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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 10^6 /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.,* 2015 and Samuel and Ifeanyi, 2015). The cultivated area in Egypt was 196968 fed., in 2014/2015 season, produced 2,888,791 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 processes in the plant including photosynthesis, enhancing the translocation of assimilates, protein synthesis, maintenance of water balance and promoting enzyme activities are well established (Marschner 1995) 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, (2005) 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, 1995; 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 *el al.,* (1983) reported that in some exotic cultivars, storage loss is even 100%. 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, 2015). About 35-40 % 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.,* 2015). 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 quantitative of onion Giza 6 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 2015/2016 and 2016/2017. 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 100 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 2, 4 and 6 months from storage were recorded at room temperature. Each plot was 3.0 x 3.5 m^2 (10.5 m^2 = 1/400 feddan). Sixty day-old transplants of onion Giza 6 cv each plot at the recommended spacing 10 cm on the third week of December. The recommended agricultural practices for onion were used. As ammonium sulphate (N 20.6%), calcium super phosphate (P_2O_5 15.5%), and potassium sulphate (K_2O 48%) 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, 60 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.,* 1965). Sampling dates were two weeks before transplants. Some main soil chemical, and fertility characteristics are presented in Table (1):

Some physiochemical analysis of the experimental soil at depth (0-30 cm) before Plantation in 2015/2016 and 2016/2017 seasons.

Properties	2015 / 2016	2016 / 2017
Physical analysis:-		
Sand (%)	8.47	10.11
Silt (%)	54.71	49.32
Clay (%)	36.82	40.57
Soil texture	Silty clay loam	
Mechanical analysis:-		
Organic matter (%)	1.60	1.72
pH soil – water suspension ratio (1:2.5)	8.14	8.00
EC (ds m^{-1}) soil – water extract ratio (1:5)	1.52	1.59
Soluble cations (meq/L):-		
Ca^{++}	7.25	7.45
Mg^{++}	2.10	2.15
Na^{+}	3.20	3.22
K^{+}	0.18	0.20
Soluble anions (meq/L) :-		
CO_3^{-}	---	---
HCO_3^{-}	3.18	3.20
Cl^{-}	4.15	4.10
SO_4^{--}	5.40	5.72
Available nutrient		
Available N %	0.19	0.18
Available P (ppm)	16	19
Available K (ppm)	250	270

Preparations of *Bacillus circulans*;

Bacillus circulans isolate obtained from the microbiology department, Agriculture Research Center, Giza, Egypt. It was inoculated in 250 ml conical flasks that possessed 100 ml Aleksandrov's medium (Zahra, 1969) for 4 week at 28°C and then, enriched on nutrient broth medium (Difco, 1984) for 48 hours at 28°C. Inocula of *B. circulans* (1x 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*(11x10^8 cell/ml) for 60 min before transplanting.

Microbiological determination:

The plate count method was used to determined *B. circulans* bacteria using Aleksandrov's medium. Plants were harvested (50 % of the plant leafs 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 150 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. ºBrix) was determined. Following 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 over dried at 65°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 chlorostannus-reduce molybdo phosphoric blue color method and measured at the wave length of 640 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 black 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) ×100
Where=
Wz = Weigh of bulbs at zero time (5Kg) 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 5% according to procedure out lined by Gomez and Gomez (1984).

Results and Discussion

Effect of potassium fertilizer, solubilizing bacteria and sulpher on:

1-Total count of *B. circulans*:

The obtained data in Table (2) clearly indicate that potassium fertilizer, *Bacillus circulans* and sulphur fertilizer populations where the count of *B. circulans* at 30 and 60 days during the two seasons, (4.06 and 15.00 × 10^6 CFU/g and 5.10 and 17.00× 10^6 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.*, (2004) and Massoud *et al,*.(2009).

