxide **(Reezi *et al.,* 2009)**.

Potassium citrate is potassium salt of citric acid which considered one of the most important organic acids in the respiratory pathways into plant cell. Additionally, citric acid plays an important role in plant metabolism, as non-enzymatic antioxidant, in chelating free radicals and protecting plant from injury could result in prolonging the shelf life of plant cells and improving growth characters **(El-Beltagi *et al.,* 2017)**.

Certain researches reported the efficacy of mancozeb as an active ingredient of fungicide controlling the purple blotch in onion **(Bhosale *et al*., 2009** and **Behera *et al*., 2014)**.

The aim of this study was to evaluate the effect of certain potassium salts (citrate, silicate, phosphate and carbonate) on; a) the disease incidence of purple blotch on onion which was naturally infected; b) the growth and yield onion seed parameters, and c) some physiological characteristics.

MATERIAL AND METHODS

Experimental design and description

Field experiments were carried out in a Farm located at Demo in El-Sultan Bahnas village, Fayoum County at El-Fayoum Governorate. Soil in this farm belongs to light clay soil type, with pH value 7.6. Irrigation water comes from Nile River. Field experiments were carried out during two successive seasons 2017/2018 and 2018/2019 on onion (Giza-red)) for seed production.

Experiments were designed in a complete randomized blocks design (CRBD) with three replicates per treatment. Four different treatments of potassium salts were sprayed; potassium silicate (KSI), potassium citrate ($C_6H_5K_3O_7.H_2O$), dipotassium hydrogen phosphate (K_2HPO_4) and potassium carbonate (K_2CO_3), other two control treatments negative (distilled water) and fungicide treatment (mancozeb 80% WP).

Onion bulbs used for these experiments were bought from field crop Institute, ARC, Giza, Egypt. These bulbs were cultivated in the eastern side of 70 cm width rows with 40 cm intervals. Each replicate was 33.6 m2 with three rows. Total numbers of plants ⁄ replicate were 120 plants. Single interval rows were left between treatments and replicates.

All plants received the same fertilizers and irrigation regime. Onion plants were treated with different treatment after 45 days of cultivation with exception to the fungicide treatment (0.3%) which was applied after the disease dispersal as treated check. The treatments were sprayed seven times during the seasons with fifteen days intervals. Concentrated solutions of potassium salts were prepared at a concentration of 15 % (v/v), according to percentage of potassium in each compound.

Disease assessment:

Disease incidence of the treated onion plants was assessed during the growing seasons 2017/2018 and 2018/2019 on all the onion plants' leaves and flower stalks of each treatment (~120 plant/replicate), whereas the disease severity was assessed on randomly 10 plants/treatment replicate. Disease assessments were conducted twice for leaves and flower stalks each season in the open field experiments (March on leaves and during May on flower stalks).

Disease incidence percentage was calculated according to the following formula (**Ravichandran *et al.*, 2017**):

$$\%\ \textbf{Disease incidence} = \frac{\textit{Number of diseased plants}}{\textit{Total No. of plants}} \times \mathbf{100}$$

Disease severity was evaluated using 0-5 scale developed by **Sharma (1986)** and modified by the author where; 0:no disease symptom, 1: a few spots towards tip covering 10 per cent leaf area or flower stalks, 2: several purplish brown patches covering up to 20 per cent of leaf area.3: several patches with paler outer zone covering up to 40 per cent leaf area or flower stalks. 4: leaf streaks covering up to 75 per cent leaf area or breaking of leaves from center or flower stalks, and 5: complete drying of the leaves or flower stalks from center.

Whereas, the percent disease severity index (DSI, %) was calculated using following formula given by **Wheeler (1969)**:

$$\text{DSI \%} = \frac{\text{Sum of all individual disease rating}}{\text{Total No. of plant assessed} \times \text{Maximum rating}} \times 100$$

Morphological and yield characteristics

Samples of plants received different treatments were collected 90 days post planting. Some agronomical characteristics in treated plants, i.e fresh weight, dry weight, thousand-seed weight, seeds weight/10 plants, inflorescences No., inflorescences height, and inflorescences No./10 plants) were determined in late June. The expected seed yield was estimated for feddan for each treatment.

Physiological characteristics

To deduce mode of action of different chemical salts treatments on disease control, samples of healthy plants were collected in randomize way and send to the lab for further analysis. Collected samples were used to determine free, conjugate and total phenols. Reduced and non-reduced sugars were also determined

Statistical analysis

All experiments were performed twice following Randomized Complete Block Design (RCBD). Analyses of variance were carried out using the MSTAT-C, 1991 program version 2.10. Fisher LSD test was employed to test for significant differences between treatments at p = 0.05 (**Gomez and Gomez, 1984**).

