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Onion Quality and Storage Ability Affected by Potassium Humate and NPK Doses

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Received: January 29, 2019; **Published:** April 30, 2019

Abstract

Onion is a very important vegetable crop particularly in Egypt and generally in the whole world. Minia governorate is well known for its onion and garlic with high production and good qualities of the products. Great amounts of onion bulbs produced during April and May in Minia are stored for several months up to a year until the new production of the next season. In order to cover the market needs for dry bulbs throughout the year, a substantial amount of total product has to be stored in storage rooms before marketing at different stores. Moreover, storage is applied at various steps throughout the marketing process from farmer-to-consumer, where bulbs are stored for either short or long term depending on market needs. Therefore, these experiments were conducted to study the behavior of stored yellow onion bulbs (Giza 6 Mohassan cultivar) previously treated with different doses of potassium humate (2 and 4 kg/fed) and NPK fertilizers (50 and 100% of the recommended dose/fed) during the growing winter seasons of 2015/2016 and 2016/2017. Harvested bulbs from different treatments were stored for 10 months in storing rooms and data of single bulb weights before and after storing, Weight loss percentage, bulb diameters, culls and sprouted bulbs were recorded. Results showed that the single treatment of 100% of the recommended dose NPK affected the production of bulbs and gave higher values of bulb weights before storing these bulbs comparing to the single dose of 50% of the recommended dose but unfortunately was not good for storage and resulted in the highest percentages of culls and sprouted bulbs after storing for 10 months. On the contrary, onion plants treated with the combination of 4 kg of potassium humate and 100% or 50% of the recommended dose of NPK fertilizers gave the highest values of bulb weights and these bulbs were suitable for storing with good qualities and lower percentages of culls and sprouting bulbs. From the previous results, it is recommended to treat onion plants with 4 kg of potassium humate plus 50% or 100% of the recommended dose of NPK during the growing season to get high yield of bulbs with good quality to be suitable for storing for several months.

Keywords: *Onion (Allium cepa L.); Bio Stimulants; NPK; Storage Ability*

Introduction

Onion (*Allium cepa* L.) belongs to the family Amaryllidaceae and is one of the most important mono-cotyledonous crops. It is a cross pollinated and cool season vegetable crop [1]. It can be eaten fresh, fried, roasted or boiled and can be dried. It is also used as spice or for medicinal purposes [2]. High amounts of fresh and dried onion products are exported from Egypt to different countries all over the world [3]. The world annual production of onion is about 85,795,191 tons of dry bulbs, with 6,521,723 tons of them being marketed worldwide [4]. The average cultivation area of onion in Egypt was about 155000 feds with a production of an average of 18.0 ton of bulbs/fed [5].

Humic acid or potassium humate plays an important role in improving soil pH which reflected on elements availability to be absorbed by plant roots and consequently improve plant growth and productivity [6]. Potassium humate can reduce water evaporation from the soil. Also, it increases soil water holding capacity, permeability of the plant membranes and intensify enzyme systems of plants. It enhances cell division, root growth, and decrease stress deterioration. Under the effect of humic acids, plants grow more stronger and acquire best resistance of plant diseases [7]. Humates reduces soil erosion by increase cohesive forces of the fine soil particles. They enhance the soil structure, especially physical properties by increasing buffering qualities and exchange capacity; enhance chelation of many nutrients and increases their availability for plants. It is also used in the case of the negative effect of salt that would inhibit the growth of plants and uptake of nutrients [8,9]. It is commonly used as major component of bio-stimulant formulations such as cytokinins and auxins [10]. Efficiency of Humic substances depends not only on the type of these substances, nature of source material, type of application and treatment levels, but also on the model system, i.e. experimental conditions, growing media and plant species [11-13].

Storage is the most important factor for postharvest losses for food in China, whereas in India storage losses throughout the marketing process account for about 42% of total losses [14,15]. In developed countries the larger part of postharvest losses takes place at retail, food service, and consumer sites (5 - 30% of total losses), in developing countries the losses during the marketing process from production to retail sites account for almost 50% of total losses [13]. The major postharvest losses are caused by processes related to bulb dormancy physiology such as sprouting and rooting, which usually appear during long-term storage or post-storage period and contribute to weight losses, visual appearance degradation, and quality changes and in severe cases in total production loss [16]. Therefore, the objective of this study was to evaluate the effect of different single or combined doses of both humic substances (potassium humate) and NPK fertilizers on quality and storage ability of onion stored for long time periods.