Table 2. 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 *Bacillus circulans* (CFU x 10^6 /g soil)			
	Season 2015/2016		Season 2016/2017	
	30 days	60 days	30 days	60 days
no fertilization+ (0) Kg S (control)	0.21	0.29	0.21	0.33
B. circulans + (0) Kg S	0.24	1.30	0.25	1.58
K. sulphate + (0) Kg S,	0.28	1.33	0.29	2.40
Feldspar + (0) Kg S	0.29	1.51	0.32	0.43
K. sulphate + B. circulans+ (0) Kg S	0.33	2.30	0.36	2.50
Feldspar + B. circulans + (0) Kg S	0.26	2.90	0.39	3.50
no fertilization + (100) Kg S	0.31	3.00	0.42	4.22
B. circulans + (100) Kg S	0.39	4.90	0.45	5.40
K. sulphat + (100) Kg S,	1.60	5.70	1.70	5.40
Feldspar + (100) Kg S	1.21	5.00	2.00	10.00
K. sulphate+ B. circulans + (100) Kg S	3.50	14.0	3.50	16.00
feldspar + B. circulans + (100) Kg S	4.06	15.0	5.10	17.00

2- Dehydrogenase Enzyme Activity:

The results in Table (3) showed application of 100 kg S fed^{-1} gave the higher values of dehydrogenase enzyme activity in the rhizosphere of onion plants cultivated in soil compared 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* 30days (29.200 and 28.257µg), at 60 days, (50.950 and 49.990 µg) among the other studied treatments in the both seasones compared to control treatment.

Interactions between potassium fertilizer, *B. circulans* and sulphur fertilizer revered 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 35.600 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*	33.067	19.158	32.147
100 K.g S		29.575	49.433	28.614	48.448
LSD5%		0.175	1.656	0.202	1.851
Feldspar , K. sulphate and *B.circulans*					
no fertilization		20.075	33.075	19.068	32.030
Bcirculans		20.650	36.100	19.713	35.140
K. sulphate		23.475	38.275	22.518	37.452
Feldspar		27.600	41.525	26.633	40.573
K. sulphate+ *B.circulans*		28.075	47.575	27.127	46.600
feldspar + *B.circulans*		29.200	50.950	28.257	49.990
LSD5%		0.157	1.697	0.186	0.980
Interaction A×B					
no fertilization	(0)Kg S	16.400	25.400	15.413	24.433
B.circulans		23.750	30.800	22.723	39.627
K. sulphate		17.600	33.000	16.670	29.827
Feldspar		23.700	34.650	22.757	40.453
K. sulphate+ *B.circulans*		20.550	36.450	19.600	32.297
feldspar + *B.circulans*		26.400	38.100	25.437	42.607
no fertilization	100 K.g S	21.700	40.750	20.733	33.697
B.circulans		33.500	41.400	32.533	47.450
K. sulphate		21.650	43.550	20.683	35.480
Feldspar		34.500	48.400	33.570	57.720
K. sulphate+ *B.circulans*		22.800	٥٨.٧٠٠	21.847	37.147
feldspar + *B.circulans*		35.600	63.800	34.667	62.833
LSD5%		0.377	2.400	0.445	2.347

*dehydrogenase enzyme activity (µg TPF)