RESULT AND DISCUSSION

1- Efficacy of potassium salts in controlling onion purple blotch disease under field conditions

Data obtained in Table (1) indicated that spraying of different mineral salts; K_2HPO_4, K_2CO_3, K-Citrate and K- Silicate led to different degrees of protection against purple blotch disease. Data also showed that all treatments significantly reduced the percentage of disease incidence or disease severity in leaves and flower stalks and increased seed yield compared with control treatment. K_2HPO_4 gave the best result in decreasing disease incidence or disease severity in leaves and flower stalks (29.41, 26.53% and11.46, 22.8%, respectively). K_2CO_3 and K- Silicate occupied the second rank, decreasing disease incidence or disease severity in leaves and flower stalks**.** K-citrate occupied the least rank, decreasing disease incidence or disease severity in leaves and flower stalks (43.6, 32.07% and 18.13, 40.16%, respectively). K_2HPO_4 recorded the highest yield if compared with any other treatment, giving 303 Kg seed yield/fed. K-citrate recorded the lowest quantity of seed yield compared with other treatments and gave 233 Kg seed yield/fed, whereas controls gave 58 Kg seed yield/fed. The obtained results are in good accordance with previous investigators such as **Singh *et al*. (2004); Abd El-Aal *et al*. (2005), El-Bassiouny (2006)** and **Shafeek *et al.* (2013)**. These results may be due to the role of potassium element in metabolism and many processes needed to sustain and promote plant vegetative growth and development. Moreover, K plays a major role in many physiological and biochemical processes such as cell division and elongation and metabolism of carbohydrates and protein compounds (**Marschner, 1995**). The obtained results are in a good accordance with those recorded by **Abd El-Aal *et al*. (2005), Abou El-Nasr and Ibrahim (2011), Saud *et al.* (2013)** and **Shafeek *et al*. (2013)** who found that increasing potassium fertilizer levels increased plant height, number of leaves per plant and leaves fresh weight. Copper sulphate has antifungal effect on conidia and linear growth could be attributed to copper ions which can catalyze the production of highly hydroxyl radicals, with subsequent damage to lipids, proteins, DNA and other bioprocesses.

Potassium phosphate is used as a fertilizer and the principal source of phosphorus for plants in agriculture, but in some cases, when used as a foliar spray, disease resistance of plants is improved. In these regards, many investigations reported the use of potassium salts as a chemical agent for induction of plant resistance (**Stromberg and Brishammar, 1991** and **Yurina *et al*., 1993**).

Table 1: Effect of using different potassium salts in controlling onion (Giza-red) purple blotch under field conditions as average of the two seasons 2017/2018 and 2018/2019

Treatment	Disease Incidence on		Disease severity on		Seed yield (Kg/fedd)
	leaves	Flower talks	leaves	Flower stalks	
K_2HPO_4	29.41 d	26.53 d	11.46 d	22.8 ef	303.00 ab
K_2CO_3	34.33 c	32.57 c	13.70 cd	25.87 de	273.00 c
K-Citrate	43.6 b	32.07 c	18.13 b	40.16 c	233.00 e
K-Silicate	32.26 c	38.00 b	15.40 c	45.00b	253.00 d
Mancozeb	25.38 e	21.5 e	18.8 b	26.9 d	228.00 f
Control	70.40 a	84.70 a	86.41 a	79.24 a	58.00 g

Values with the same letter in the same column are not significantly different at $P<0.05$.

2- Effect of spraying different potassium salts on agronomical characteristics of onion plants

Effects of spraying application of different chemical salts on agronomical characteristics of onion plant are shown in Table (2). Data showed that all treatments led to significant increases in all parameters, which were measured, including fresh and dry weight of inflorescences /10plants, 1000-seed weight, seeds weight/10 plants, inflorescences No./ 10 plant, flower stalk height, and flower stalks No./10 plants) compared to control treatment. The treatment of K_2CO_3 gave the highest fresh and dry weights (880 and 454 g, respectively) followed by K_2HPO_4, then K-Citrate, while the control treatment gave the lowest fresh and dry weights, respectively. In addition, the treatment of K_2HPO_4 generated the highest inflorescence and yield components compared to control treatment. For potassium (K), it activates numerous enzymes, which are critical for various metabolic processes, such as biosynthesis, transport, and transformation of sugars and starch (**Lester *et al*., 2010 and Niu *et al.*, 2013**).

Potassium plays important roles in different processes in plants including photosynthesis, respiration, ion uptake and transport, protein synthesis and enzyme activation (**Mengel, 2007**). These results are in agreement with previous reports by **Saud *et al*. (2013) and Shafeek, *et al.* (2013)** who reported that increasing potassium fertilizer levels increased plant height, number of leaves per plant and leaves fresh weight.

