

Effect of Potassium Fertilizer, Solubilizing Bacteria and Sulphur on Yield, Bulb Quality, Storability and Black Mould Disease of Onion

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Abstract

This work was conducted to study the influence of potassium fertilizer, solubilizing bacteria (*Bacillus circulans*) and sulphur on yield, bulb quality, storability and black mould disease of onion. The study revealed that application of feldspar, *Bacillus circulans* and sulphur fertilizer was the best treatment, where it recorded the higher values of the total count of *Bacillus circulans* (CFU x 10⁶ /g soil), dehydrogenase enzyme activity in the rhizosphere of onion plants cultivated in soil, plant height (cm), fresh weight (ton fed⁻¹) and yield (ton fed⁻¹) of onion, highest values of total soluble solids (TSS), nitrogen, phosphorus and potassium contents, as well as the lowest values of weight loss percentage of onion bulb and black mold percent during the storage period for 6 months in the both seasons, this treatments would be suitable for productivity, quality and storability for onion production cv. Giza 6 in Egypt under experimental conditions.

Keywords: *Onion, fertilizer, potassium solubilizing bacteria, black mold disease.*

Introduction

(*Allium cepa* L.) is one of the most important commercial vegetable crops in the world including Egypt (Hussein *et al.*, 2014). It is used throughout the year in the form of salad and for cooking with other vegetables, as well as it has several medical uses (Gupta *et al.*, 2012). Onion is highly valued as both flavoring agent and storing plant material for about eight to ten months (Kumar *et al.*, 2010 and Samuel and Ifeanyi, 2010). The cultivated area in Egypt was 196968 fed., in 2014/2010 season, produced 2888691 tons/fed., with an average of 14.67 tons/fed., as mentioned by the (Anonymous, 2001).

Potassium plays key role in onion production. Generally a heavy dose of fertilizer is recommended for onion cultivation, onion is very responsive to potassium. The essential role of potassium in numerous physiological and biochemical proc-

esses in the plant including photosynthesis, enhancing the translocation of assimilates, protein synthesis, maintenance of water balance and promoting enzyme activities are well established (Marschner 1990). Among the various nutrients required to produce high yield, potassium deficiency dramatically reduced leaf area and dry matter accumulation and affected assimilate partitioning among plant tissues (Zhao *et al.*, 2001). Sindhu *et al.*, (2010) reported that potassium solubilizing bacteria (KSB), when used as bio fertilizer for agriculture, can reduce the use of application of chemical fertilizer and support ecofriendly crop production. Potassium solubilizing bacteria (KSB) dissolve potassium from insoluble K-bearing minerals such as micas, ilite and orthoclase by excreting organic acids which either directly dissolved rock K or chelated silicon ions to bring K into the solution. Sheng, (2000) stated that using KSB led to

improve the growth of pepper plants. Deepa *et al.*, (2018) found that, the physiological loss in weight, sprouting, rotting and black mould incidence were declined and number of marketable bulbs and TSS of bulb significantly increased during storage with increasing levels of potassium.

Sulphur has been found not only to increase the bulb yield of onion but also improves its quality, especially pungency and flavor (Jaggi and Dixit, 1999). Severe sulphur deficiency during bulb development has detrimental effect on yield and quality of onion (Ajay and Singh, 1994). Sulphur containing secondary compounds are not only important for nutritive value or flavors but also for resistance against pest and diseases (Bell, 1981). Balasubramonian *et al.*, (1979) reported that onion required sulphur fertilization in increasing the production. There are many S-containing compounds, which have been linked, directly or indirectly, with the defenses of plants against microbial pathogens; these include thionins, defensins, glucosinolates, crucifer phytoalexins, alliin, and glutathione (Hell, 1997).

Onion black mold rot disease is the most destructive disease of storages and in the field (Wani and Taskeen, 2011). Rajam, (1992) reported that among the post harvest diseases of onion is black mold rot caused *Aspergillus niger* which was the predominant one. The pathogen is transmitted by contaminated seed or soil. The infection usually begins at germination of onion seeds and may continue throughout storage (Hayden and Maude, 1992. Hayden *et al.*, 1994a, b; Koycu and Ozer, 1997; and