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

Data given in Table (4) 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 (5.683 and 5.767 ton fed^{-1}) and yield (4.677 and 5.087 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 potassium 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-high1 (cm)	Weight (ton /fed)	Yield t/fed	P-high (cm)	Weight (ton /fed)	Yield t/fed
Sulphure							
(0) S		64.528	4.511	3.825	65.294	4.739	4.041
100 K.g S		69.478	5.478	4.332	69.767	5.544	4.886
LSD5%		**0.550**	**0.164**	**0.120**	**1.184**	**0.183**	**0.043**
feldspar , K. sulphate and *B.circula*ns							
no fertilization		60.450	3.917	3.473	61.167	4.033	3.732
B.circulans		62.617	4.417	3.737	63.417	4.817	4.140
K. sulphate,		66.500	5.000	3.922	67.400	5.167	4.205
Feldspar		68.117	5.200	4.144	68.750	5.317	4.522
K. sulphate+ *B.circulans*		71.267	5.750	4.548	70.817	5.750	5.095
feldspar + *B.circulans*		73.067	5.683	4.677	73.633	5.767	5.087
LSD5%		**0.755**	**0.138**	**0.215**	**1.604**	**0.339**	**0.121**
Interaction A×B							
no fertilization	(0)Kg S	58.767	3.267	3.107	59.533	3.600	3.283
B.circulans		62.133	4.567	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	5.300	4.603
K. sulphate+ *B.circulans*		62.733	4.333	3.660	64.233	4.700	3.890
feldspar + *B.circulans*		70.267	5.667	4.183	70.567	5.633	4.520
no fertilization	100 K.g S	64.833	4.700	3.777	65.400	4.833	4.130
B.circulans		71.400	5.700	4.510	72.100	5.800	4.913
K. sulphate		68.767	5.233	4.193	68.533	5.267	4.310
Feldspar		73.767	6.267	4.903	73.100	6.233	5.880
K. sulphate+ *B.circulans*		71.233	5.633	4.800	72.200	5.700	4.957
feldspar + *B.circulans*		74.900	5.733	4.553	75.067	5.833	5.217
LSD5%		**1.347**	**0.401**	**0.184**	**NS**	**NS**	**0.105**

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 10.592 %), nitrogen (2.185 and 2.188 %), phosphorus (0.416 and 0.417 %) and potassium contents (0.853 and 0.858 %) of onion were recorded in application combined feldspar with *B. circulars*. The lowest values of total soluble solids (TSS) (9.503 and 9.638), nitrogen (1.817 and 1.820), phosphorus (0.370 and 0.371) and potassium (0.752 and 0.760) contents were recorded in control treatment. The obtained results are in accordance with those obtained by Balasubramonian *et al*., (1979) 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 (2005) 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 5. 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
LSD5%		**0.090**	**0.046**	**0.002**	**0.011**	**0.086**	**0.040**	**0.003**	**0.011**
Feldspar, K. sulphate and *B.circula*ns									
no fertilization		9.503	1.817	0.370	0.752	9.638	1.8.20	0.371	0.760
B.circulans		9.823	1.870	0.375	0.756	9.750	1.883	0.379	0.777
K. sulphate		10.040	2.055	0.385	0.770	9.993	2.057	0.387	0.798
Feldspar		10.248	2.113	0.393	0.805	10.162	2.110	0.396	0.820
K. sulphate+ *B.circulans*		10.28	2.175	0.416	0.852	10.519	2.182	0.417	0.862
feldspar + *B.circulans*		10.607	2.185	0.416	0.853	10.592	2.188	0.417	0.858
LSD5%		**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	1.697	0.360	0.737	9.397	1.710	0.361	0.740
B.circulans		9.800	1.937	0.381	0.767	9.880	1.930	0.381	0.780
K. sulphate		9.590	1.760	0.364	0.750	9.570	1.790	0.366	0.757
feldspar		10.057	1.980	0.386	0.780	9.930	1.997	0.392	0.797
K.sulphate+ *B.circulans*		9.860	1.930	0.383	0.760	9.820	1.927	0.383	0.780
feldspar+ *B.circulans*		10.220	2.180	0.387	0.7.80	10.167	2.187	0.392	0.817
no fertilization	100 K.g S	9.890	2.007	0.390	0.790	9.737	2.000	0.391	0.790
B.circulans		10.607	2.220	0.397	0.820	10.587	2.220	0.402	0.850
K. sulphat		10.087	2.050	0.405	0.797	9.991	2.057	0.403	0.807
feldspar		10.970	2.300	0.427	0.920	11.047	2.307	0.432	0.917
K.sulphate+ *B.circulans*		10.327	2.110	0.415	0.827	10.327	2.110	0.418	0.827
		10.887	2.260	0.417	0.880	10.857	2.267	0.417	0.890
feldspar+ *B.circulans*		10.887	2.260	0.417	0.880	10.857	2.267	0.417	0.890
LSD5%		**0.221**	**0.113**	**0.004**	**0.026**	**0.210**	**NS**	**0.009**	**0.028**

