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Effect of fertilizer Packages and polymers on onion yield and quality under Bahariya Oasis conditions

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ABSTRACT

The experiment was done in order to know the influence of hydrogel polymers on growth, yield and storage ability of onion fertilized with NPK packages in AL-Kasr, Bahariya Oasis, Costal Desert of Egypt during two successive winter seasons of 2013 - 2014 and 2014 - 2015. A factorial spilt plot design was used in arranging treatments *i.e.* NPK packages 100-60-100 (recommended dose) (P_1), 75-45-75 (P_2) and 50-30-50 (P_3) units of NPK in addition to control (P_0) without additions. The treatments were arranged randomly in main plots, while hydrogel polymers *i.e.* (H_0), (H_{50}), (H_{75}), (H_{100}), (H_{125}) and (H_{150}) treatments were 0, 50, 75, 100, 125 or 150 % of recommended dose (10 kg/fed.) which were occupied subplots.

The results indicated that P_1 or/ and H_{100}, H_{125} and H_{150} treatments significantly increased plant height, plant leaves number, plant leaves area besides, fresh and dry weight per plant through growing seasons. Also, the absolute growth rate (AGR) and net assimilation rate (NAR) influenced positively by P_1 and P_3 treatments of NPK or / and H_{100} and H_0 and H_{50} hydrogel treatments respectively. In addition, P_1 or/ and H_{100} to H_{150} treatments significantly enhanced yield and its components *i.e.* bulbing ratio, rotation ratio, number of doubled bulbs per plot, No. of early flowering plants per plot (EFP), bulb fresh weight (g) at harvest date, average of total yield per plot and per fed. as well as marketable yield per fed. Furthermore, tested nitrogen use efficiency indicated that highest onion bulbs quantity produced from one unit of nitrogen obtained by P_1 and P_1+H_0 treatments.

Keep quality of harvested bulbs showed that onion bulbs produced from soil treated by P_1 was positive significantly affected in loss weight (g), dry matter (%), rotten and sprouted bulbs after four months of storing, while TSS percentage significantly increased by all packages when compared with control treatment. H_{125} and H_{150} hydrogel treatments achieved high loss weight, rotten and sprouted bulbs, while H_{75} and H_{100} produced highest TSS percent after storing period. Also the combination between NPK packages and hydrogel polymers significantly positive affected dry matter percentage, rotten and sprouted bulbs. The highest marketable yield after storing period attained from individual P_1, H_{100}, H_{125} and H_{150} or from the combination of P_0+H_{100}, P_0+H_{125}, P_0+H_{150} and P_1+H_{100}.

Keywords: NPK packages. Hydrogel polymers, Growth parameters, AGR, NAR, Onion (*Allium cepa* L.) bulbs yield and its components, NUE, Storing ability.

Introduction

Onion (*Allium cepa* L.) is a member of *Allieaceae* family, herbaceous biennial plant. The consumer part is a bulbs which are formed of modified bases leaves (scales) grown in first growing season. Onion is one of most important local and exporting vegetable crops which is contribute with 4.7 % of national income of agricultural in Egypt (Abd Almohsen, 2006).

Egyptian deserts are accommodate and varied in nature of its territory. Poverty nutrients and inholding water in sandy soils and scarcity potable agricultural irrigation water are the determination in horizontal deserts development.

Nitrogen, phosphorus and potassium are consider essential elements for plant life where its contribute the formation of all vital protoplasm and nucleic compounds such as amino acids, nucleic acids, enzymes, translocation power and sugar compounds (ADP, ATP, NAD and NADP and glucose-6-phosphate, etc.…), phospholipids, starch building and chlorophyll. These essential elements increase plant activity and in sequence increase the number of cells, number of leaves, leave area and the length of plant. They encourage vegetative growth and prolong the life of the plant. In this respect, Abdul Ghaffoor *et al*. (2003) found that NPK at level of 150:100:50 kg ha^{-1} significantly

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increased plant height, leaf length and number of leaves per plant as well as bulb diameter, marketable yield and total yield per hectare.

Omotoso and Shittu (2007) found that growth parameters (plant height, leaf area, root length, number of leaves), yield and yield components of okra were significantly increased with higher rate application (300 kg h^{-1}) of NPK 15:15:15 fertilizers when tested under Nigeria condition.

Yaso and Abdel-Razzak (2007) studied different combinations of NPK fertilizers under Egypt reclaimed calcareous soil conditions. They noticed that significantly positive effects on most important bulb characteristics *i.e.* number of days to maturity, average bulb weight, marketable yield, total yield, and percentage of single and double bulbs. However, high N at rates of 120:00:00 and 120:30:00 NPK kg/fed. increased the number of days to bulb maturity viz. delayed bulbs maturity. While, low N rates treatments (60:30:00 NPK kg/fed.) decreased the number of days to maturity.

Hafez and Soubeih (2012) reported that NP at rate of 100: 20 L fed^{-1} in acidic form during growing season significantly increased growth characteristics expressed as plant high, number of leaves and branches per plant, plant leaf area and fresh and dry weight as well as yield and its components of eggplant under saline soil conditions.

Assefa *et al*. (2015) cleared that under Ethiopia condition that a combination of N, P, S, and Zn fertilizers at rate of 130-20-21-15 kg he^{-1} gave a significant higher onion bulbs yield (4760 kg he^{-1}) over the control (2996.5 kg he^{-1}).

Yaso and Abdel-Razzak (2007) found that total soluble solids (T.S.S) contents of mature bulb, percentage of bolters and percentage of sprouted bulbs after six months of storage period did not show any significant effect under any NPK combination.

Dantata (2014) studied the different levels of nitrogen (0, 55, 110 and 165 kg N ha^{-1}) and phosphorus (0, 45, 90 and 135 kg P ha^{-1}) fertilizers under Nigeria conditions on onion storage, he found that onion bulb weight at storage, percent of sprouted bulbs and percent of rotted bulbs were significantly (P=0.05) influenced by higher levels of nitrogen and phosphorus.

Recently, hydrogel polymers have raised interest among agricultural researchers as soil amendment, water holder and have no said effect on environment. Especial preparing of polymer chains can form new components with networks can be absorbent water molecules further, when using it as soil conditioners, improve water holding capacity, decrease evapotranspiration and allow plants to mitigate the drought stress (Abedi-Koupai *et al*. 2008 and Chirino *et al.*, 2008). In this respect, Ghasemi and Khushkhui (2008) reported that hydrophilic gels under Iran conditions had positive and significant effect on number, diameter, fresh and dry weight of flower also, number and area of leaves, shoot fresh and dry weight, shoot number and plant height as well as root fresh and dry weight, root/shoot proportion and coverage area of *Chrysanthemum morifolium* under drought stress. As well, Shi *et al.* (2010) reported that were attempted to alleviate the plant damage using hydrogel resulted in protected plants from salt-induced and water deficient stress. Also, Gales *et al.* (2012) found that hydrogel can be release a significant amount of water in different plant life stages according to their consumption. They also found, 15 kg hydrogel polyacrylamide ha^{-1} positively influenced plant height, leaves chlorophyll contents and yield of corn and soybean under Iasi, Romania conditions. Furthermore, Vijayalakshmi, *et al.* (2012) tested the effect of six polymers on water absorption rate and soil moisture holding capacity of loamy sand soil. Observed that maximum water absorption by polymers were between 114 and 311.5 times of weight and reported that the polymers are effective tools as soil conditioners in increasing water holding capacity, reducing infiltration rate and cumulative evaporation and improving water conservation of sandy soils. Addition, under Bermejillo, Durango, Mexico conditions, Yáñez-Chávez *et al.* (2014) found that hydrogel at doses of 12.5 and 25 kg ha^{-1} significantly increased plant height and stem thickness and flag leaf length and width of forage maize mainly 74 days after planting and reported, these responses follows higher moisture content, measured at three depth (15, 30 and 60 cm), in the hydrogel-treated soil when compared with control.