Sirois *et al.*, 1998). Visual symptoms are not observed on sets developing from seeds infected with pathogen because of latent infection (Ozer and Koycu, 1997) visible external and internal symptoms of black mold occur on infected marketable bulbs (Sumner, 1990; Sinclair and Letham, 1996). Quadri *et al.*, (1982) revealed that the spoilage caused by *A. niger* was as high as 80%. *A. niger* a soil saprophyte being ubiquitous attacks onion by producing various enzymes and toxins and establishes itself in bulb and other tissues. Bulb rot contributes to 10-50% of storage losses of different varieties during 3 months storage period under local conditions (Metthananda, 1992). Rahim *et al.*, (1983) reported that in some exotic cultivars, storage loss is even 10%. Onion bulbs are highly susceptible to post-harvest rots, caused by microorganisms particularly fungi during storage period, which have been known to produce toxins caused injurious to human and animal health (Samuel and Ifeanyi, 2010). About 30-40% of stored onion is lost due to storage diseases. Amongst all *Aspergillus* spp. (especially *A. niger*) is the most virulent pathogen in the field and storage (Kumar *et al.*, 2010). Post-harvest diseases of onion are due to latent infection from that under field conditions and if these infections are minimized before harvest it is possible to reduce the post-harvest losses (Raju and Naik, 2006). The aim of this work was to study the effect of potassium fertilizer, *Bacillus circulans* and sulphur on growth, yield and its components, bulb quality as well as bulb storability of onion to improve the qualitative and quanti-

tative of onion Giza ٦ cultivar yield under experimental conditions.

Materials and Methods

A field experiment was carried out at Mallawi Agriculture Research Station, Minia Governorate, Egypt, during the two successive seasons ٢٠١٥/٢٠١٦ and ٢٠١٦/٢٠١٧. The experiments were carried out in split plot layout with Randomized Complete Blocks Design (RCBD) with three replicates, The main plot for two levels from sulphur (without or with ١٠٠ kg fed⁻¹) and sub plots were allocated levels of potassium fertilizer and bio-fertilizer (*Bacillus circulans*), no fertilization, bio-fertilizer (*Bacillus circulans*), potassium sulphate, feldspar, potassium sulphate with bio-fertilization feldspar with bio-fertilization. The growth characters, yield, bulb quality and storability after ٣, ٤ and ٦ months from storage were recorded at room temperature. Each plot was ٣,٠ x ٣,٥ m² (١٠,٥ m² = ١/٤٠٠ feddan). Sixty day-old transplants of onion Giza ٦ cv each plot at the recommended spacing ١٠ cm on

the third week of December. The recommended agricultural practices for onion were used. As ammonium sulphate (N ٢٠,٦%), calcium super phosphate (P₂O₅ ١٥,٥%), and potassium sulphate (K₂O ٤٨%) fertilizers used as sources of nitrogen, phosphorus and potassium, respectively. The recommend amounts of mineral N and P fertilizers for onion production were used. The amount of mineral N fertilizers was splitted into two portions, one half being applied one month after transplants time before the first irrigation and the remaining portion was applied before the second irrigation, ٦٠ days from transplants. While, the amounts of phosphorus and sulphur were added at soil preparation directly. The seedling was dips in bio fertilizes (*B.circulans*) before transplants. Samples of soils were analyzed using methods cited by (Black *et al.*, ١٩٦٥). Sampling dates were two weeks before transplants. Some main soil chemical, and fertility characteristics are presented in Table (١):

Some physiochemical analysis of the experimental soil at depth (٠-٣٠ cm) before Plantation in ٢٠١٥/٢٠١٦ and ٢٠١٦/٢٠١٧ seasons.

Properties	٢٠١٥ / ٢٠١٦	٢٠١٦ / ٢٠١٧
Physical analysis:-		
Sand (%)	٨,٤٧	١٠,١١
Silt (%)	٥٤,٧١	٤٩,٢٢
Clay (%)	٣٦,٨٢	٤٠,٥٧
Soil texture	Silty clay loam	
Mechanical analysis:-		
Organic matter (%)	١,٦٠	١,٧٢
pH soil – water suspension ratio (١:٢,٥)	٨,١٤	٨,٠٠
EC (ds m ⁻¹) soil – water extract ratio (١:٥)	١,٥٢	١,٥٩
Soluble cations (meq/L):-		
Ca ⁺⁺	٧,٢٥	٧,٤٥
Mg ⁺⁺	٢,١٠	٢,١٥
Na ⁺	٣,٢٠	٣,٢٢
K ⁺	٠,١٨	٠,٢٠
Soluble anions (meq/L) :-		
CO ₃ ⁻	---	---
HCO ₃ ⁻	٣,١٨	٣,٢٠
Cl ⁻	٤,١٥	٤,١٠
SO ₄ ⁻	٥,٤٠	٥,٧٢
Available nutrient		
Available N %	٠,١٩	٠,١٨
Available P (ppm)	١٦	١٩
Available K (ppm)	٢٥٠	٢٧٠

Preparations of *Bacillus circulans*;

Bacillus circulans isolate obtained from the microbiology department, Agriculture Research Center, Giza, Egypt. It was inoculated in 200 ml conical flasks that possessed 100 ml Aleksandrov's medium (Zahra, 1969) for 1 week at 28°C and then, enriched on nutrient broth medium (Difco, 1984) for 48 hours at 28°C. Inocula of *B. circulans* (1×10^8 cell/ml) before transplanting the seedlings washed with water and air dried then inoculated by dipping its root system in cell suspension of *Bacillus circulans* (1×10^8 cell/ml) for 60 min before transplanting.