5- On storability of onion:

Results in Table (6) showed that the effect of sulphur fertilizer levels on weight loss (%) of onion bulb during the storage period for 6 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 6 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 6 months in the two growing seasons. The lowest values on weight loss % of onion during the storage period for 6 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 2.445%), four months (8.990 and 8.768%) and six months (13.259 and 12.533) 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 (4). It could be revealed from the results that application feldspar, *B. circulans* and sulphur recorded the lowest values 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.* (2014) 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 2015/2016			Season 2016/2017		
		2 months	4 months	6 months	2 months	4 months	6 months
Sulphure							
(0) S		3.458*	11.354	16.118	3.027	11.376	15.573
100 K.g S		3.069	9.654	13.806	2.598	9.432	13.229
LSD5%		**0.124**	**0.335**	**0.816**	**0.049**	**0.553**	**0.644**
feldspar , K. sulphate and *B.circulans*							
no fertilization		3.652	12.480	17.055	3.280	13.135	16.668
B.circulans		3.502	11.905	16.705	3.133	11.660	15.772
K. sulphate		3.217	10.480	15.287	2.775	10.705	14.718
Feldspar		3.125	10.000	14.775	2.695	9.375	14.117
K. sulphate+ *B.circulans*		3.075	9.170	12.700	2.35	8.778	12.600
feldspar + *B.circulans*		3.012	8.990	13.259	2.445	8.768	12.533
LSD5%		**0.154**	**0.458**	**1.721**	**0.089**	**0.622**	**1.060**
Interaction A×B							
no fertilization	(0)Kg S	3.803	13.097	17.543	3.450	14.130	17.450
B.circulans		3.500	11.863	16.567	3.110	12.140	15.887
K. sulphate		3.637	12.683	17.363	3.283	12.860	16.520
Feldspar		3.367	11.127	16.047	2.983	10.640	15.023
K. sulphate+ *B.circulans*		3.510	11.943	16.733	3.133	12.493	16.070
feldspar + *B.circulans*		2.923	9.017	13.840	2.417	8.917	13.367
no fertilization	100 K.g S	3.363	11.183	16.333	2.980	10.000	15.467
B.circulans		2.887	8.817	13.217	2.410	8.750	12.767
K. sulphate		3.293	9.840	14.500	2.763	9.590	14.200
Feldspar		2.883	8.600	12.267	2.360	8,357	11.333
K. sulphate+ *B.circulans*		3.140	9.380	14.233	2.550	9.180	13.733
feldspar + *B.circulans*		2.857	8.500	10.900	2.307	7.967	11.000
LSD5%		**Ns**	**0.819**	**ns**	**0.120**	**Ns**	**Ns**

* Bulb weigh loss (%)

6-On onion black mould incidaence:

Results in Table (7) cleared that sulphur fertilizer had a significant effect on black mold % of onion bulb during the storage period for 6 months in both seasons. The present results indicated that increasing sulphur fertilizer to 100 kg S fed^{-1} decreased onion black mold compared to 0 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, 1981). Results in Table (7) 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 (2015/2016 and 2016/2017). The lowest values on onion black mold % of onion were obtained during the storage period for 6 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 (4.333, 4.333 and 4.567, 3.833%), four months (7.667, 7.667 and 10.667, 10.000%) and six months (14.433 and 15.300) among the other studied treatments in the 1st and 2nd 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*. 2010). 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 6 months in the two seasons are shown in Table (5). 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 (4.000 and 3.600), four (6.667 and 8.000) and six months (14.000 and 14.333) compared to control (no fertilization). Black mold % of onion bulb during the storage period for two (15.167 and 15.500), four (24.333 and 25.333) and six months (28.667 and 30.333) among the other studied treatments in the 1st and 2nd seasons respectively.