Materials and Methods

Two field experiments were conducted to study the effect of mineral fertilizer packages and hydrogel polymers individually or in interacting on vegetative growth, yield and its quality and storability of onions (*Allium cepa* L.) Giza 20 cultivar. The experimental sit was under AL-Kasr, Baharya oasis conditions, located in latitude and longitude (28º 20' 6.84" N and 28º 49' 48.14" E) in consecutive seasons 2013 - 2014 and 2014 - 2015.

Onion seeds were sown 75 days before transplanting to experimental field. The seedlings were planted on the first of December of both investigated seasons and the harvest was on May 15th. Traditional agricultural practices were performed before planting and during the growing season - organic fertilization, plowing, irrigation and control of weed, diseases and pests according to agricultural ministry recommendations.

Split plot statistical design was used for data analysis. The whole experimental area divided into 4 replicates, the treatments randomly distributed in each replicate, the fertilizer packages which were 100-60-100 (P_1), 75-45-75 (P_2) and 50-30-50 (P_3) units of NPK in addition to control (P_0) (without additions) were arranged randomly in main plots, while hydrogel polymers *i.e.* (H_0), (H_{50}), (H_{75}), (H_{100}), (H_{125}) and (H_{150}) treatments which were 0, 50, 75, 100, 125 or 150 % of recommended dose (10 kg/fed.), respectively within sub-plots, each sub-plot was 21 m^2 (0.9 m width x 23.3 m length) have 750 plants. Every sub-plot divided into two equal parts each part contain 375 plants, a part marked for determine growth characters and the second for assaying the quality, total yield, marketable yield and storability.

Ammonium nitrate (33.5 %N), calcium super phosphate (15.5 % P_2O_5) and potassium sulfate (48.5 % K_2O) were used as sources of nitrogen, phosphorus and potassium, respectively. The NPK packages treatments were divided into 5 equal parts each applied every 4 weeks, started after one month of transplanting. While hydrogel polymers treatments were applied during soil preparation.

Estimated physical and chemical analysis of the experimental soil and irrigation water analysis were determined by methods described by Piper (1950), Jackson (1962) and Richards (1954), respectively as shown in Tables (A, B and C).

Data recorded:

Growth characters:-

Ten plants from experimental area were randomly taken every 4 weeks during growing season started December 28th to April 17th in addition to a sample at harvest time (May 15th) for recording all the periodical biometric observations during the growth and development of onion crop as affected by given treatments. The various recorded parameters were plant height (cm) from dick to higher point of plant, number of leaves / plant, beside fresh and dry weight (g) / plant, moreover at harvested time. In addition, plant leaves area as described in A.O.A.C. (1990).

Table A: Mechanical properties of the experimental soil.

Seasons	Soil depth (cm)	Graph color	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Class texture
						%				
1st	0 – 45 cm	Yellow	2.3	14.6	31.7	18.8	6.1	15.6	11.8	Sandy loam
					72.4					
2nd			2.1	13.2	33.4	19.4	7.2	14.0	10.7	
					75.3					

USDA Texture

Table B: Chemical analysis of the experimental soil.

Seasons	Soil depth (cm)	pH	EC dS/m^2	Saturation soluble extract							
				Soluble anions (meq/L)				Soluble Cations (meq /L)			
				CO_3^{-2}	HCO_3^-	SO_4^{-2}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
1st	0- 45 cm	7.52	2.18	-	1.88	6.06	16.94	5.41	2.83	15.34	1.89
2nd		7.46	2.22	-	1.64	6.34	18.51	5.25	2.97	16.47	1.91

Table C: Chemical analysis of the irrigation water.

Season	pH	EC	Soluble anions (meq/L)				Soluble cations (meq/L)			
		dS/m	$CO_3^=$	HCO_3^-	So_4^{-2}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
1st	7.18	1.98	-	0.92	3.06	12.85	3.51	2.43	13.21	1.32
2nd	7.28	2.03	-	0.97	3.76	15.05	3.01	2.37	13.82	0.82

Growth analysis parameters expressed as absolute growth rate (AGR) was determined according to the equation described by Radford (1967) as follow:

$$AGR\ (gm/day) = \frac{W_2 - W_1}{T_2 - T_1}$$

Where:
W_1 = plant dry weight of the first sample (g /plant) which was taken after 8 weeks.
W_2 = plant dry weight of the second sample (g /plant) was taken after 20 weeks.
T_1 = first sample time (days). T_2 = second sample time (days).

In addition, net assimilation rate (NAR) was calculated using the equation described by Watson (1947) as follow:

$$NAR4 = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{Log_e L_2 - Log_e L_2}{T_2 - T_1}$$

Where:
W_1 = plant dry weight in the first sample. W_2= plant dry weight in the second sample.
T_1 = first sample time. T_2 = second sample time.
Log_e = nature logarithm. L_1 = plant leaves area of first sample.
L_2 = plant leaves area of second sample.

Yield and its components:

Bulbing and rotation ratios were calculated as following:

$$\text{Bulbing ration} = \frac{\text{Nick diameter (mm)}}{\text{Bulb diameter (mm)}}$$

$$\text{Bulbing ration} = \frac{\text{Horizontal diameter of bulb (cm)}}{\text{Vertical diameter of bulb (cm)}}$$

Horizontal, vertical and nick diameters of bulb were determined at harvest time , also, number of double bulb / plot, number of early flowering scape plants (EFP) / plot, bulb fresh weight, average of total plot yield, total yield and marketable yield ton/fed.

Nitrogen use efficiency:

Nitrogen use efficiency was calculated according to Singh *et al.* (2002) as the following equation:

$$\text{Nitrogen use efficiency, NUE(KG onion bulbs/nitrogen unit} = \frac{\text{Bs Y in N treatment- Bs Y in zero N}}{\text{Quantity on N fertilizer applied(kg/fed)}}$$

Where: Bs Y = bulbs yield

Storability

10 kg of onion bulbs were taken from each plot divided into four equal parts and stored in burlap sacks which were put as one layer on wood shelves under room temperature has good ventilation to study the storability of onion. Monthly samples up four months were determined loss of weight, TSS, rotten and sprouted bulbs, bulbs weight, dry matter (%) and net weight. Also, marketable yield ton/fed after storing period was calculated as follow:

$$\text{Marketable yield ton/fed after storing period} = \frac{\text{Net weight}}{2500} \times 100 \times \frac{\text{Marketable yield at harvest}}{100}$$

Results

I. Plant growth parameters:

Data illustrated in Tables (1, 2, 3, 4 and 5) showed that plant growth measurements expressed as plant height, number of leaves per plant, plant leaves area and fresh and dry weight/ plant measured through growing seasons after 4, 8, 12, 16 and 20 weeks from transplanting in addition to the sample at harvest time.

A. The height (cm) and leaves number per plant, Tables 1 and 2:

Illustrated data showed that NPK packages significantly increased plant height through growing period up to harvest time except in first and second samples. The highest value produced from P_1 treatment which increased plant height with 27.7% over control. The significant effect of NPK package on plant leaves number started after 8 weeks of transplanting up to harvest time. P_1 treatment also achieved the highest number of leaves with 24.1% above control.

Data also, clearly showed that H_{75}, H_{100}, H_{125} and H_{150} treatments significantly increased plant height and plant leaves number when compared with control treatment. In last sample, there are significant differences among them, except, in last sample taken at harvest time. The highest plants obtained with H_{150} treatment during growing seasons. The observation that leaves number not increased since March 20th (after 16 weeks of transplanting) up to harvest time, although there are significant differences between treatments.

Regarding, the interaction between NPK package and hydrogel portions, data indicated that all measured samples during both growing seasons had no significant affect on plant height, except after 20 weeks of transplanting and at harvest time. The highest values recorded with treatment of P_1 + H_{100} followed by P_1+H_{125} and the latest values were attained from P_0 +H_0 treatment. Moreover, the expressions of mixing study factors significantly affected on number of leaves per plant in the period from Jan 25th until March 20th. Also, the superiority was acquired from combined P_1 with H_{150} or H_{125} or H_{100} and the latest values were associated with P_0+H_0 during late mentioned period.