Microbiological determination:

The plate count method was used to determine *B. circulans* bacteria using Aleksandrov's medium. Plants were harvested (50% of the plant leaves turned yellow). Harvest was done at 5th and 10th of May for first and second seasons respectively. A random sample of ten plants from each experimental unit was taken at 100 days after planting and the following data were recorded:

- Plant height (cm).
- Dehydrogenase activity in the rhizosphere of onion plants at 30 and 60 days the bacterial population dynamics in the rhizosphere of the plants and the dehydrogenase activity in the rhizosphere of onion plants was determined according to the method described by Skujins, 1976.

At the appropriate stage of maturity the bulbs in each plot were harvested and then

- Fresh total yield (ton fed⁻¹)
- Total yield (ton fed⁻¹) was calculated.
- Total soluble solids percentage (T.S.S. °Brix) was determined. Fol-

lowing the procedure of Waskar *et al.*, 1999.

- N, P and K analysis
- Percentage % black mould disease in bulbs.
- Weight losses percentage %.

Concentrations of N, P, and K were analyzed from matured bulbs. Five clean sample bulbs from each plot were collected randomly. The bulbs were ground and oven dried at 70°C for 48 h. The finely ground and dried tissues were wet digested using sulphuric-perchloric acid mixture (1:1) as described by A.O.A.C (2000). Total nitrogen percentage was determined by Kjeldahl method according to Jackson (1967). Total phosphorus percentage was estimated calorimetrically using the chlorostannous-reduce molybdo phosphoric blue color method and measured at the wave length of 620 nm using spectrophotometer as described by Jackson (1967). Total Potassium percentage was determined using the flame photometer as described by Jackson (1967).

All treated bulbs of each storage treatment collected back in mesh bags to the storage at room temperature (28±2) five kilogram bulb of each treatment are arranged in randomized complete block design with three replications observation on the black mould of bulbs were recorded at weekly intervals.

Disease assessments.

By the end of every storage period, bulbs were screened for disease incidence of black mould on regular intervals two, four and six months after storage. Percentages of black mould disease in bulbs were estimated and calculated as follows:

Lose weigh of bulbs reduction = $(Wz - Wa/Wz) \times 100$

Where=

Wz = Weigh of bulbs at zero time (°Kg) and

Wa= Weigh of bulbs after storage

Statistical analysis:

Data collected were subjected to Analysis of Variance (ANOVA) for obtained data in each season was performed. The measured variables were analyzed using MSTATC. Differences among treatments were evaluated by LSD test at ٥% according to procedure out lined by Gomez and Gomez (١٩٨٤).

Results and Discussion

Effect of potassium fertilizer, solubilizing bacteria and sulpher on:

١- Total count of *B. circulans*:

The obtained data in Table (٢) clearly indicate that potassium fertilizer, *Bacillus circulans* and sulphur fertilizer populations where the count of *B. circulans* at ٣٠ and ٦٠ days during the two seasons, (٤,٠٦ and ١٥,٠٠ $\times 10^7$ CFU/g and ٥,١٠ and ١٧,٠٠ $\times 10^7$ CFU /g soil) respectively gave the highest values in total count of *B. circulans*. The improvement may be as a result of the important role of these microorganisms in improving soil fertility and plant development *Bacillus spp.* and releasing certain nutrient elements (P, Fe, Zn, Mn and K) in addition to contributing with some plant growth substances. These results are in line with those obtained by Abd El-Mageed *et.al.*, (٢٠٠٤) and Massoud *et al.*, (٢٠٠٩).

Table ٢. Effect of potassium fertilizer, *B. circulans* and sulphur on total count of *B. circulans* of onion plants in the two growing seasons.

Treatments	Total count of <i>Bacillus circulans</i> (CFU x 10^7 /g soil)			
	Season ٢٠١٥/٢٠١٦		Season ٢٠١٦/٢٠١٧	
	٣٠ days	٦٠ days	٣٠ days	٦٠ days
no fertilization+ (٠) Kg S (control)	٠,٢١	٠,٢٩	٠,٢١	٠,٣٣
B. circulans + (٠) Kg S	٠,٢٤	١,٣٠	٠,٢٥	١,٥٨
K. sulphate + (٠) Kg S,	٠,٢٨	١,٣٣	٠,٢٩	٢,٤٠
Feldspar + (٠) Kg S	٠,٢٩	١,٥١	٠,٣٢	٠,٤٣
K. sulphate + B. circulans+ (٠) Kg S	٠,٣٣	٢,٣٠	٠,٣٦	٢,٥٠
Feldspar + B. circulans + (٠) Kg S	٠,٢٦	٢,٩٠	٠,٣٩	٣,٥٠
no fertilization + (١٠٠) Kg S	٠,٣١	٣,٠٠	٠,٤٢	٤,٢٢
B. circulans + (١٠٠) Kg S	٠,٣٩	٤,٩٠	٠,٤٥	٥,٤٠
K. sulphat + (١٠٠) Kg S,	١,٦٠	٥,٧٠	١,٧٠	٥,٤٠
Feldspar + (١٠٠) Kg S	١,٢١	٥,٠٠	٢,٠٠	١٠,٠٠
K. sulphate+ B. circulans + (١٠٠) Kg S	٣,٥٠	١٤,٠	٣,٥٠	١٦,٠٠
feldspar + B. circulans + (١٠٠) Kg S	٤,٠٦	١٥,٠	٥,١٠	١٧,٠٠