Table 7. 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							
(0) S		6.528 *	10,639	17.761	6.283	13.000	18.100
100 K.g S		5.917	8.278	16.756	4.800	14.333	16.444
LSD5%		**0.431**	**1.989**	**1.097**	**1.387**	**1.242**	**0.187**
• **feldspar, K. sulphate and *B.circulans***							
no fertilization		11.333	17.333	23.333	10.417	23.500	24.333
B.circulans		5.333	7.667	16.033	4.567	10.967	15.200
K. sulphate		6.333	8.750	18.133	5.367	16.500	16.933
Feldspar		5.667	7.667	16.517	4.500	10.967	16.067
K. sulphate+ *B.circulans*		4.333	7.667	15.100	4.567	10.667	15.800
feldspar + *B.circulans*		4.333	7.667	14.433	3.833	10.000	15.300
LSD5%		**1.107**	**1.360**	**1.580**	**1.006**	**1.187**	**1.416**
Interaction A×B							
no fertilization	(0)Kg S	15.167	24.333	28.667	15.500	25.333	30.333
B.circulans		7.500	10.33	18.000	4.800	11.333	16.067
K. sulphate		4.667	8.167	19.600	5.400	11.333	15.533
Feldspar		6.667	9.333	15.633	4.200	10.600	16.067
K. sulphate+ *B.circulans*		4.000	8.333	17.667	4.200	10.000	16.067
feldspar + *B.circulans*		6.667	8.000	14.867	4.067	9.400	16.667
no fertilization	100 K.g S	6.667	8.667	17.000	5.333	10.667	18.333
B.circulans		4.667	7.333	15.067	4.333	10.600	14.333
K. sulphate		4.667	7.333	16.667	5.333	9.667	16.333
Feldspar		**4.000**	7.000	15.400	4.800	9.333	16.067
K. sulphate+ *B.circulans*		4.000	8.000	15.000	4.933	9.333	15.533
feldspar + *B.circulans*		4.000	6.667	14.000	3.600	8.000	14.333
LSD5%		**1.565**	**1.924**	**2.235**	**1.423**	**1.680**	**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 6 months.

References

Abd El-Mageed, Y.T., Hassan, M.N.M. and Gheeth, R.H.M. (2004). Comparative studies of using chemical and biofertilizers on the growth and yield of two snap bean cultivars. Hort. Dept., Fac. Agric., Minia Univ., Egypt.

Ajay, K., Singh, O. (1994). Role of sulphur in nutrient utilizationand catalase activity in onion crop. Indian Journal of Agricultural Research 28, 15-19.

Anonymous, (2001). Annual progress report for Kharif, 1998. Division of Plant Pathology, S.K. University of Agriculture Science and Technology (Kashmir), 34 p.

AOAC International, (2000). Official methods of analysis of AOAC International. Association of Official Analytical Chemists, 2000.

Balasubramonian, A.S., Raman, G.V. and Moorthy, K.K.K.(1979). Effect of sulphur application on the yield and quality of onion (*Allium cepa* L.). Agric. Res. J. Karala, 17: 138-140.

Basma R. A. Rashwan; Ali, M.A.M. and Ferweez, H. (2018). Growth, yield, bulb quality and storability of Garlic (*Allium sativum L.*) as affected by using poultry manure, sulphur and different levels of phosphorus fertilizer J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 9 (10): 447 – 459.

Bell, A.A. (1981). Biochemical mechanism of disease resistance. Ann. Rev. Plant Physiol. 32: 2 1-81.

Black, C.A. (1965). Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. Amer. Soci. Agron., Madison, Wisconsin, USA.

Dayal H, *et al.* (2010). Effect of nitrogen, phosphorus and zinc on growth and yield of ber cv. Gola under arid and semi-arid conditions. Indian J Hortic.67:277-280.

Deepa, A.H., Wagh, A.P. and Nagre, P.K. (2018). Effect of different doses and splits of potassium on storage of onion. Research & Reviews: Journal of Ecology and Environmental Sciences, ISSN: 2347-7830.