Materials and Methods

Materials

Onion seedlings of "Giza 6 Mohassan" cultivar at the age of 70 days were brought from the Center of Experiments and Agricultural Research, Minia University, Shousha, Egypt and were used in these experiments. The seedlings were planted at the beginning of November in the farm of the Vegetable Experimental Farm, Horticulture Department, Faculty of Agriculture, Minia University, Minia, Egypt in two successive winter seasons of 2015/2016 and 2016/2017 to get the products for this study.

Treatments

The plantation area was split into plots (5X10 m for each plot). Three plots were used as replicates of each treatment (the experiments consisted of 18 plots) and each plots consisted of 7 lines and two rows of onion seedlings were planted on each line (15 cm apart between each two seedlings in the row). Six treatments were used in these two experiments as follow and were distributed in plots in a Randomized Complete Block Design (RCBD):

1. Control (50% of the recommended dose of NPK)
2. Control (100% of the recommended dose of NPK)
3. 2 kg Potassium Humate + (50% of the recommended dose of NPK)
4. 2 kg Potassium Humate+ (100% of the recommended dose of NPK)
5. 4 kg Potassium Humate + (50% of the recommended dose of NPK)
6. 4 kg Potassium Humate + (100% of the recommended dose of NPK)

The recommended dose (RD) of NPK was ammonium nitrate (33.5% N) at the rate of 500 kg dose per fed, plus calcium super phosphate (15.5% P_2O_5) at the rate of 400 kg dose per fed, plus potassium sulphate (48% K_2O) at the rate of 100 kg dose per fed. The 50%

of the recommended dose was a 50% of the previously described full dose. The calcium super phosphate doses (50% and 100% of the recommended doses) were applied to the soil during the pre-planting preparation of this soil and the ammonium nitrate and potassium sulphate doses (50% and 100% of the recommended doses) were applied at three doses; the first one was after one month from seedlings plantation and 15 and 30 days after the first dose. Regarding the potassium humate (PH) application, 2 kg or 4 kg were dissolved in 400 liters of irrigation water (river water used for irrigation) and then were applied to their described plots as aforementioned above during the time of seedlings plantation. The used potassium humate was Humus® Hungary (water soluble potassium humate crystals contain: 90% humus potassium, 1.5% humus ferro, 0.7% humus magnesium, 4.4% humus calcium).

Other horticultural practices recommended by the Egyptian Ministry of Agriculture for onion cultivation were followed until the harvest time. At harvest time, samples of 100 kg for each replicate from all treatments were collected and cured for two weeks in a shading place to be ready for this study. This was repeated in the two successive seasons. All collected cured samples were stored in a storing room (the temperature was about 26°C and the room was ventilated well) for 10 months (from June of the production year to February of the next year) in the two successive seasons.

Recorded data

The following data were recorded before or after storing bulbs for 10 months:

1. Bulb equatorial diameter (cm) before storing.
2. Bulb vertical diameter (cm) before storing.
3. Average weight of single bulbs (g) before storing.
4. Average weight of single bulbs (g) after storing.
5. Weight loss % of bulbs after storing.
6. Culls % of bulbs after storing.
7. Sprouting % of bulbs after storing.

Data Analysis

Recorded data were subjected to the ANOVA analysis using the MSTATC software version 3.0 and means were compared using the Duncan's Multiple Range test at 5% of confidence degree according to [17].

Results

All data were recorded after curing the obtained onion bulbs from all treatments for two weeks and then these bulbs were stored for 10 months in room temperature as described before except the average single bulb weights and bulb diameters which were recorded before storage. Also, photos of bulbs were taken before and after storage to show the effect of the applied treatments on these bulbs before and after the long-term storage.