٢- Dehydrogenase Enzyme Activity:

The results in Table (٣) showed application of ١٠٠ kg S fed⁻¹ gave the higher values of dehydrogenase enzyme activity in the rhizosphere of onion plants cultivated in soil com-

pared with zero kg S fed⁻¹. Data also showed the positive effect of potassium fertilizer and *B. circulans* on dehydrogenase enzyme activity in the two growing seasons. The highest values on dehydrogenase enzyme activity were recorded in the combined

treatment feldspar with *B. circulans* at 30 days (29,200 and 28,207 µg), at 60 days, (00,900 and 49,990 µg) among the other studied treatments in the both seasons compared to control treatment.

Interactions between potassium fertilizer, *B. circulans* and sulphur fertilizer reversed to dehydrogenase enzyme activity in the rhizosphere of onion plants. It could be revealed from the results that application feldspar,

B. circulans compared to control and other treatments. The significantly increase values were 30,600 and 63,800 µg TPF (triphenylformasan) at 30 and 60 days during the second season on the other hand, it recorded 34,667 and 62,833 µg TPF at 30 and 60 days, respectively during the second season. These results are in line with those obtained by Massoud *et al.*, (2009).

Table 3. Effect of potassium fertilizer, *B. circulans*, sulphur and interactions on dehydrogenase enzyme activity for 30 and 60 days in the rhizosphere of onion plants in two growing seasons.

Treatments	Season 2015/2016		Season 2016/2017		
	30 days	60 days	30 days	60 days	
Sulphure					
(0) S	20,117*	33,077	19,108	32,147	
100 K.g S	29,070	49,433	28,714	48,448	
LSD%	0,170	1,706	0,202	1,801	
Feldspar, K. sulphate and <i>B.circulans</i>					
no fertilization	20,070	33,070	19,078	32,030	
<i>Bcirculans</i>	20,700	37,100	19,713	30,140	
K. sulphate	23,470	38,270	22,018	37,402	
Feldspar	27,700	41,020	27,733	40,073	
K. sulphate+ <i>B.circulans</i>	28,070	47,070	27,127	47,700	
feldspar + <i>B.circulans</i>	29,200	00,900	28,207	49,990	
LSD%	0,107	1,797	0,187	0,980	
Interaction A×B					
no fertilization	(0)Kg S	17,400	20,400	10,413	24,433
<i>B.circulans</i>		23,700	30,800	22,723	39,727
K. sulphate		17,700	33,000	17,770	29,827
Feldspar		23,700	34,700	22,707	40,403
K. sulphate+ <i>B.circulans</i>		20,000	37,400	19,700	32,297
feldspar + <i>B.circulans</i>		27,400	38,100	20,437	42,707
no fertilization	100 K.g S	21,700	40,700	20,733	33,797
<i>B.circulans</i>		33,000	41,400	32,033	47,400
K. sulphate		21,700	43,000	20,783	30,480
Feldspar		34,000	48,400	33,070	07,720
K. sulphate+ <i>B.circulans</i>		22,800	08,700	21,847	37,147
feldspar + <i>B.circulans</i>		30,700	63,800	34,667	62,833
LSD%		0,377	2,400	0,440	2,347

*dehydrogenase enzyme activity (µg TPF)

3-On plant height, fresh weight and bulb yield:

Data given in Table (2) show that using of 100 kg fed⁻¹ of sulphur scored the higher values of plant height (cm), fresh weight (ton fed⁻¹) and yield (ton fed⁻¹) of onion compared with zero kg fed⁻¹. Results also showed that potassium fertilizer and *B. circulans* had a significant effect on plant height (cm), fresh weight (ton fed⁻¹) and yield (ton fed⁻¹) of onion in the two growing seasons. The highest values of plant height (73,067 and 73,633 cm), fresh weight (0,683 and 0,767 ton fed⁻¹) and yield (2,677 and 0,087 ton fed⁻¹) were recorded in application combined feldspar with *B. circulans*. The lowest values were recorded in control treatment among the other studied treatments in the 1st and 2nd seasons respectively. Interactions between po-

tassium fertilizer, *B. circulans* and sulphur had a significant effect on plant height (cm), fresh weight (ton fed⁻¹) and yield (ton fed⁻¹) in the two growing seasons except plant height and fresh weight in the second season. This result might be due to better growth and development of onion plant. This higher photosynthate accumulation in the clove from higher leaves/plant would ensure higher bulbs, large bulb diameter and higher bulb fresh weight, similar results were obtained by Kuldeep *et al.*, (2012) Basma *et al.*, (2018). Onion is an important sulphur-loving crop and sulphur is essentially required for proper growth and yield of crops. Sulphur has been found not only to increase the bulb yield but also improve its quality especially pungency and flavors (Jaggi and Dixit, 1999).