Difco Manual, (1984). Dehydrated culture media and reagents for microbiology. laboratories incorporated Detroit. Michigan, 48232 USS, p: 621.

Gomez, K.A. and Gomez, A.A., (1984). Statistical procedures for agricultural research. 2nd ed. John Wiley and Sons, New York,.

Gupta, R., Khokhar, M.K.and Lal, R. (2012). Management of the black mould disease of Onion. J. Plant Pathol Microb., 3:133.

Hayden, N.J. and Maude, R.B. (1992). The role of seed-borne *Aspergillus niger* in transmissim of black mould of onion. Plant Patho., 41:573-581.

Hayden, N.J., Maude, R.B., Proctor, F.J. (1994a). Studies on the biology of black mold in (*Aspergillus niger*) on temperate and tropical onions 1. A comparison of sources of the disease in temperate and tropical field crops, Plant Pathol., 43: 562-569.

Hayden, N.J., Maude, R.B. and Proctor, F.J. (1994b). Studies on the biology of black mold *(Aspergillus niger*) on temperate and tropical onions 2. The effect of treatments on the control of seed- borne *A.niger*, Plant Ptho., 43: 570-578.

Hell R.(1997). Molecular physiology of plant sulfur metabolism. Planta, 202: 38–148.

Hussein, M., Hassan, M. and Abo-Elyousr, K. (2014). Biological control of *Botrytis allii* by *Trichoderma viride* on onion *Allium cepa.* World Applied Sciences Journal. Vol. 32 (3): 522 -526.

Jackson, M.L., (1967). Soil Chemical Analysis. Prentice-Hall of India Pvt. Ltd., New Delhi, 498p.

Jaggi, R.C. and Dixit, S.P. (1999). Onion (*Allium cepa*) responses to sulphur in representative vegetable growing soils of Kangra Valley of HimachalPradesh. Indian J. Agric. Sci., 69: 289-291.

Koycti, N.D. and 0zer, N. (1997). Determination of Seed borne Fungi in Onion and Their.Transmission to Onion Sets Phytoparasitica 25 (1):25-31.

Kuldeep.S., Patel, N., Bhadhauriaand, H. S. and Wankhade, V. R. (2012). Effect of entegrated nutrient management on growth and yield of garlic (*Allium sativum* L). Adv. Res. J. Crop Improv., 3(2): 164-166.

Kumar, V., Sharma, N.S. and Sagar, N.A. (2015). Post harvest management of fungal diseases in onion. A Review. Int. J. Curr. Microbiol. App. Sci., 4(6): 737-752.

Marschner H. (1995). *Mineral nutrition of higher plants.* second edition. 889pp. London: Academic Press, £29.95 (paperback). D.T. Clarkson

Massoud, O.N., Ebtsam, M. Morsy and Nadia H. El-Batanony (2009). Field response of snap bean (Phaseolus vulgaris L.) To N2-fixers bacillus carculans and arbuscular mycorrhizal fungi inoculation through accelerating rock phosphate and feldspar weathering., Australian Journal of Basic and Applied Sciences, 3(2): 844-852.

Metthananda, K.A. (1992). Varietal evaluation for storability of big onion. Seasonal Report, Maha 1991/1992, Agriculture Research Station. Maha Illuppallama. pp. 43-47.

Ozer, N. and Koycu, N.D. (1997). The pathogenicity of *Aspergillus niger* and some Fusaruim species on onion seed and seedlings. In: Proceedings of the 1o th Congress of the Mediterranean Phatopathology Union, 1-5June 1997, Monpellnier (France), pp 277-281.

Quadri, S.M.H., Srivastava, K.J., Bhonde, S. Pandey, R. U.B. and Bhagchandani, (1982). Fungicidal bioassay against certainimportant pathogens of onion. Pesticides1 6:11-16.

Rahim. M., Husain, A. A. and Siddique, M.A. (1983). Production of bulb and storage ability of three cultivars of onion. Punjab Vegetable Grower 17/18: 13-20.