Phenotypic feature of bulbs before and after storage

Figure 1 is showing that bulbs differed in size according to the treatment and the full recommended dose of NPK increased the bulb size comparing to the 50% of the recommended dose (RD) regardless the potassium humate (PH) treatment. Also, applying 2 kg or 4 kg of PH in combination with the 50% or 100% of the RD of NPK increased bulb sizes as can be observed obviously in figure 1. Also, the figure shows that increasing the dose of NPK increased the culls in stored bulbs however, the culls bulbs percentage decreased by the dose of PH showing the importance of this organic material in preserving the quality of onion bulbs during storage in room temperature.

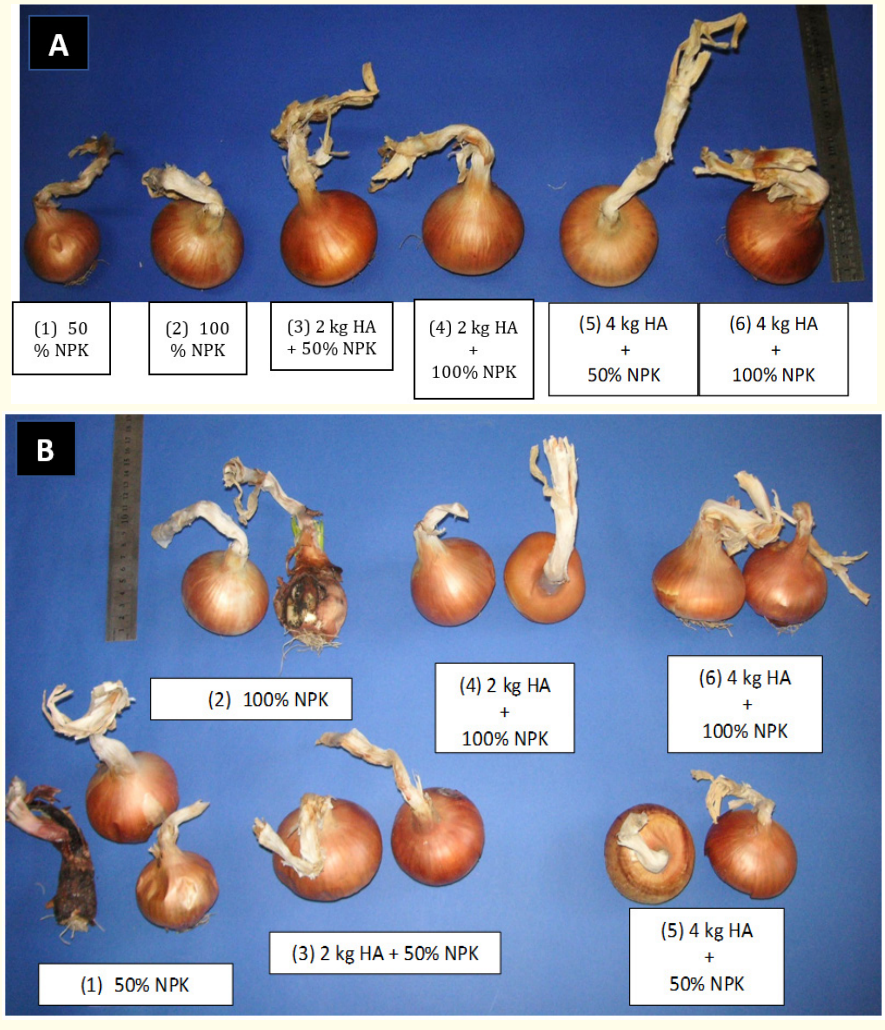

Figure 1: *Photos of onion bulbs obtained from all treatments (potassium humate and NPK dosses) after curing for two weeks and before storing for 10 months (A) and after storing in room temperature for 10 months (B). Photos show normal, culls and sprouting bulbs non-treated or treated with different doses of potassium humate and NPK fertilizers (single and combined treatments).*