Table 4. Effect of potassium fertilizer, *B. circulans*, sulphur and interactions on plant height, fresh weight and yield of onion in the two growing seasons.

Treatments	Season 2015/2016			Season 2016/2017			
	P-high (cm)	Weight (ton /fed)	Yield t/fed	P-high (cm)	Weight (ton /fed)	Yield t/fed	
Sulphure							
(0) S	64,028	4,011	3,820	60,294	4,739	4,041	
100 K.g S	69,478	0,478	4,332	69,767	0,044	4,887	
LSD%	0,000	0,164	0,120	1,184	0,183	0,043	
feldspar , K. sulphate and <i>B.circulans</i>							
no fertilization	60,400	3,917	3,473	61,167	4,033	3,732	
<i>B.circulans</i>	62,617	4,417	3,737	63,417	4,817	4,140	
K. sulphate,	66,000	0,000	3,922	67,400	0,167	4,200	
Feldspar	68,117	0,200	4,144	68,700	0,317	4,022	
K. sulphate+ <i>B.circulans</i>	71,267	0,700	4,048	70,817	0,700	0,090	
feldspar + <i>B.circulans</i>	73,067	0,683	4,677	73,633	0,767	0,087	
LSD%	0,700	0,138	0,210	1,604	0,339	0,121	
Interaction A×B							
no fertilization	(0)Kg S	08,767	3,267	3,107	09,033	3,600	3,283
<i>B.circulans</i>		62,133	4,067	3,840	62,800	4,467	4,180
K. sulphate		60,883	3,900	3,473	61,867	4,333	3,667
Feldspar		64,400	4,933	4,000	64,967	0,300	4,603
K. sulphate+ <i>B.circulans</i>		62,733	4,333	3,660	64,233	4,700	3,890
feldspar + <i>B.circulans</i>		70,267	0,667	4,183	70,067	0,633	4,020
no fertilization	100 K.g S	64,833	4,700	3,777	60,400	4,833	4,130
<i>B.circulans</i>		71,400	0,700	4,010	72,100	0,800	4,913
K. sulphate		68,767	0,233	4,193	68,033	0,267	4,310
Feldspar		73,767	6,267	4,903	73,100	6,233	0,880
K. sulphate+ <i>B.circulans</i>		71,233	0,633	4,800	72,200	0,700	4,907
feldspar + <i>B.circulans</i>		74,900	0,733	4,003	70,067	0,833	0,217
LSD%		1,347	0,401	0,184	NS	NS	0,100

4-On total soluble (TSS), nitrogen, phosphorus and potassium content:

Results in Table (5) Showed that application of 100 kg S fed⁻¹ had

the higher values of total soluble solids (TSS), nitrogen, phosphorus and potassium contents of onion compared to application of zero kg fed⁻¹

in the two growing seasons. Onion required sulphur fertilization in increasing the dry matter production. Data in Table (5) indicated that potassium fertilizer and *B. circulans* had a significant effect on total soluble solids (TSS), nitrogen, and phosphorus and potassium contents by onion in the two growing seasons. The highest values on total soluble solids (TSS) (10.607 and 10.092 %), nitrogen (2.180 and 2.188 %), phosphorus (0.416 and 0.417 %) and potassium contents (0.803 and 0.808 %) of onion were recorded in application combined feldspar with *B. circulans*. The lowest values of total soluble solids (TSS) (9.003 and 9.638), nitrogen (1.817 and 1.820), phosphorus (0.370 and 0.371) and potassium (0.702 and 0.760) contents were recorded in control treatment. The obtained results are in accordance with those obtained by Balasubramonian *et al.*, (1999) and Singh and Rathi (1987). Among the various nutrients required to produce high yield, potassium deficiency dramatically reduced leaf area and

dry matter accumulation and affected assimilate partitioning among plant tissues (Sindhu *et al.*, 2010). Potassium solubilizing bacteria (KSB) dissolve potassium from insoluble K-bearing minerals such as micas, illite and orthoclase, by excreting organic acids which either directly dissolved rock K or chelated silicon ions to bring K into the solution. Sheng (2000) stated that using KSB led to improve the growth of pepper plants.