Rajam, S.R. (1992). Studies on the post harvestfungal spoilage of onion. M. Sc. Ag. Thesis (Unpublished), Tamil NaduAgricultural University, Coimbatore.

Raju K, Nail MK (2006). Effect of pre-harvest spray of fungicides and botanicals on storage diseases of onion. Indian Phytopath., 59 (2): 133-141.

Samuel, O. and Ifeanyi, O. (2015). Fungi associated with the deterioration of post-harvest onion bulbs sold in some markets in Awka, Nigeria. Bioengin.Biosci., 3(5): 90-94.

Sheng, X.F. (2005). Growth promotion and increased potassium uptake of cotton and rape by apotassium releasing strain of Bacillus edaphicus. Soil Biol. and Biochem. 37: 1918-1922.

Sinclair, P.J. and Letham, D.B. (1996). Incidence and sites of visible infection of *Aspergillus niger* on bulbs of two onion (*Allium cepa*) cultivars. Australian Plant Pathol., 25: 8-11.

Sindhu, S.S., Dua, S., Verma, M.K. and Khandelwal, A. (2010). Growth promotion of legumes byinoculation of rhizosphere bacteria. In: Microbes for legume improvement. Khan, M.S., Zaidi, A. and Musarrat, J., Eds. Springer-Wien New York, Germany. pp. 195-235.

Singh, A. and Rathi, K.S. (1987). Effect of planting pattern, nitrogen and sulphur on growth and yield of toria. Indian J. Agron., 32: 450-452.

Sirois, K.L., LoParco, D.P. and Lorbeer, J.W.(1998). Development of a bio-assay to determine the presence of specified fungal pathogen of onion. In: Proceedings of the Biennial National Onion (and Other Allium) Research Conference, California, 10-12 December 1998, pp. 231-237.

Skujins, J., (1976). Extracellular enzymes in soil. CRC Crit. Rev. Microbiol., 4: 383-421.

Sumner, D.R. (1995). Black mold, In: Schwartz H.F., Mohan, S.K. Eds.), Compendium of Onion and Garlic Diseases. AmericanPhytopathology Society Press, Minnesota USA, 26-27.

Wani, A.H. and Taskeen. (2011). Management of black mold rot of onion. Mycopathol., 9: 49-49.

Waskar, D.P., Khedlar, R.M. and Garande, V.K. (1999). Effect of post harvest treatment on shelf life and quality of pomegranate in evaporative cooling chamber and ambient conditions. J. Food Sci. Technol.; 2:114–117.

Zahra, M.K. (1969). Studies on silicate bacteria M.Sc. Thesis, Fac. Agric., Cairo Univ. Egypt. pp.44.71-73.101-111.

Zaki, H.E.M., Toney, H.S. and Abd El-raouf, R.M.(2014). Response of two garlic cultivars (*Allium sativum* L.) to inorganic and organic fertilization. Nature and Science; 12(10): 52 -60.

Zhao, D., Oosterhuis, D. and Bednarz, C. (2001). Influence of Potassium Deficiency on Photosynthesis, Chlorophyll Content, and Chloroplast Ultrastructure of Cotton Plants. Photosynthetica, 39, 103.

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تاثير التسميد البوتاسى والبكتريا المذيبه للبوتاسيوم والكبريت على المحصول وجوده الابصال والقدره 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 و٢٠١٦/ ٢٠١٧ لدراسة تأثير التسميد البوتاسي والبكتيريا الميسره للبوتاسيوم والكبريت على المحصول وجودة الابصال والقدرة التخزينية ومرض العفن الاسود فى البصل (صنف جيزة ٦). اوضحت النتائج التى تم الحصول عليها ان هناك تأثيرا معنويا لهذه المعاملات. اضافة الفلسبار والتسميد الكبريتى اعطت افضل المعاملات لانها سجلت اعلى القيم فى العدد الكلى للبكتيريا الميسره للبوتاسيوم ونشاط انزيم الديهيدروجينيز وارتفاع النبات والوزن الطازج ومحصول الابصال بالطن للفدان 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.