B. Leaves area cm^2 /plant (Table 3):

The leaves area were determined only in four samples of the treatments effect, also, for assay net assimilation rate through the plant active growing phases from 25th Jan to April 17th . Data showed that largest plant leaves area was associated with P_1 in all studied samples. The increment portions were 38.5, 57.0, 57.0 and 46.1 % in the first, second, third and fourth samples respectively.

Data pointed that onion leaves area significantly affected with hydrogel treatments in all over taken samples. The highest values were recorded in plants treated with H_{150}.

C. Fresh and dry weight g/plant represented in Tables 4 and 5:

The results showed that the effect of the different levels of mineral fertilizer led to gradual increases in fresh and dry weight of the plants, the gradually increases begin from January 25th until harvest time. The increases were slow until March 20th then multiplied during the following growing period arriving to harvest. The heavy fresh and dry plants in all samples were related to the highest level (P_1) of the fertilizer packages compared to the control treatment and the rest of the treatments.

The results also show that all hydrogel levels in all samples resulted in significantly higher fresh weight of the plant as compared to the control treatment. The best results were always produced of H_{150}. Also, plants dry weight was in the same trend except H_{100}, H_{125} and H_{150} treatments showed no significant differences among them.

The combination between NPK packages and hydrogel levels indicated significant increases in plants fresh weight in all samples except in first one as compared with control. The heavy plants were associated with P_1+H_{125} and P_1+H_{150} treatments and sometimes P_1+H_{100}. While, the combination not affected in plant dry weight in earlier plant age, but after 12 weeks of transplanting through growth period until harvest time P_1+H_{100} and sometimes P_1+H_{150} significantly increased plant dry weight and produced the highest dry mater accumulation.

Table 1: Effect of NPK packages, hydrogel polymers and their interaction on plant height (cm) of onion *cv.* Giza 20.

Sample time / NPK / Hydrogel	4 WAT (Dec. 28th)					8 WAT (Jun. 25th)				
	P_{0}	P_{1}	P_{2}	P_{3}	Effect of hydrogel	P_{0}	P_{1}	P_{2}	P_{3}	Effect of hydrogel
H_{0}	27.6	27.9	27.0	27.6	27.5	28.3	29.4	28.1	28.6	28.6
H_{50}	28.6	28.3	27.7	28.3	28.2	29.4	29.9	29.0	29.4	29.4
H_{75}	28.5	28.5	28.9	28.9	28.7	29.5	30.3	30.4	30.1	30.1
H_{100}	28.4	28.7	28.9	28.4	28.6	29.6	30.6	30.6	29.9	30.2
H_{125}	28.7	28.4	29.0	28.9	28.7	30.0	30.5	30.8	30.4	30.4
H_{150}	28.6	28.8	29.2	28.4	28.7	30.4	31.1	31.3	30.0	30.7
Effect of NPK	28.4	28.4	28.4	28.4		29.5	30.3	30.1	29.7	

LSD at 0.05 for NPK = NS NS
LSD at 0.05 for hydrogel = NS 1.38
LSD at 0.05 for interaction = NS NS

	12 WAT (Feb. 22th)					16 WAT (Mar. 20th)				
H_{0}	29.4	33.1	30.7	30.5	30.9	33.9	43.1	37.9	36.7	37.9
H_{50}	30.8	34.3	32.0	31.6	32.2	36.5	46.3	40.1	38.4	40.3
H_{75}	31.3	35.3	34.0	32.8	33.3	37.6	47.8	43.6	40.3	42.3
H_{100}	31.9	37.4	35.2	33.0	34.4	39.0	53.8	46.7	41.6	45.3
H_{125}	32.6	37.6	35.8	33.8	34.9	40.1	53.1	44.3	42.7	45.1
H_{150}	33.1	38.8	36.9	33.9	35.7	41.0	53.9	49.3	43.1	46.8
Effect of NPK	31.5	36.1	34.1	32.6		38.0	49.7	43.7	40.5	

LSD at 0.05 for NPK = 0.71 3.4
LSD at 0.05 for hydrogel = 1.53 4.2
LSD at 0.05 for interaction = NS NS

	20 WAT (Apr. 17th)					At harvest (May. 15th)				
H_{0}	34.5	45.1	38.5	37.5	38.9	32.3	46.2	38.8	37.6	38.7
H_{50}	37.2	48.2	41.0	39.4	41.5	35.2	49.8	42.0	39.6	41.7
H_{75}	38.6	50.0	44.7	41.5	43.7	37.2	51.8	45.8	42.6	44.3
H_{100}	40.1	56.5	48.2	43.0	47.0	39.3	58.7	49.5	44.1	47.9
H_{125}	41.4	55.9	45.8	44.1	46.8	42.4	58.4	47.1	46.0	48.5
H_{150}	42.3	56.5	50.8	44.5	48.5	44.3	57.8	52.4	46.1	50.1
Effect of NPK	39.0	52.0	44.9	41.7		38.5	53.8	45.9	42.7	

LSD at 0.05 for NPK = 2.6 1.91
LSD at 0.05 for hydrogel = 4.1 2.68
LSD at 0.05 for interaction = 7.2 3.99
WAT = weeks after transplanting

Table 2: Effect of NPK packages, hydrogel polymers and their interaction on No. of leaves / plant of onion *cv.* Giza 20.

Sample time / NPK / Hydrogel	4 WAT (Dec. 28th)					8WAT (Jun. 25th)				
	P_{0}	P_{1}	P_{2}	P_{3}	Effect of hydrogel	P_{0}	P_{1}	P_{2}	P_{3}	Effect of hydrogel
H_{0}	3.3	3.2	3.4	3.3	3.3	3.7	4.3	4.3	3.9	4.0
H_{50}	3.7	3.8	3.6	3.7	3.7	4.2	5.3	4.6	4.5	4.7
H_{75}	3.8	3.9	3.8	3.9	3.9	4.5	5.7	5.2	4.9	5.1
H_{100}	4.1	4.1	4.3	4.1	4.1	4.8	6.2	5.9	5.2	5.5
H_{125}	4.2	4.1	4.3	4.2	4.2	4.9	6.6	6.2	5.3	5.7
H_{150}	4.2	4.3	4.2	4.3	4.3	5.0	6.9	6.5	5.8	6.1
Effect of NPK	3.9	3.9	3.9	3.9		4.5	5.8	5.4	4.9	

LSD at 0.05 for NPK = NS 0.7
LSD at 0.05 for hydrogel = 0.3 0.9
LSD at 0.05 for interaction = NS 1.3

	12 WAT (Feb. 22th)					16WAT (Mar. 20th)				
H_{0}	4.5	6.9	6.3	5.3	5.7	5.9	8.5	7.7	6.4	7.1
H_{50}	5.2	8.4	6.9	6.3	6.7	6.8	10.9	8.4	7.7	8.5
H_{75}	5.6	9.3	8.2	7.0	7.5	8.6	11.2	9.4	8.3	9.4
H_{100}	6.1	10.7	9.7	7.8	8.6	9.3	11.9	10.7	9.3	10.3
H_{125}	6.4	11.2	10.3	8.4	9.1	9.5	12.9	11.3	9.6	10.8
H_{150}	6.7	11.4	11.2	9.4	9.7	9.7	12.8	11.9	10.4	11.2
Effect of NPK	5.7	9.6	8.8	7.4		8.3	11.4	9.9	8.6	

LSD at 0.05 for NPK = 0.5 1.2
LSD at 0.05 for hydrogel = 1.5 2.6
LSD at 0.05 for interaction = 3.1 3.6