Data for interactions between of potassium fertilizer, *B. circulans* and sulphur on total soluble solids (TSS), nitrogen, phosphorus and potassium contents by onion in the two growing seasons. Result cleared that interaction applications had a significant effect on the all previous traits, irrespective of interaction applications with or without sulphur. This result might be due to sulphur has been found not only to increase the bulb yield but also improve its quality especially pungency and flavors (Jaggi and Dixit, 1999).

Table 6. Effect of potassium fertilizer, *B. circulans*, sulphur and interactions on total soluble solids (TSS), nitrogen, phosphorus and potassium contents of onion in the two growing seasons.

Treatments	Season 2015/2016				Season 2016/2017				
	T.S.S (%)	N (%)	P (%)	K (%)	T.S.S (%)	N (%)	P (%)	K (%)	
Sulphure									
(0) S	9,827	1,926	0,386	0,777	9,807	1,932	0,387	0,783	
100 K.g S	10,423	2,146	0,399	0,822	10,411	2,148	0,402	0,842	
LSD%	0,090	0,046	0,002	0,011	0,086	0,040	0,003	0,011	
Feldspar, K. sulphate and <i>B.circulans</i>									
no fertilization	9,003	1,817	0,370	0,702	9,638	1,820	0,371	0,760	
<i>B.circulans</i>	9,823	1,870	0,370	0,706	9,700	1,883	0,379	0,777	
K. sulphate	10,040	2,000	0,380	0,770	9,993	2,007	0,387	0,798	
Feldspar	10,248	2,113	0,393	0,800	10,162	2,110	0,396	0,820	
K. sulphate+ <i>B.circulans</i>	10,28	2,170	0,416	0,802	10,019	2,182	0,417	0,812	
feldspar + <i>B.circulans</i>	10,607	2,180	0,416	0,803	10,092	2,188	0,417	0,808	
LSD%	0,171	0,019	0,004	0,014	0,141	0,019	0,006	0,019	
Interaction A×B									
no fertilization	(0) Kg S	9,207	1,797	0,370	0,737	9,397	1,710	0,371	0,740
<i>B.circulans</i>		9,800	1,937	0,381	0,767	9,880	1,930	0,381	0,780
K. sulphate		9,090	1,770	0,374	0,700	9,070	1,790	0,376	0,707
feldspar		10,007	1,980	0,386	0,780	9,930	1,997	0,392	0,797
K.sulphate+ <i>B.circulans</i>		9,860	1,930	0,383	0,760	9,820	1,927	0,383	0,780
feldspar+ <i>B.circulans</i>		10,220	2,180	0,387	0,780	10,167	2,187	0,392	0,817
LSD%		0,171	0,019	0,004	0,014	0,141	0,019	0,006	0,019
no fertilization	100 K.g S	9,890	2,007	0,390	0,790	9,737	2,000	0,391	0,790
<i>B.circulans</i>		10,607	2,220	0,397	0,820	10,087	2,220	0,402	0,800
K. sulphat		10,087	2,000	0,400	0,797	9,991	2,007	0,403	0,807
feldspar		10,970	2,300	0,427	0,920	11,047	2,307	0,432	0,917
K.sulphate+ <i>B.circulans</i>		10,327	2,110	0,410	0,827	10,327	2,110	0,418	0,827
feldspar+ <i>B.circulans</i>		10,887	2,260	0,417	0,880	10,807	2,267	0,417	0,890
LSD%		0,221	0,113	0,004	0,026	0,210	NS	0,009	0,028

6- On storability of onion:

Results in Table (7) showed that the effect of sulphur fertilizer levels on weight loss (%) of onion bulb during the storage period for 7 months in the two seasons. Results cleared that sulphur fertilizer levels had a significant effect on weight loss % of onion bulb during the storage period for 7 months in both seasons. The present results indicated that increasing sulphur fertilizer. Combined with potassium fertilizer and *B. circulans* had a significant effect on weight loss % of onion during the storage period for 7

months in the two growing seasons. The lowest values on weight loss % of onion during the storage period for 7 months by onion were recorded in feldspar with *B. circulans*. The lowest values of weight loss % of onion bulb during the storage period for two months (3,012 and 2,440%), four months (8,990 and 8,768%) and six months (13,209 and 12,033) among the other studied treatments in the 1st and 2nd seasons respectively. Water loss of onion bulb was lower at higher potassium levels and this relationship is proved to be significant in

the absence of N application. These results agree with those mentioned by Deepa *et al.*, (2018).

No significant interactions between potassium fertilizer, *B. circulans* and sulphur fertilizer with regard to weight loss % of onion bulb during the storage period for 6 months in the two seasons are shown in Table (ξ). It could be revealed from the results that application feldspar, *B. circulans* and sulphur recorded the lowest val-

ues of weight loss % of onion bulb during the storage period for two months except four months in first season and two months in second season. Zaki *et al.* (2018) referred that there was decrease in bulb weight loss during storage might be due to improve the uptake of both macro and microelements, which positively influenced by biofertilizer with/without sulphur.