Bulb equatorial and horizontal diameters (cm) after storing

Bulb equatorial and horizontal diameters reflecting the size of onion bulbs were recorded for single bulbs after curing and before storage for 10 months and are illustrated in table 1. These data shows that in general the combinations of PH and NPK doses significantly increased both equatorial and horizontal diameters of onion bulbs comparing to those obtained by the single applications of 50% and/or 100% of the RD of NPK in the two seasons. The grand means of equatorial diameters were 5.7 and 6.3 cm in the first and second seasons, respectively and the grand means of horizontal diameters were 6.7 and 7.6 cm in the same seasons. The combined treatment (4 kg of PH + 100% of the RD of NPK) increased those two diameters to be 6.46, 7.32 cm and 7.78, 8.80 cm in the first and second season, respectively comparing to 5.16, 5.10 cm and 5.44, 6.16 cm for the control treatment (50% of NPK) with significant differences among them. The other treatments and combinations resulted in bulbs with diameter values in between the treatment with the highest values and the control treatment (50% of NPK) as shown in table 1.

Treatments	Bulb equatorial diameter (cm)		Bulb horizontal diameter (cm)	
	2015/2016	2016/2017	2015/2016	2016/2017
Control (50% NPK)	5.16 c	5.10 e	5.44 d	6.16 f
Control (100% NPK)	5.28 c	5.54 d	6.26 c	6.64 e
2 kg potassium humate + (50% NPK)	6.00 b	6.02 c	7.16 ab	7.52 d
2 kg potassium humate + (100% NPK)	6.10 ab	6.80 b	6.74 bc	8.22 c
4 kg potassium humate + (50% NPK)	5.40 c	7.04 ab	7.20 ab	8.52 b
4 kg potassium humate + (100% NPK)	6.46 a	7.32 a	7.78 a	8.80 a
Mean of treatments	5.7	6.3	6.7	7.6

Table 1: *Effect of potassium humate and NPK doses on onion bulb equatorial and horizontal diameters after curing for two weeks and before storing bulbs for 10 months.*

Average weight of single bulbs (g) before and after storing and weight loss (%)

The average single bulb weight is an important yield component character as it reflects the quality and total yield of onion crop along with the number of bulbs per plot or per fed. In this study the average bulb weight of bulbs after curing for two weeks and before storing these bulbs for 10 months along with weight values of the same bulbs after the storage period were recoded to know the percentage of weight loss after this long-period storage. Data in table 2 shows that the lowest values of cured single bulb weight before storage were obtained from onion plants received only 50% of the RD of NPK (79.6 and 80.9g) in the first and second seasons, respectively. On the contrary, the highest values (172.8 and 176.3g) of bulb weight before storage were obtained from the treatment (4 kg of PH + 100% of the RD of NPK) in the same seasons, means this treatment gave bulbs with doubled weights comparing to the control treatment (50% of the RD of NPK), so that this treatment can increase the total yield up to two times that of the control treatment. Interestingly, only 2 kg of PH can also double the total yield obtained from the control treatment (50% of the RD of NPK) as it produced bulbs with average weight (161.8 and 161.2g) in the two seasons, respectively with insignificant differences with the treatment which gave the highest values.

Treatments	Single bulb weight (g) before storage		Single bulb weight (g) after storage		Weight loss % after storage	
	2015/2016	2016/2017	2015/2016	2016/2017	2015/2016	2016/2017
Control (50% NPK)	79.6 d	80.9 f	52.0 e	53.7 d	34.67 a	33.62 a
Control (100% NPK)	116.2 c	114.7 e	82.3 d	79.6 c	29.17 ab	30.60 ab
2 kg potassium humate + (50% NPK)	145.0 b	153.0 c	105.2 c	117.6 b	27.45 ab	23.14 ab
2 kg potassium humate + (100% NPK)	161.8 a	161.2 b	121.2 ab	110.2 b	25.09 ab	31.64 ab
4 kg potassium humate + (50% NPK)	142.3 b	142.9 d	110.3 bc	109.5 b	22.49 b	23.37 ab
4 kg potassium humate + (100% NPK)	172.8 a	176.3 a	127.9 a	136.5 a	25.98 ab	22.58 b
Mean of treatments	136.3	138.0	99.8	101.2	27.48	27.49