	20WAT (Apr. 17th)					At harvest (May. 15th)				
H_{0}	6.0	8.9	7.9	6.5	7.3	6.0	9.2	7.9	7.0	7.5
H_{50}	7.1	11.4	8.6	7.7	8.7	7.2	11.7	8.3	8.1	8.8
H_{75}	8.9	11.7	9.6	9.2	9.8	9.0	12.0	9.2	9.7	10.0
H_{100}	9.7	12.4	10.9	10.3	10.8	10.2	12.5	11.5	10.1	11.1
H_{125}	9.8	12.4	11.1	10.8	11.0	10.1	11.8	11.7	10.5	11.0
H_{150}	10.0	12.4	11.5	10.5	11.1	10.1	12.3	12.4	11.0	11.5
Effect of NPK	8.6	11.5	9.9	9.2		8.8	11.6	10.2	9.4	

LSD at 0.05 for NPK = 0.6 0.2
LSD at 0.05 for hydrogel = 1.8 0.5
LSD at 0.05 for interaction = NS NS
WAT = weeks after transplanting

Table 3: Effect of NPK packages, hydrogel polymers and their interaction on leaves area cm^2 / plant of onion *cv.* Giza 20

Sample time / NPK / Hydrogel	8WAT (Jun. 25th)					12WAT (Feb. 22th)				
	P_0	P_1	P_2	P_3	Effect of hydrogel	P_0	P_1	P_2	P_3	Effect of hydrogel
H_0	206	306	278	248	259	313	649	503	403	467
H_{50}	246	381	313	291	308	384	823	578	497	570
H_{75}	259	418	365	325	342	415	941	732	575	666
H_{100}	279	460	426	341	376	468	1162	903	653	797
H_{125}	291	486	447	357	395	503	1218	978	721	855
H_{150}	304	525	478	387	423	535	1289	1096	815	934
Effect of NPK	264	429	385	325		436	1014	798	611	

LSD at 0.05 for NPK = 8.8 18.3
LSD at 0.05 for hydrogel = 14.2 34.8
LSD at 0.05 for interaction = 29.1 63.6

	16 WAT (Mar. 20th)					20 WAT (Apr. 17th)				
H_0	521	1253	925	679	845	664	1334	972	787	939
H_{50}	655	1730	1081	847	1078	857	1851	1143	981	1208
H_{75}	849	1824	1316	959	1237	1113	1970	1398	1227	1427
H_{100}	964	2226	1627	1124	1485	1268	2410	1729	1434	1710
H_{125}	1012	2365	1616	1198	1548	1334	2356	1647	1549	1721
H_{150}	1068	2403	1905	1313	1672	1410	2414	1938	1540	1826
Effect of NPK	845	1967	1412	1020		1108	2056	1471	1253	

LSD at 0.05 for NPK = 18.9 22.8
LSD at 0.05 for hydrogel = 25.1 36.4
LSD at 0.05 for interaction = 42.5 51.3

WAT = weeks after transplanting

Table 4: Effect of NPK packages, hydrogel polymers and their interaction on fresh weight (g)/ plant of onion *cv.* Giza 20.

Sample time / NPK / Hydrogel	4 WAT (Dec. 28th)					8WAT (Jun. 25th)				
	P_0	**P_1**	**P_2**	**P_3**	**Effect of hydrogel**	**P_0**	**P_1**	**P_2**	**P_3**	**Effect of hydrogel**
H_0	28.2	27.5	29.0	27.8	28.1	31.2	39.2	35.3	33.7	34.86
H_{50}	32.0	32.6	30.8	31.7	31.8	37.7	48.6	41.2	40.1	41.9
H_{75}	33.5	33.6	33.0	33.8	33.5	39.8	53.6	46.0	43.9	45.8
H_{100}	35.6	35.2	36.8	35.2	35.7	42.5	60.8	52.9	46.2	50.6
H_{125}	36.5	35.7	36.9	36.1	36.3	43.5	64.9	55.1	47.4	52.7
H_{150}	37.2	37.4	36.8	37.6	37.2	44.6	68.4	57.9	51.9	55.7
Effect of NPK	33.8	33.7	33.9	33.7		39.9	55.9	48.1	43.9	

LSD at 0.05 for NPK = NS 1.65
LSD at 0.05 for hydrogel = 3.04 2.87
LSD at 0.05 for interaction = NS 5.52

	12WAT (Feb. 22th)					16WAT (Mar. 20th)				
H_0	39.9	58.1	53.4	45.4	49.21	60.1	80.9	76.1	73.9	72.6
H_{50}	46.4	77.4	61.6	56.0	60.4	72.8	101.1	85.1	82.8	85.5
H_{75}	49.6	87.5	73.5	62.4	68.2	80.1	105.2	96.4	86.2	92.0
H_{100}	54.6	105.3	86.6	70.0	79.1	83.3	117.2	102.3	96.6	99.8
H_{125}	57.2	110.7	92.0	75.1	83.7	84.6	127.3	108.4	100.8	105.3
H_{150}	59.4	113.0	99.9	84.2	89.1	86.7	127.3	113.4	102.7	107.5
Effect of NPK	51.2	92.1	77.8	65.5		77.9	109.8	97.0	90.5	

LSD at 0.05 for NPK = 1.32 3.02
LSD at 0.05 for hydrogel = 3.40 3.98
LSD at 0.05 for interaction = 6.80 6.47

	20WAT (Apr. 17th)					At harvest (May. 15th)				
H_0	79.3	123.5	118.7	101.6	105.8	130.9	234.8	198.5	168.9	183.3
H_{50}	101.4	181.9	141.4	123.5	137.0	159.9	262.1	225.4	200.4	212.0
H_{75}	127.3	186.0	157.9	146.6	154.4	181.5	271.9	250.7	218.9	230.7
H_{100}	138.4	198.0	179.2	164.2	170.0	192.0	288.2	261.7	229.4	242.8
H_{125}	140.6	197.7	181.1	171.6	172.8	199.4	292.2	267.4	239.0	249.5
H_{150}	143.9	197.9	188.5	168.1	174.6	212.6	291.1	279.2	249.3	258.0
Effect of NPK	121.8	180.8	161.1	145.9		179.4	273.4	247.1	217.7	

LSD at 0.05 for NPK = 2.9 4.5
LSD at 0.05 for hydrogel = 7.2 6.8
LSD at 0.05 for interaction = 14.6 12.5

WAT = weeks after transplanting

Table 5: Effect of NPK, hydrogel polymers and their interaction on dry weight (g)/ plant of onion *cv.* Giza 20.