Table 6. Effect of potassium fertilizer, *B. circulans*, sulphur and interactions on weight loss % of onion bulb during storage period for 6 months of onion in two growing seasons.

Treatments	Season 20/2016			Season 2016/2017			
	2 months	ξ months	6 months	2 months	ξ months	6 months	
Sulphure							
(0) S	3,408*	11,30ξ	16,118	3,027	11,376	10,073	
100 K.g S	3,069	9,60ξ	13,806	2,098	9,ξ32	13,229	
LSD%	0,12ξ	0,330	0,816	0,0ξ9	0,003	0,6ξξ	
feldspar , K. sulphate and <i>B.circulans</i>							
no fertilization	3,602	12,ξ80	17,000	3,280	13,130	16,668	
<i>B.circulans</i>	3,002	11,900	16,700	3,133	11,660	10,772	
K. sulphate	3,217	10,ξ80	10,287	2,770	10,700	1ξ,718	
Feldspar	3,120	10,000	1ξ,770	2,690	9,370	1ξ,117	
K. sulphate+ <i>B.circulans</i>	3,070	9,170	12,700	2,30	8,778	12,600	
feldspar + <i>B.circulans</i>	3,012	8,990	13,209	2,ξξ0	8,768	12,033	
LSD%	0,10ξ	0,ξ08	1,721	0,089	0,622	1,060	
Interaction A×B							
no fertilization	(0)Kg S	3,803	13,097	17,0ξ3	3,ξ00	1ξ,130	17,ξ00
<i>B.circulans</i>		3,000	11,863	16,067	3,110	12,1ξ0	10,887
K. sulphate		3,637	12,683	17,363	3,283	12,860	16,020
Feldspar		3,367	11,127	16,0ξ7	2,983	10,6ξ0	10,023
K. sulphate+ <i>B.circulans</i>		3,010	11,9ξ3	16,733	3,133	12,ξ93	16,070
feldspar + <i>B.circulans</i>		2,923	9,017	13,8ξ0	2,ξ17	8,917	13,367
no fertilization		100 K.g S	3,363	11,183	16,333	2,980	10,000
<i>B.circulans</i>	2,887		8,817	13,217	2,ξ10	8,700	12,767
K. sulphate	3,293		9,8ξ0	1ξ,000	2,763	9,090	1ξ,200
Feldspar	2,883		8,600	12,267	2,360	8,307	11,333
K. sulphate+ <i>B.circulans</i>	3,1ξ0		9,380	1ξ,233	2,000	9,180	13,733
feldspar + <i>B.circulans</i>	2,807		8,000	10,900	2,307	7,967	11,000
LSD%	Ns		0,819	ns	0,120	Ns	Ns

* Bulb weigh loss (%)

๒-On onion black mould incidence:

Results in Table (๖) cleared that sulphur fertilizer had a significant effect on black mold % of onion bulb during the storage period for ๒ months in both seasons. The present results indicated that increasing sulphur fertilizer to ๑๐๐ kg S fed⁻¹ decreased onion black mold compared to ๐ kg S fed⁻¹. Sulphur containing secondary compounds are not only important for nutritive value or flavors but also for resistance against pest and diseases (Bell, ๑๙๙๑). Results in Table (๖) Showed that potassium fertilizer and *B. circulans* significantly decreased onion black mold after two, four and six months under storage conditions compared to untreated controls in two successive seasons (๒๐๑๐/๒๐๑๑ and ๒๐๑๑/๒๐๑๒). The lowest values on onion black mold % of onion were obtained during the storage period for ๒ months. Potassium sulphate with, bio-fertilizer (*B. circulans*) and feldspar with *B. circulans* recorded the lowest values of onion black mold % of onion bulb during the storage period for two months (๕,๒๓๓, ๕,๒๓๓ and ๕,๐๖๗, ๓,๘๓๓%), four months (๗,๖๖๗, ๗,๖๖๗ and ๑๐,๖๖๗, ๑๐,๐๐๐%) and six months (๑๕,๕๓๓ and

๑๐,๓๐๐) among the other studied treatments in the ๑st and ๒nd seasons respectively. Potassium is responsible for the activation of nitrate reductase enzyme enhance its quality, shelf life of fruit and vegetables, reduces lodging of crops, enhance winter hardiness and imparts disease. Potassium is one of the three major nutrients taken up by the plant in large quantities and the adequate level of potassium increases crop resistance to various diseases (Dayal, *et al.* ๒๐๑๐). A significant interactions between K, sulphate, feldspar, *B. circulans* and sulphur fertilizer with regard to black mold% of onion bulb during the storage period for ๒ months in the two seasons are shown in Table (๐). It could be revealed from the results that all treatments recorded the lowest values of black mold % of onion bulb during the storage period for two (๕,๐๐๐ and ๓,๖๐๐), four (๖,๖๖๗ and ๘,๐๐๐) and six months (๑๕,๐๐๐ and ๑๕,๓๓๓) compared to control (no fertilization). Black mold % of onion bulb during the storage period for two (๑๐,๑๖๗ and ๑๐,๐๐๐), four (๒๕,๒๓๓ and ๒๐,๒๓๓) and six months (๒๘,๖๖๗ and ๓๐,๓๓๓) among the other studied treatments in the ๑st and ๒nd seasons respectively.