Table 2: Effect of spraying different chemical salts on agronomical characteristic of onion plant under field conditions as average of the two seasons 2017/2018 and 2018/2019

Treatments	Fresh weight(g)	Dry weight(g)	1000 seed weight (g)	Seeds weight/ 10 plants (g)	N. flower stalk /plant	Flower stalk height (cm)	N. inflorescence /10 plants
	For Inflorescences /10 plants						
K_2HPO_4	816 b	456 a	4.61 ab	172 a	5.33 a	85.2 a	54.66 a
K_2CO_3	880 a	454 a	4.48 b	155 b	4.33 ab	79.43 b	45.33 c
K-Citrate	640 c	312 c	4.50 b	132 d	5.33 a	67.76 d	47.66 bc
K-Silicate	615 d	334 b	4.23 b	143 c	4.33 ab	78.00 b	42.00 d
Mancozeb	547 e	316 c	4.20 b	135 d	4.00 c	73.50 c	41.33 d
Control	179 f	77 d	3.0 c	33 e	2.33 d	48.63 e	28.66 e

*** Values with the same letter in the same column are not significantly different at *P*<0.05.**

3- Physiological changes (total phenols content and sugars formation) in the onion leaves and flower stalks that naturally infected by purple blotch disease and treated with different potassium salts chemicals.

Effects of spraying application of different chemical salts on the contents of phenolic compounds and sugars in leaves and flowering stalks of onion plant are shown in **Tables (3 and 4).** Data showed that K-silicate application exceeded the all other treatments and led to significant increases in free phenols and reduced sugars contents in onion leaves compared to control treatment. The treatment of K-Citrate occupied the second order for free phenols content, and K_2HPO_4 occupied the second order for reduced sugars content in onion leaves. Whereas K_2CO_3 and K_2HPO_4occupied the third order for free phenols content, and K_2HPO_4 and K_2CO_3 occupied the third order for reduced sugars content.

Table 3: Evaluation of the spraying of different chemical salts on total phenols content and sugars formation in onion leaves in open field as average of the two seasons 2017/2018 and 2018/2019

Treatment	Phenols (mg/g fresh weight)			Sugars (%)		
	Free	Conj.	Total	Reduced	Non Reduced	Total
K_2HPO_4	0.90 c	1.01 c	1.91 a	1.63 ab	1.19 bc	2.82 a
K_2CO_3	0.91 bc	0.98 c	1.89 a	1.52 bc	1.24 bc	2.76 a
K-Citrate	0.97 abc	0.94 c	1.91 a	1.48 c	1.32 b	2.80 a
K-Silicate	1.01 a	0.90 c	1.91 a	1.69 a	1.12 c	2.81 a
Mancozeb	0.73 bc	1.11 a	1.84 a	1.46 b	1.33 b	2,79 a
Control	0.50 e	1.37 a	1.87 a	0.90 d	1.88 a	2.78 a

Values with the same letter in the same column are not significantly different at *P*<0.05.

Table 4: Evaluation of the spraying of different potassium salts on total phenols content and sugars formation in onion flower stalks in open field as average of the two seasons 2017/2018 and 2018/2019

Treatment	Phenols (mg/g fresh weight)			Sugars (%)		
	Free	Conj.	Total	Reduced	Non Reduced	Total
K_2HPO_4	1.53 b	0.81 c	2.34 a	1.58 ab	0.97 ab	2.55 a
K_2CO_3	1.18 e	1.11 a	2.29 a	1.38 ab	1.14 ab	2.52 a
K-Citrate	1.31 d	1.02 ab	2.33 a	1.35 ab	1.18 ab	2.53 a
K-Silicate	1.42 c	0.90 bc	2.32 a	1.45 ab	1.09 ab	2.54 a
Mancozeb	1.48 c	0.81 c	2.29 a	1.56 b	0.97 ab	2.53 a
Control	1.66 a	0.67 d	2.33 a	1.71 a	0.83 b	2.54 a

Values with the same letter in the same column are not significantly different at *P*<0.05.

These positive results of free phenols and reduced sugars contents obtained from the application of K-silicate may be attributed to the beneficial effects of both K and silicon (Si) for plants against environmental stresses, including biotic stress such as purple blotch (**Liang *et al.*, 2005)**. In addition, Si can prevent pathogen penetration into host tissues. Reduction in disease incidence in plants treated with Si sources under field conditions is not probably due to the fungistatic effects of Si, but