Table 2: *Effect of potassium humate and NPK doses on onion single bulb weights before and after storing bulbs for 10 months and weight loss percentage after storage.*

Regarding the average single bulb weight after storing onion bulbs for 10 months, table 2 shows that the combined treatment (4 kg of PH + 100% of the RD of NPK) gave the highest values of average bulb weights (127.9 and 136.5g) in the two studied seasons to lose (25.98 and 22.58%) of their weights, with almost insignificant differences with those obtained from the combination (2 kg of PH + 100% of the RD of NPK) which gave (121.2 and 110.2g) to lose (25.09 and 31.64%) and the combination (4 kg of PH + 50% of the RD of NPK) that gave (110.3 and 109.5g) and lost (22.49 and 23.37%) of their weights. On the other hand, the control treatment (50% of the RD of NPK) which gave bulbs with the lowest values of bulb weights after storage (52.0 and 53.7) showed the highest percentages of weight loss (34.67 and 33.62%). It is clear from this table that the NPK doses increased onion bulb weights but also increased the percentages of weight losses of bulbs and contrary the PH addition to the NPK doses increases bulb weights more but decreased their weight loss percentages.

Culls % of bulbs after storing

When onion bulbs obtained from plants received (100% of the RD of NPK without PH) were stored for 10 months they showed the highest percentages of culls bulbs (73.0 and 68.8%) followed by those received 50% of the RD of NPK (42.8 and 51.2%) in the first and second seasons, respectively. On the contrary, those received the combination (4 kg of PH + 100% of the RD of NPK) gave the lowest values of culls bulbs (6.0 and 5.0%) followed by those received (4 kg of PH + 50% of the RD of NPK) to give (15.0 and 13.2%) of the stored bulbs in the two studied seasons. Using only 2 kg of PH decreased the percentage of culls bulbs as described in table 3. This means, the PH had a good role in decreasing the lost amount of bulbs as culls.

Treatments	Culls bulbs (%)		Sprouted bulbs (%)	
	2015/2016	2016/2017	2015/2016	2016/2017
Control (50% NPK)	42.8 b	51.2 b	34.4 b	32.0 a
Control (100% NPK)	73.0 a	68.8 a	41.0 a	34.4 a
2 kg potassium humate + (50% NPK)	34.8 bc	34.4 d	21.2 c	16.8 c
2 kg potassium humate + (100% NPK)	30.4 c	43.8 c	39.8 a	25.6 b
4 kg potassium humate + (50% NPK)	15.0 d	13.2 e	9.8 d	9.2 d
4 kg potassium humate + (100% NPK)	6.0 d	5.0 f	17.6 c	16.4 c
Mean of treatments	33.7	36.1	27.3	22.4

Table 3: *Effect of potassium humate and NPK doses on the percentage of onion Culls and sprouted bulbs after storing bulbs for 10 months.*

Sprouting % of bulbs after storing

The same trend with culls bulbs percentages was obtained with the sprouted onion bulbs when healthy cured bulbs were stored for 10 months at room temperature (Table 3). The combined treatment (4 kg of PH + 100% of the RD of NPK) applied to onion plants resulted in the lowest values in their stored bulbs (17.6 and 16.4%) in the first and second seasons, respectively. On the other hand, plants received 100% of the RD of NPK gave bulbs which lost about (41.0 and 34.4%) of their bulbs as sprouted bulbs. Moreover, any plants received 2 or 4 kg of PH in combination with NPK doses decreased the lost percentages of sprouted bulbs after storage. Means, PH had a positive effect on the percentage of sprouting bulbs after the long-term of storage period (Table 3).

Discussion

Onion is planted in Minia (Middle Egypt) using either sets or transplants (both are produced from seeds planted in nurseries for about two months to produce seedlings or for about 5 months to produce sets). Sets are almost planted in the open fields during August and

September of the year and their product can be harvested in December and January but the product cannot be stored for long periods. Whereas, seedlings are almost planted during November and December to get the yield in April and May and the product can be stored for long periods (up to a year). The quality of the stored onion bulbs depends on many factors, e.g., treatments applied to the plants during the production season and also on storing conditions. Hence, these experiments were conducted to study the effects of chemical (NPK doses) and organic (potassium humate) fertilizations applied during the growing seasons on the quality of stored onion bulbs for 10 months in storing rooms. The main objectives of storage are not only to ensure availability throughout the year but also to maintain the maximum quality and to limit as much as possible losses from biotic and abiotic factors [4].