Sample time / NPK / Hydrogel	4 WAT (Dec. 28^{th})					8WAT (Jun. 25^{th})				
	P0	P_1	P_2	P_3	Effect of hydrogel	P_0	P_1	P_2	P_3	Effect of hydrogel
H_0	3.34	3.59	3.76	3.55	3.56	3.53	5.04	4.41	3.95	4.23
H_{50}	3.53	3.87	3.69	3.79	3.72	3.83	5.24	4.40	4.28	4.44
H_{75}	3.59	4.12	3.91	3.89	3.88	3.94	5.92	4.81	4.60	4.82
H_{100}	3.72	4.42	4.23	3.82	4.05	4.11	6.94	5.37	4.58	5.25
H_{125}	3.79	4.02	4.16	3.93	3.98	4.14	6.54	5.55	4.77	5.25
H_{150}	3.83	4.12	3.98	4.03	3.99	4.16	6.74	5.66	5.17	5.43
Effect of NPK	3.63	4.02	3.96	3.83		3.95	6.07	5.04	4.56	
LSD at 0.05 for NPK =				NS				0.10		
LSD at 0.05 for hydrogel =				0.22				0.34		
LSD at 0.05 for interaction =				NS				NS		
	12WAT (Feb. 22^{th})					16WAT (Mar. 20^{th})				
H_0	4.63	6.82	5.27	5.70	5.61	6.45	7.21	7.13	7.05	6.96
H_{50}	5.10	7.14	5.29	6.46	6.00	6.75	7.63	7.55	7.43	7.34
H_{75}	5.30	8.57	6.54	7.06	6.87	6.82	7.94	7.82	7.74	7.58
H_{100}	5.71	9.17	7.75	7.50	7.53	6.91	8.15	8.03	7.95	7.76
H_{125}	5.87	8.22	8.29	8.17	7.64	7.01	8.41	8.21	8.17	7.95
H_{150}	5.98	8.19	8.85	8.06	7.77	7.18	9.18	8.78	8.50	8.41
Effect of NPK	5.43	8.02	7.00	7.15		6.85	8.09	7.92	7.81	
LSD at 0.05 for NPK =				0.17				0.13		
LSD at 0.05 for hydrogel =				0.25				0.24		
LSD at 0.05 for interaction =				0.61				0.47		
	20WAT (Apr. 17^{th})					At harvest (May. 15^{th})				
H_0	11.28	20.20	18.10	14.01	15.90	15.3	27.9	24.6	20.1	22.0
H_{50}	12.82	24.10	18.60	16.22	17.94	17.1	33.8	27.2	23.7	25.4
H_{75}	15.74	25.20	20.38	18.91	20.06	20.5	36.1	30.5	28.3	28.9
H_{100}	16.79	27.60	22.59	20.29	21.82	22.9	38.9	36.8	33.8	33.1
H_{125}	16.85	24.81	22.69	21.56	21.48	21.7	37.3	34.4	32.5	31.5
H_{150}	16.94	24.17	23.08	20.88	21.27	21.4	35.7	35.3	32.8	31.3
Effect of NPK	15.07	24.35	20.91	18.65		19.8	35.0	31.5	28.5	
LSD at 0.05 for NPK =				0.53				0.88		
LSD at 0.05 for hydroge =				1.20				1.36		
LSD at 0.05 for interaction =				2.12				2.72		

WAT = weeks after transplanting

D. Growth analysis parameters, Table 6:

D.1. Absolute growth rate (AGR)**:** is the total weight gain in the plant within a specific time interval expressed as (g day^{-1}). Data clearly showed that studied treatments significantly influenced the total accumulation rate of dry matter in shoots.

The highest values of dry matter accumulation as affected with NPK packages were obtained by treatments of P_1 followed with P_2. The increase percentages were 62.7 and 42.6%, respectively. Also, the treatments of H_{100} and H_{125} achieved the highest accumulate values of dry matter when compared with other hydrogel or control treatments with percentage 55.4 and 52.2% more than control. The combination treatments between NPK packages and hydrogel polymers P_1+H_{100} and P_1+H_{75} increased dry matter accumulation more than individual factors and other combination treatments. The increases percentages were 189.6 and 170.4% more than lowest value which related with control treatment (P_0+H_0).

D.2. Net assimilation rate (NAR): is expressed as increase in dry matter per unit of leaf area per time unit it is expressed as (µg cm^2 day^{-1}). Data presented in Table 6 indicated that all studied treatments significantly affected NAR.

Data clearly indicated that high level of NPK packages (P_1) led to decrease NAR as compared with the treatment of P_3. Also, the highest values of NAR achieved from plants received low doses of hydrogel polymers (H_{50}) and control treatments when compared with high doses. Furthermore, the effect of interaction among studied factors resulted high net assimilation rate of P_2+H_0 and P_2+H_{50} treatments as compared with other treatments.

These results may be due to the shortage of intervals among plants that received high doses of mineral fertilizers and hydrogen for their augment size, the light can't access to the lower parts of them that are in the shade. On the contrary, the small doses of treatment materials produced small plants in size can light access to all its parts led to higher photosynthesis efficiency.

Table 6: Effect of NPK, hydrogel polymers and their interaction treatments on absolute growth rate AGR (g day^{-1}) and net assimilation rate NAR (µg cm^2 day^{-1}) of onion *cv.* Giza 20.

NPK / Hydrogel	AGR (g day^{-1})				
	P_0	**P_1**	**P_2**	**P_3**	**Effect of hydrogel**
H_0	0.0849	0.1547	0.1505	0.1175	0.1269
H_{50}	0.1069	0.2245	0.1691	0.1421	0.1607
H_{75}	0.1405	0.2296	0.1853	0.1705	0.1815
H_{100}	0.1509	0.2459	0.2049	0.1870	0.1972
H_{125}	0.1513	0.2176	0.2040	0.1998	0.1932
H_{150}	0.1521	0.2075	0.2073	0.1870	0.1885
Effect of NPK	0.1311	0.2133	0.1869	0.1673	

LSD at 0.05 for NPK = 0.0057
LSD at 0.05 for hydrogel = 0.0119
LSD at 0.05 for interaction = 0.0237

NPK / Hydrogel	NAR (µg cm^2 day^{-1})				
	P_0	**P_1**	**P_2**	**P_3**	**Effect of hydrogel**
H_0	0.0946	0.0974	0.1189	0.1109	0.1054
H_{50}	0.0952	0.1051	0.1146	0.1092	0.1060
H_{75}	0.1043	0.0998	0.1046	0.1090	0.1044
H_{100}	0.1003	0.0909	0.0958	0.1068	0.0984
H_{125}	0.0959	0.0797	0.0964	0.1068	0.0947
H_{150}	0.0924	0.0729	0.0865	0.0980	0.0874
Effect of NPK	0.0971	0.0909	0.1028	0.1068	

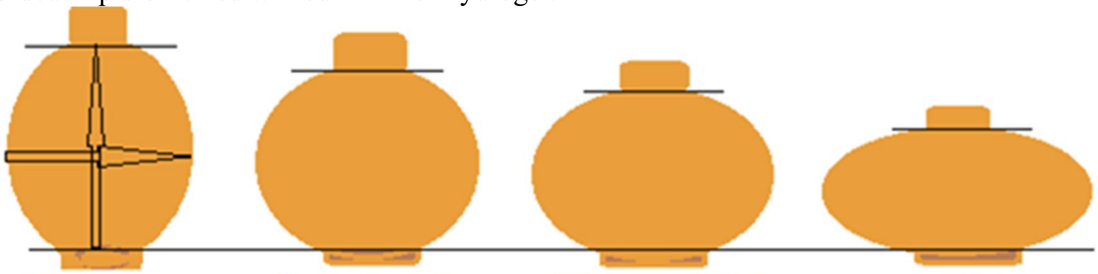
LSD at 0.05 for NPK = 0.0018
LSD at 0.05 for hydrogel = 0.0063
LSD at 0.05 for interaction = 0.0127

2. Yield and its component, Tables 7 and 8:

Table 7 show the effect of NPK packages, hydrogel polymers and the interaction between them on onion crop performance at harvest time through following studied characters:

According to effect of NPK packages, P_1 treatment significantly decreased bulbing ratio, while maximum bulbing ratio was attributed by control treatment. On other hand, increasing hydrogel polymers treatments significantly increased bulbing ratio gradually up to high rate of it, where the highest bulbing ratio (0.29) was associated with H_{150} treatment and the lowest (0.21) found in plots no received hydrogel (control). The combination treatments behavior showed that minimum bulbing ratio achieved from P_1+H_0 followed by P_2+H_0 while the highest ratio was associated with P_0+H_{150}.