Si can act as physical barrier against pathogen penetration or Si can be used as inducer for defense response in plants (**Shen *et al.*, 2010**). On the other hand, Si can stimulate accumulation of polymerized phenolic compound **(Cherif and Belanger, 1992**). There are numerous explanations of the Si role to suppress onion disease like: the emerging role of Si as a biologically active element capable of improving the natural defense system of the plant. Si-treated plants exhibited increased activity of peroxidases, chitinases, polyphenol oxidases and flavonoid phytoalexins, which play an important role in the resistance of the plant to fungal pathogens (**Fawe *et al.*, 1998**). Furthermore, the higher production of glycosylated phenolics, antimicrobial products such as diterpenoid phytoalexins and a proline-rich protein in the Si-treated plants indicated that these products can have a role in the protection effects of Si against plant diseases (**Rodrigues *et al.*, 2003**). The bioactivity of Si as a regulator of plant defense mechanisms may be explained through the biochemical properties. Si bind with hydroxyl groups of proteins which involved in signal transduction. Also, Si may interfere with cationic co-factors of the enzymes which influencing pathogenesis-related events. Therefore, Si may interact with several key components of plant stress signaling systems leading to induced resistance (**Elsharkawy *et al.*, 2015**).

The biosynthesis of the osmoregulator solutes is a physiological approach to increase disease tolerance in plants. Among them, sugars usually accumulate in response to abiotic stress (**Munns and Tester, 2008**). Usually, soluble carbohydrate (sugars) content was significantly increased under stress conditions. **Shekari *et al.* (2017)** found that addition of Si increased soluble sugars content in dill plants grown under abiotic stress. Similar to phenols, increase in sugars under abiotic stress was considered as an important way for protective mechanism by means of osmotic adjustment (**Munns and Tester, 2008**). The beneficial effects of Si are associated with its high deposition in plant tissues, improving their strength and rigidity (**Ma and Yamaji, 2006**). It is also possible that Si plays an active role in resistance to plant diseases by stimulating defense mechanisms due to the increased activity of antioxidant enzymes (**Balakhnina and Borkowska, 2013**).

CONCLUSION

Examined potassium salts in this study gave promised safe alternative control methods for onion purple blotch in onion seed production with reference to the chemical fungicide.

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تأثير بعض أملاح البوتاسيوم على إصابة نباتات البصل لانتاج البذور بمرض اللطخة الارجوانية وعلى بعض ملصفات الفسيولوجية والمحصولية

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[٢] المعمل المركزي للزراعة العضوية، مركز البحوث الزراعية ، الجيزة ، مصر.

يعتبر مرض اللطخة الارجوانية من أكثر الامراض تدميرا لمحصول البصل بمصر حيث قد تصل نسبة الخسائر منه الى ١٠٠% من محصول البصل المنزرع لانتاج البذرة. يتم مكافحة ذلك المرض بالمبيدات الكيميائية والتي أدى الاستخدام المفرط لها بصفة عامة الى الاضرار بالبيئة والتوزازن الطبيعي للكائنات الحية، الامر الذئ أدى الى ضرورة إيجاد وسائل بديلة لتلك الكيملويات أكثر امانا وفاعلية لمكافحة مرض اللطخة الارجوانية بالبصل. تم تنفيذ التجارب الحقلية بدمو (قرية السلطان بهنس) بمحافظة الفيوم خلال الموسمين ٢٠١٨/٢٠١٧ و ٢٠١٩/٢٠١٨ على البصل المعد لانتاج البذرة. تم الرش بأربعة املاح من البوتاسيوم (سليكات البوتاسيوم، سترات البوتاسيوم، فوسفات البوتاسيوم ثنائي القاعدية، وكربونات البوتاسيوم)، هذا بالإضافة الى معاملتين مقارنة إحداهما تم الرش فيها بالماء مقطر والأخرى بمبيد المادة الفعالة به مانكوزيب ٨٠%. قد أعطت فوسفات البوتاسيوم ثنائي القاعدية افضل النتائج في تقليل نسبة وشدة الإصابة على الأوراق والشماريخ الزهرية، متبوعة بكربونات وسليكات البوتاسيوم. في حين أظهرت كربونات البوتاسيوم أعلى وزن جاف وطازج للنورات متبوعة بفوسفات البوتاسيوم ثنائي القاعدية وسترات البوتاسيوم. وأدت المعاملة بفوسفات البوتاسيوم ثنائي القاعدية إلى أعلى محصول من النورات مقارنة بمعاملة المقارنة (ماء). وكان أعلى المعاملات تأثيراً إيجابياً على مستوى الفينولات والسكريات المختزلة هي سليكات البوتاسيوم. وقد أظهرت كل أملاح البوتاسيوم المختبرة إمكانية استخدامها كوسيلة مكافحة بديلة آمنة لمكافحة مرض اللطخة الأرجوانية في البصل مقارنة بالمبيدات.

الكلمات الدالة:
بصل لانتاج البذرة، البوتاسيوم، سليكات، سترات، فوسفات، كربونات، اللطخة الارجوانية.