Data showed that the product of bulbs differed according to the treatment. Application of only 50% of the RD of NPK resulted in Bulbs with small sizes and lower values of weight after curing and before storing, whereas the full dose (100% of the RD of NPK) resulted in bulbs with bigger sizes and higher values of bulb weights but these obtained bulbs were not good for storage. Bulbs lost high percentages of their weights during storage and the percentages of culls and sprouted bulbs were the highest. On the contrary, all onion plants received 2 kg or 4 kg of PH in combination with the NPK doses (50% or 100% of the RD) produced bulbs with the biggest sizes and the highest values of bulb weights and also, the quality of these bulbs was better and could be produced for longer periods with the lowest percentages of culls and sprouted bulbs [6,8] revealed that using foliar application or addition with humic acid of onion plants markedly increased growth, bulb yield, quality and chemical constituents.

Storage of onions is a multiplex process, including many factors that could be divided into those that affect onion bulbs before their harvest from the field and those that involve processes related to after harvest conditions and physiology processes [18]. Most of these factors are genetically controlled and vary among the cultivars according to their photoperiodic classification, whereas environmental and growing conditions are also important and greatly contribute to significant variations in storage potential within the same cultivar or from year to year. Therefore, the first step to increase storage potential would be the selection of the proper cultivar, since there are significant differences in storability between the cultivars and not all of them are suitable for storage. The cultivar used in this study (Giza 6 Mohassan) is a good cultivar in production and also its bulbs can be stored for longer periods but is highly affected by agricultural practices and treatments applied to plants [2]. As soon as the cultivar is selected, both pre-harvest and postharvest factors are useful means to improve storability, marketability (weight losses, texture, and color depth of bulbs), and quality (chemical composition, nutritional value, antioxidant activity) of dry onion bulbs.

Pre-harvest conditions that affect storability are related to genetic background and growing conditions and include, apart from the selection of the cultivated cultivar, cultivation practices such as irrigation and fertilization that could be controlled in favor of better storability of onion bulbs. This was clear in this study as onion plants were clearly affected by the chemical or organic fertilizers and also affected by the used doses. Organic matters or bio-fertilizers such as humic substances have many benefits such as increasing the capacity of moisture retention and cationic exchange capacity [19,20] in soils. Humic substances are composed of humic acids, fulvic acids and humin from biochemical transformations of compounds of soil organic matter such as lignin, cellulose, hemicellulose, sugars and amino acids [21]. Humic substances assist in the transport and absorption of nutrients [22,23] due to the formation of complexes and chelates, reducing the need for chemical fertilizer application [24]. In addition, Humic substances have important action in the cellular metabolism of N, increasing the level of NO_3^- [25], increasing respiration and the speed of enzymatic reactions of the Krebs cycle [26], increasing the content of chlorophyll [23], acting on protein synthesis [27,28] and active hormones such as auxin, cytokinins, gibberellins [29], polyamines and abscisic acid [30,31]. All these activities of humuc acid or potassium humate in combination with the NPK doses were the reasons in this study to increase the production of bulbs, bulbs big sizes and ability for long term storage with lower percentages of bulb weight loss, culls and sprouted bulbs.

Conclusion

These experiments were conducted to study the effects of chemical (50% and 100% of the recommended doses of NPK) and organic (potassium humate in combination with the NPK doses) fertilizers on product quality and storage ability for long-term periods of onion bulbs. Results showed that the combinations of NPK and potassium humate increased onion bulbs size, weight and storage ability for 10 months and reduced the culls and sprouted bulbs percentages during this long period of storage under room temperature. Hence, it is recommended for onion growers and producers to use 2 or 4 kg of potassium humate plus 50% or 100% of the recommended dose of NPK to produce high quality onion bulbs with good storage abilities.

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Volume 5 Issue 5 May 2019