Data presented in Table 7 clearly showed that all studied factors significantly influenced rotation ratio. Rotation ratio significantly increased as NPK packages applied when compared by control treatment, while no significant effect found within fertilizer packages treatments. The highest record of rotation was 1.27 (bulb is flat shape) while the lowest value was 1.11 (bulb is flattened globe shape) produced of control plots. On other hand, rotation ratio increased as hydrogel polymers amount increased up to 15 kg fed^{-1} (H_{150}). Regarding, the maximum flat bulbs (1.32) produced from interaction treatment P_2+H_{150}, while the lowest rotation which was 0.87 (the bulb is pear shape) recorded in plots treated without NPK or hydrogel.



$$\text{Rotation ration (RR)}= \frac{\text{Horizontal diameter of bulb (cm)}}{\text{Vertical diameter of bulb (cm)}}$$

Data point to that onion bulbs significantly influenced by NPK doses, where doubled bulbs increased with NPK doses increases. The maximum number of double bulbs was 38.3 obtained from P_1 with percentage 10.9% of total plants as compared to control treatment which was produced only 7% of doubled bulbs. Furthermore, hydrogel significantly increased doubled bulbs when compared with control treatment but no significant effect found within hydrogel treatments. The highest number of double bulbs was 34.7 with percentage of 9.9% as compared with no hydrogel treatment (control). Regarding, the interaction among studied factors, the treatments showed significant effect on number of double bulbs. The highest values were obtained from greatest dose of NPK (P_1) within each of hydrogel treatments except H_0. The lowest values were attained from any of P_0 and P_3 within each of hydrogel treatments in addition to P_2+H_0 and P_2+H_{50}.

The variation between number of early flowering plants / plot (EFP) originally present within the studied NPK packages and those flowered due to variation in hydrogel polymer, the early flowering plants significantly affected by studied factors and combination among them.

Maximum value of EFP was obtained from P_1 with percentage of 14.17% of all experimental plot plants (350 plant) as compared by 5.73% which was produced from control treatment. Also, the higher dose of hydrogel (H_{150} and H_{125}) acquired the highest number of EFP with 3.91% more than those found in control plot (8.97%). Regarding, the interaction effect on EFP, data indicated that P_1+H_{150} and P_1+H_{125} treatments were attributed by higher value, while minimum number was associated by P_0 within all hydrogel doses except H_0.

It is worth that the heavy fresh weight of bulbs most need to such treatments for increase total and marketable yield, data presented in Table 8 showed high significant increases in bulbs fresh weight according to use high rates of NPK or / and hydrogel polymers.

The high dose of NPK package (100:60:100) surpass on other package treatments, where the increases of bulbs fresh weight were 7.1, 15.2 and 27.1 %, while average of total yield per plot and total yield ton per fed increased by 7.3, 14.2 and 26.1%, also achieved increases in the marketable yield by percentage of 2.8, 7.2 and 13.4% over P_1, P_2 and control respectively.

Also, high doses of hydrogel (H_{150}, H_{125} and H_{100}), haven't significant variation between them when compared with other hydrogel treatments increased fresh weight of onion bulbs, average of total yield per plot, also, total and marketable yield per fed. The increments values when compared with control were 25.8±4.9, 28.0±0.9, 28.0±0.9 and 22.3±0.1% respectively.

Regarding, the interaction among studied factors on recently mentioned parameters, Table 8 showed that higher values were related by combined high doses of NPK and hydrogel polymers, the maximum increments of fresh bulbs weight, total yield per plot and feddan, also, marketable yield when compared with control (P_0+H_0) were 46.8±7.4, 48.5±0.9, 48.5±0.9 and 40.1±0.2 % respectively

Table 7: Effect of NPK, hydrogel polymers and their interaction on bulbing ratio, rotation ratio, number of doubled bulbs / plot and number of early flowering plants / plot at harvest time of onion *cv.* Giza 20.

NPK / Hydrogel	Bulbing ratio at harvest time					Rotation ratio at harvest time				
	P_0	P_1	P_2	P_3	Effect of hydrogel	P_0	P_1	P_2	P_3	Effect of hydrogel
H_0	0.26	0.17	0.20	0.21	0.21	0.87	1.26	1.24	1.27	1.16
H_{50}	0.28	0.21	0.22	0.23	0.23	0.94	1.22	1.28	1.25	1.17
H_{75}	0.27	0.22	0.26	0.24	0.24	1.09	1.25	1.27	1.24	1.21
H_{100}	0.27	0.23	0.26	0.26	0.25	1.23	1.25	1.25	1.25	1.24
H_{125}	0.27	0.28	0.26	0.27	0.27	1.26	1.29	1.26	1.26	1.27
H_{150}	0.29	0.29	0.28	0.28	0.29	1.29	1.28	1.32	1.29	1.29
Effect of NPK	0.27	0.23	0.25	0.25		1.11	1.27	1.27	1.26	
LSD at 0.05 for NPK =			0.01					0.01		
LSD at 0.05 for hydrogel =			0.01					0.01		
LSD at 0.05 for interaction =			0.03					0.02		
	Number of double bulb / plot					No. of early flowering plants / plot (EFP)				
H_0	25.8	29.8	27.5	26.0	27.3	24.3	35.8	34.0	31.5	31.4
H_{50}	25.5	36.3	29.5	27.8	29.8	22.8	40.5	36.5	32.3	33.0
H_{75}	25.3	37.3	33.0	29.8	31.3	20.3	43.5	39.5	34.8	34.5
H_{100}	24.0	40.5	36.5	30.8	32.9	17.8	46.3	42.3	37.3	35.9
H_{125}	23.0	42.8	33.8	32.3	32.9	17.8	64.8	49.8	39.5	42.9
H_{150}	23.8	43.5	38.8	32.8	34.7	17.3	66.8	53.5	43.0	45.1
Effect of NPK	24.5	38.3	33.2	29.9		20.0	49.6	42.6	36.4	
LSD at 0.05 for NPK =			4.1					2.1		
LSD at 0.05 for hydrogel =			5.2					3.4		
LSD at 0.05 for interaction =			9.5					5.6		

WAT = weeks after transplanting

Table 8: Effect of NPK, hydrogel polymers and their interaction on bulb fresh weight (g) at harvest time and total yield kg / plot of onion *cv.* Giza 20.

NPK / Hydrogel	Bulb fresh weight (g) at harvest					Total yield (kg)/ plot				
	P_0	P_1	P_2	P_3	Effect of hydrogel	P_0	P_1	P_2	P_3	Effect of hydrogel
H_0	81.1	129.7	113.2	100.2	106.1	28.32	45.08	39.13	34.88	36.85
H_{50}	98.5	144.9	127.8	116.8	122.0	34.58	50.33	44.43	41.38	42.68
H_{75}	111.2	151.2	140.1	126.5	132.3	39.26	52.19	49.41	45.20	46.52
H_{100}	115.3	157.3	145.2	134.7	138.1	41.53	55.34	51.58	47.37	48.95
H_{125}	121.7	161.2	149.7	140.0	143.2	43.13	56.10	52.70	49.35	50.32
H_{150}	130.5	158.1	155.6	147.1	147.8	45.99	55.89	55.03	51.49	52.10
Effect of NPK	109.7	150.4	138.6	127.6		38.80	52.49	48.71	44.95	
LSD at 0.05 for NPK =				8.2				2.8		
LSD at 0.05 for hydrogel =				11.5				3.6		
LSD at 0.05 for interaction =				19.3				7.2		
	Total yield (Ton)/ fed					Marketable yield (Ton)/ fed.				
H_0	11.33	18.03	15.65	13.95	14.74	9.71	14.65	12.90	11.66	12.23
H_{50}	13.83	20.13	17.77	16.55	17.07	11.92	15.71	14.42	13.71	13.94
H_{75}	15.70	20.88	19.77	18.08	18.61	13.66	16.06	15.67	14.74	15.03
H_{100}	16.61	22.14	20.63	18.95	19.58	14.63	16.65	15.99	15.26	15.63
H_{125}	17.25	22.44	21.08	19.74	20.13	15.24	15.54	16.05	15.69	15.63
H_{150}	18.39	22.35	22.01	20.59	20.84	16.23	15.31	16.21	16.13	15.97
Effect of NPK	15.52	21.00	19.49	17.98		13.56	15.65	15.21	14.53	
LSD at 0.05 for NPK =				0.32				0.28		
LSD at 0.05 for hydrogel =				0.85				0.37		
LSD at 0.05 for interaction =				1.37				0.74		

WAT = weeks after transplanting

3. Nitrogen use efficiency: Data presented in Table 9 show there were significant differences coefficient among levels of mineral fertilization, highest bulbs quantity produced from one unit of nitrogen obtained by high level of NPK package when compared by other packages. It is worth noting that calculate arithmetic mean from the 100: 60: 100 within all hydrogel treatments produced fewer bulbs than those produced by the same treatment absolutely alone P_1+H_0. This indicates that efficiency of nitrogen use decreased with using hydrogel at all levels, this also clearly showed in data resulted from interaction treatments. This may be due to the fact that the hydrogen crossbones is physically active with metal compounds, which are led to retention and non-presence in the soil solution in quantities that lead to washing with irrigation water.