Table V. Effect of potassium fertilizer, *B. circulans*, sulphur and interactions on incidence of onion black mold after two, four and six months of storage under natural infection in the two growing seasons.

Treatments	Season 2015/2016			Season 2016/2017			
	2 months	4 months	6 months	2 months	4 months	6 months	
Sulphure							
(.) S	7,028 *	10,739	17,761	7,283	13,000	18,100	
100 K.g S	0,917	8,278	17,706	4,800	14,333	17,444	
LSD%	0,431	1,989	1,097	1,387	1,242	0,187	
feldspar, K. sulphate and <i>B.circulans</i>							
no fertilization	11,333	17,333	23,333	10,417	23,000	24,333	
<i>B.circulans</i>	0,333	7,767	17,033	4,067	10,967	10,200	
K. sulphate	7,333	8,700	18,133	0,367	17,000	17,933	
Feldspar	0,767	7,767	17,017	4,000	10,967	17,067	
K. sulphate+ <i>B.circulans</i>	4,333	7,767	10,100	4,067	10,767	10,800	
feldspar + <i>B.circulans</i>	4,333	7,767	14,433	3,833	10,000	10,300	
LSD%	1,107	1,360	1,080	1,006	1,187	1,416	
Interaction A×B							
no fertilization	(.)Kg S	10,167	24,333	28,767	10,000	20,333	30,333
<i>B.circulans</i>		7,000	10,33	18,000	4,800	11,333	17,067
K. sulphate		4,767	8,167	19,700	0,400	11,333	10,033
Feldspar		7,767	9,333	10,733	4,200	10,700	17,067
K. sulphate+ <i>B.circulans</i>		4,000	8,333	17,767	4,200	10,000	17,067
feldspar + <i>B.circulans</i>		7,767	8,000	14,867	4,067	9,400	17,767
no fertilization	100 K.g S	7,767	8,767	17,000	0,333	10,767	18,333
<i>B.circulans</i>		4,767	7,333	10,067	4,333	10,700	14,333
K. sulphate		4,767	7,333	17,767	0,333	9,767	17,333
Feldspar		4,000	7,000	10,400	4,800	9,333	17,067
K. sulphate+ <i>B.circulans</i>		4,000	8,000	10,000	4,933	9,333	10,033
feldspar + <i>B.circulans</i>		4,000	7,767	14,000	3,700	8,000	14,333
LSD%	1,060	1,924	2,230	1,423	1,780	2,003	

* Black mold (%)

In conclusion, this study revealed that application of feldspar, *B. circulans* and sulphur fertilizer gave the higher values of the total count of *B. circulans* dehydrogenises enzyme activity, plant height, fresh weight, bulb yield, total soluble solids (TSS), nitrogen, phosphorus and potassium

contents by onion percentages, as well as the lowest values of weight loss percentage and black mold of onion blub during the storage period for 7 months.

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تأثير التسميد البوتاسي والبكتريا المذيبة للبوتاسيوم والكبريت على المحصول وجوده الابصال والقدرة التخزينيه ومرض العفن الاسود فى البصل

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الملخص

تم اجراء هذا العمل في محطة البحوث الزراعية بملوي محافظة المنيا خلال موسمي الشتاء ٢٠١٥ / ٢٠١٦ و ٢٠١٦ / ٢٠١٧ لدراسة تأثير التسميد البوتاسي والبكتيريا الميسره للبوتاسيوم والكبريت على المحصول وجوده الابصال والقدرة التخزينية ومرض العفن الاسود فى البصل (صنف جيزة ٦). اوضحت النتائج التى تم الحصول عليها ان هناك تأثيرا معنويا لهذه المعاملات. اضافة الفلسمبار والتسميد الكبريتى اعطت افضل المعاملات لانها سجلت اعلى القيم فى العدد الكى للبكتيريا الميسره للبوتاسيوم ونشاط انزيم الديهيدروجينيز وارتفاع النبات والوزن الطازج ومحصول الابصال بالطن للقدان واعلى قيم للمواد الصلبة الكلية و النسبه المئويه للنيتروجين والفوسفور والبوتاسيوم فى الابصال وكذلك اقل القيم بالنسبة المئوية للفقد فى المحصول وايضا نسبة الاصابة بمرض العفن الاسود فى البصل خلال الست شهور فترة التخزين لكلا الموسمين على التوالى وكانت مناسبة للانتاجية والجودة والتخزين تحت ظروف التجربة.