Table 9: Effect of NPK packages, hydrogel polymers and their interaction on nitrogen use efficiency (NUE kg onion/ nitrogen unit) of onion (*Alium sativaum* L.) cultivar Giza 20.

NPK / Hydrogel	NUE (kg onion/ nitrogen unit)		
	P_1	**P_2**	**P_3**
H_0	67.0	57.6	52.5
H_{50}	63.0	52.5	54.4
H_{75}	51.7	54.2	47.6
H_{100}	55.2	53.6	46.7
H_{125}	51.9	51.1	49.8
H_{150}	49.6	48.2	44.0
Effect of NPK	56.4	52.9	49.2

LSD at 0.05 for NPK = 1.2
LSD at 0.05 for interaction= 3.1

Storability

The storing is one of important proses can applied on onion crop after harvest. Also the treatments applied during growing season can effect on yield during storing period, especially if the bulbs contain more moisture. The follow of TSS (%) during four months of storing period indicated that TSS (%) significantly affected by NPK treatments (Table 10). The increments were related with all NPK treatments as compared by control treatment (no NPK applied). The plants treated with hydrogel through growing season showed significant increases in TSS after storing period. The highest TSS values were attained by H_{75} and H_{100} when compared with other hydrogel and control treatments.

According to losses of weight during storing period, data presented in Table 10 showed that bulbs produced in soil treated with NPK at rate of 100:60:100 had able to high losses in its weight. The losing of weight significantly increased with storing time progress. The lowest losses in weight were attributed with bulbs grown in soil untreated with NPK. Also, bulbs produced from plants treated with 12.5 and 15 kg hydrogel per feddan (H_{125} and H_{150}) significantly increased losses in weight as compared with other treatments. Minimum losses values were achieved from bulbs untreated with hydrogel.

Dry matter content is one of most important characteristic for consumer, especially if bulbs will be used in manufacturing. The NPK packages and interaction treatments with hydrogel affected significantly on dry matter percentage. The maximum values were associated with P_1 and P_2 packages, while the interaction was low significantly affected where P1, P2 and P3 within all hydrogel treatments obtained the highest values of dry matter (%).

Regarding rotten and sprouted bulbs during storing period, data presented in Table 10 showed that significant highest value was attributed with package applied at rate of 100:60:100 kg NPK during both growing seasons. Minimum rotten bulbs had gotten from untreated plants. Furthermore, the highest amounts of hydrogel applied to experimental soil (H_{125} and H_{150}) significantly increased rotten and sprouted bulbs during storing period. The interaction between studied factors resulted high significant rotten and sprouted bulbs produced from plants grown in medium contain mixture of NPK and hydrogel at rates of 100:60:100 within 7.5, 10, 12.5 and 15 kg /fed. hydrogel polymers and 75:54:75 kg of NPK within H_{125} and H_{150}. While lowest rotten and sprouted bulbs weight acquired from plots were received P_0H_0.

Finally, after storing period, net weights which are able to marketing tabulated in Table 11. The treatments we are tested showed significant effects on net weight, where the maximum net weight was achieved from whether untreated bulbs under NPK packages or hydrogel treatments. Also, there were significant differences within interaction treatments, the highest net weight were attained from P_0 within all hydrogel treatments.

Calculated marketable yield after storing period scheduled in Table 11 clearly indicated that high quantity of NPK package (P_1) or hydrogel (H_{100}, H_{125} and H_{150}) significantly gave the maximum marketable yield after storing period. While, mixture P_0+H_{100}, P_0+H_{125}, P_0+H_{150}, P_1+H_{100} and P_3+H_{150} with interaction treatments achieved the highest significant amounts of marketable yield after storing period.

Table 10: Effect of NPK, hydrogel polymers and their interaction treatments on TSS (%), loss weight, dry matter (%), rotten and sprouted bulbs of onion *cv.* Giza 20 during storing period.

NPK / Hydrogel	TSS					Loss weight (g)				
	P_0	**P_1**	**P_2**	**P_3**	**Effect of hydrogel**	**P_0**	**P_1**	**P_2**	**P_3**	**Effect of hydrogel**
H_0	10.7	13.2	11.7	11.2	11.7	398.8	464.9	439.8	428.8	433.0
H_{50}	11.3	12.9	12.5	11.8	12.1	404.8	470.3	445.5	435.0	438.9
H_{75}	12.1	14.1	13.3	12.9	13.1	408.3	476.3	453.0	439.8	444.3
H_{100}	12.5	14.4	13.7	13.4	13.5	417.8	480.0	461.0	445.8	451.1
H_{125}	12.4	12.3	12.1	13.4	12.5	425.3	489.6	467.1	449.0	457.7
H_{150}	12.3	11.9	11.3	13.5	12.3	428.3	498.8	473.8	456.2	464.3
Effect of NPK	11.9	13.1	12.4	12.7		413.8	480.0	456.7	442.4	
LSD at 0.05 for NPK =			0.7					5.6		
LSD at 0.05 hydrogel =			0.9					11.0		
LSD at 0.05 for interaction =			NS					NS		
	Dry matter (%)					**Rotten and sprouted bulbs weight (g)**				
H_0	15.8	18.8	18.1	17.2	17.5	126.6	156.2	146.7	137.8	141.8
H_{50}	15.1	19.4	18.5	18.0	17.8	130.8	167.8	156.4	142.7	149.4
H_{75}	14.8	20.1	19.4	19.1	18.4	134.9	173.7	162.0	147.7	154.6
H_{100}	14.5	20.5	20.1	19.7	18.7	137.4	181.0	166.8	152.9	159.5
H_{125}	14.5	19.6	19.4	19.3	18.2	138.1	183.3	179.3	162.0	165.7
H_{150}	14.1	19.0	19.2	19.6	18.0	142.0	195.9	190.4	168.7	174.2
Effect of NPK	14.8	19.6	19.1	18.8		135.0	176.3	166.9	152.0	
LSD at 0.05 for NPK =			0.6					5.6		
LSD at 0.05 for hydrogel =			NS					11.0		
LSD at 0.05 for interaction =			1.7					23.8		

Table 11: Effect of NPK, hydrogel polymers and their interaction treatments on net weight (g) and marketable yield (ton/fed) after storing onion bulbs *cv.* Giza 20.

NPK / Hydrogel	Net weight (g)					Marketable yield (ton/fed)				
	P_0	**P_1**	**P_2**	**P_3**	[illegible]	**P_0**	**P_1**	**P_2**	**P_3**	[illegible]
H_0	1975	1879	1914	1933	1925	8.43	11.45	10.29	10.12	10.07
H_{50}	1964	1862	1898	1922	1912	9.59	11.39	10.84	10.57	10.60
H_{75}	1957	1850	1885	1913	1901	11.44	11.87	10.69	10.84	11.21
H_{100}	1945	1839	1872	1901	1889	12.27	12.17	11.50	11.22	11.79
H_{125}	1937	1827	1854	1889	1877	12.47	11.67	11.67	11.60	11.85
H_{150}	1930	1805	1836	1875	1861	12.43	11.27	11.77	11.89	11.84
Effect of NPK	1951	1844	1876	1906		11.10	11.64	11.13	11.04	

LSD at 0.05 for NPK = 20 0.21
LSD at 0.05 for hydrogel = 29 0.28
LSD at 0.05 for interaction = 52 0.56
WAT = weeks after transplanting

Discussion

Fertilizers are sources of plant nutrition that can applied to increase soil fertility. They are intended to supply plants need directly rather than indirectly through modification of such properties such as soil pH and structure. There is usually a dramatic improvement in both quantity and quality of plant growth when appropriate fertilizers are added (Nahed, 2007). In this experiment, NPK packages significantly increased plant height, leaves number, leaves area besides, fresh and dry weight per plant through growing seasons up to harvest date. The highest value produced from NPK at rate of 100:60:100 kg fed^{-1} (P_1). Also, growth analysis parameters expressed as absolute growth rate (AGR) and net assimilation rate (NAR) significantly influenced by NPK, also the highest values of dry matter accumulation in plant tissues were related by treatments of P_1 follow with P_2. While NAR increased with the treatment of P_3. In addition, yield and its components *i.e.* bulbing ratio, rotation ratio, number of doubled bulbs per plot, No. of early flowering plants per plot (EFP), bulb fresh weight (g) at harvest, total yield per plot as well as total yield and marketable yield per fed. significantly effected with NPK packages where the most effect was attained by NPK at rates of 100:60:100 kg fed^{-1}. The results were obtained by many investigators who found that mineral fertilization led to increase growth parameters (Abdul Ghaffoor *et al*., 2003 on onion; Omotoso and Shittu, 2007 on okra; Yaso and Abdel-Razzak, 2007 on onion, Selim *et al*. 2009, Abo Sedera *et al.* 2010 on strawberry; Hafez and Soubeih, 2012 on eggplant and Oloyede *et al*., 2013 on pumpkin). In addition to those who have recently mentioned, Assefa *et al*., 2015 found that fertilization with major elements enhanced crops yield in quantity and quality. Furthermore, the optimum NPK package increased bulbs quality after storage period. Such finding were reported by Dantata, 2014, while Yaso and Abdel-Razzak (2007) recorded that no significant effect found in such measurements after six months of storage period of bulbs treated by different levels of NPK. These results may be due to the vital role played by the nutrients in the plant. Nitrogen is one of the most yield-limiting nutrients in crop production in most agroecosystems. Nitrogen is included in amino acids, which is the basic structure of the protein molecule and nucleic proteins. Most cells protoplasm is formed from protein. Nitrogen plays numerous key roles in plant biochemistry, including being an essential constituent of enzymes, chlorophyll, nucleic acids, storage proteins, cell walls, and a vast array of other cellular components (Harper, 1994 and Fageria and Moreira, 2011). Thus, the presence of nitrogen helps to increase the cells size and their elongation in turn rapid division of plant cells. Nitrogen enters the formation of hormones, enzymes, vitamins and chlorophyll. Thus, leads to an increase in the number and size of plant members and increase its fresh and dry weight (Estefanous and Sawan, 2003; Rajput and Patel, 2009 and Hafez and Soubeih, 2012). This means increases in the stored compounds of protein. After vegetative growth stage, stored components transferee to the storage members, which are the bases of the leafy leaves in the bulbs, forming onion bulbs (Dantata, 2014). Increasing Nitrogen fertilization leads to increased moisture content in the plant cell and becomes juice so that the dry matter decreased, also the cell cellular wall become thinner and is more prone to disease than cells that given the optimum dose of nitrogen (Hafez and Soubeih, 2012).

Phosphorus is one of the most yield-limiting nutrients. Phosphate plays many roles in the physiology and biochemistry of plants. It is a component of important compounds like phospholipids, phosphorylated sugars and proteins, DNA (deoxyribonucleic acid), and RNA (ribonucleic acid). It is also a component of ATP (adenosine 5-triphosphate), PEP (phosphoenolpyruvate), NADPH (nicotinamide adenine dinucleotide phosphate, reduced), and other biochemicals that use the phosphate bond in energy utilization and storage (Blevins, 1994 and Fageria, *et al*. 2006). Phosphorus helps to increase the total root volume, especially the adventitious roots and fibrous roots, which helps to increase the absorption of nutrients from soil solution and improve plant growth. Fageria *et al.* (2006) reported that root dry weight was reduced 62% in rice, 74% in common bean, 50% in corn, and 21% in soybean without added soil P, when compared to adequate P in a Brazilian Oxisol.

Potassium is not directly involved in the formation of important plant compounds, but it is necessary to activate many enzymes in plants, and it is also required for photosynthesis, transport of photosynthate, and protein synthesis (Blevins, 1994). Potassium plays a role in cell growth following cell division by serving as a major component in cell turgor. It also maintains ionic balance (osmotic pressure in plant cells and thus maintains the cells' turgidity) and electrical neutrality in plants (Fageria and Moreira, 2011). Also potassium helps to increase dry matter in the plants and plays an important role in opening and closing the stomata.

Also, data showed that hydrogel significantly affected the recently mentioned growth parameters, growth analysis, also yield and its components during growing seasons as well as the measurements had taken through storing period.

The highest increases of plant height, leaves number and area besides fresh and dry weight were attained by H_{100}, H_{125} and H_{150} treatments with no significant differences within them. Also, the highest dry matter accumulation (AGR) was achieved from H_{100}, on the contrary, exist of NAR was for H_0 and H_{50}. Similar results were reported by Akhter *et al.* (2004); Abedi-Koupai *et al*. 2008; Chirino *et al.*, 2008 and Yáñez-Chávez *et al.* (2014), also, Gilbert *et al.* (2014) found that hydrogels increased plant height, root length and diameter after transplanting under semi-arid lands of Kenya conditions. These results may be due to the abundance of soil moisture catched by hydrogel in plant root zone and increase the plant absorption of it (Gales *et al.*, 2012). While, the low NAR with high levels of hydrogel may be due to increase the plant crowding on unit of land area which is in turn delayed the rate of photosynthesis in lowest parts of plants, on contrary, the plants grown in medium treated with no hydrogel have smallest size and the intervals spaces between them are large and all parts of the plant are exposed to light, so that increasing the rate of photosynthesis and high NAR (Gilbert *et al*., 2014 and Pattanaaik, 2015). Also, All the parameters of the onion crop yield and its quality, whether desirable such as rotation, weight of the bulb and experimental plot yield and the yield per feddan or undesirable, such as double bulbs and early flowering significantly increased when used the high-level of hydrogel (H_{100}, H_{125} and H_{150}). These results agree with those found by Pattanaaik *et al.* (2015). It is obvious that the strength or weakness of vegetative plant growth is reflected in storage organs (seeds, fruits, tubers or represented by the bulbs in the onion crop). The increasing yield may be due to the fact that the soil was wet for a long time increasing the microbial activity which released plant nutrients from complex compounds in the soil, as well as increasing vegetative growth and in turn crop yield (Gales *et al.*, 2012 and Pattanaaik *et al*., 2015).

Obtained data of onion bulbs storage ability affected by hydrogel treatments pointed that TSS, dry matter percentage and marketable yield after storing period significantly increased by increasing hydrogel up to 150% of recommended dose (10kg fed.$^{-1}$). Certainly, increasing the moisture losses from bulbs tissues led to decreases in bulbs weight followed by increase of total soluble solids and dry matter during storage period. These results agree with those found by Pattanaaik *et al*. (2015).

Conclusion

The obtained results of the effect of fertilizer packages and polymers on onion yield and quality under Bahariya Oasis conditions indicated that the useful treatment for increase the onion bulbs productivity weather at harvest or after storing period is by applying NPK at a recommended dose and high water absorbance polymers especially in sandy agricultural soils. The application of macro nutrients (NPK) or / and hydrogel polymer causes great increases in growth parameters and productivity of onion bulbs when added at rate of 100:60:100 NPK or/ and 10 fed^{-1} hydrogel. In addition to enhancing the bulbs quality after storing period.

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