Effect of Both Soil Improvements and Irrigation Levels on Potato Productions

L. M. AL-Jawadi\(^1\) and H. M. Hassan\(^2\)

\(^1\) Horticulture Office, Ministry of Agriculture, Iraq.
\(^2\) College of Agriculture and Forestry, University of Mosul, Iraq

*Corresponding author’s e-mail: dr_hesham10@uomosul.edu.iq

Abstract. This study dealt with the effect of the irrigation water quantity added at the irrigation levels I\(_1\) and I\(_2\) (100 and 50\% of available water and the effect of correlation between the polymer and animal amendments added to the soil on the potato crop. Result showed that the plant properties were impacted by the irrigation level I\(_1\) compared to the level I\(_2\). The values of site 2 were superior over the values of site 1 in terms of the plant height, number of stems, dry root weight, average weigh of the tuber and the yield of each plant. The interference treatment P\(_3\)O\(_2\) of the irrigation level I\(_1\) achieved the best values for the two sites, in addition to the positive role played by the soil improvements (polymer and animal amendments), which meliorated the values of porosity, infiltration, increased water retention by soil and decreased the bulk density. In addition to that, there is an evident effect of the irrigation level I\(_1\) and the interference amongst the levels P\(_3\)O\(_2\), P\(_2\)O\(_2\) and P\(_3\)O\(_1\) on the total number of the tubers and the total production in comparison to their counterparts at the irrigation level I\(_2\). The treatment P\(_3\)O\(_2\) achieved the best results in terms of the number of tubers and the total production at the irrigation level I\(_2\) for both sites whereas the effect of I\(_1\) irrigation level with the animal amendments was clear in terms of number of the big tubers and big-size production. The interference between the polymer and the animal amendments at the I\(_1\) level, showed a clear superiority in terms of tubers number and the productivity as small tubers for planting and the interference treatment P\(_3\)O\(_2\) recorded the highest results at the irrigation level for both of the two sites.

1. Introduction

Water has a major role throughout all the stages of the plant growth and development. Therefore irrigation is considered one of the most important operations for managing the green crops due to its role in determining the quality and the quantity of the crops by means of providing water and nutrients to the crops. The shortage in rain within the dry and semi-dry regions conditions leads to the shortage of resources required to meet the water needs for the crops. So, it is necessary to exploit the water efficiently and effectively as much as possible [41]. Water needs change in accordance with the type of crop grown, stage of its growth, the prevailing weather condition and the type of soil. Excessive irrigation is often regarded as costly and harmful and irrigation process is vital to keep the available water near from the plant roots and if the quantity needed to be added is determined, the efficiency of good irrigation would be fulfilled and it can be reached if we limit the loss by surface flow or infiltration outside the root group in addition to evaporation from the soil surface. Also, the shortage of water has an effect, to a certain degree, on the plant according to the type of the crop, stage of growth, soil type and the prevailed weather conditions [25]. Potato is considered one of the vegetable crops, which is sensitive to the moisture content as the moisture increase or decrease the matrix potential due to irregular irrigation and the increase in transpiration results in plant physiological drought in addition to major damage especially in the stage of tubers evolution and development. This causes a significant decrease in the total output of the tubers and a deterioration in the quality and storage characteristics of tubers. Therefore, light irrigation with short period intervals is better than the copious irrigation with long intervals. So, the moisture content shouldn't be reduced to less than 65\% of the field capacity in order to obtain good potato growth and production [40]; [10]; [1] argued that there is a difference in terms of the potato plant need to water according to the growth stages and the stage of form tuber...
bulging is regarded as the most critical stage in the plant life and any shortage in the soil moisture during this stage leads to a decrease in the yield and its quality. The property of the yield is tightly connected with a set of physiological processes which are affected with the environmental conditions in which the plant grows throughout its various stages of growth. Water matrix potential is considered the most influencing factors in production and the stages of tuber growth and bulging until the maturity are considered the most important in the plant life. Lack of water and irregular irrigation during these stages lead to a decrease in the yield [38]; [26].

Javad [24] concluded that there was a huge decrease in the yield incurred by water potential as a main cause in the stages of growth. We can avoid this damage by means of using polymers that limit water potential which affects the yield and its components and the efficiency of using the water. [13] found that the average bulging increases by 22% in the irrigation treatment compared to the case without irrigation. Moreover, [23] indicated that using PAM in sandy soils enhanced the plant by providing additional dose of water as this addition led to increasing moisture preservation by 40%, and this in turn improved the root suction to water and nutrients and encouraged the vegetative growth. On the other hand, subjecting the plant to matrix potential results in a significant decrease in the dry weight due to the poor growth of roots that hinders the nutrients and water necessary for growth. This finding is in conformity with what was mentioned by several scholars that the growth of roots and dry weight decrease significantly with the decrease of soil moisture levels or when the plant is exposed to water potential [3]; [27]; [39]; [5] demonstrated that using PAM and blending it with the soil gave the highest yield as it is capable of preserving the water in the soil and decreasing the loss by evaporation transpiration or deep infiltration outside the root zone for the purpose of improving the soil properties relevant to water and enhancing the growth of plant roots and increasing the yield. On the other hand [14]; [20] indicated that animal amendments importance in the alternative environmentally-safe agriculture to produce potato tubers. The study conducted by [30]; [11] that the addition of animal amendments resulted in an increase in the vegetative growth properties for potato plants. Also, concluded that using the animal amendment with an average of (30 ton.hectare-1) led to an resulted in an increase in the average weight of the tubers.

2. Materials and Methods
A field study was conducted in the sites with different textures in Nineveh Governorate for Spring season 2012. The first site (site1) is represented by AlGubba area with clay texture in the northern part of Mosul city, while site2 is located in the south east part of Mosul with loam texture represented by AlMazaree site. The topography of the two sites are plain area. Samples were collected from the soil for the depth (0 – 0.3m) using a soil drill. Three samples were taken from each site after that they were dried by air, blended, grinded and then sieved with 2 mm diameter sieve to identify some properties of the experiment soil (tables 1, 2 and 3).

| Site    | pH      | Ec µс | O.M g.kg⁻¹ | available N g.kg⁻¹ | available P g.kg⁻¹ | available K g.kg⁻¹ | available carbonate g.kg⁻¹ | Site1 (AlGubba) | Site2 (AlMazaree) |
|---------|---------|-------|-------------|-------------------|-------------------|-------------------|--------------------------|-----------------|-----------------|
| Site1   | 2.70    | 7.62  | 42.7        | 7.72              | 7.72              | 7.77              | 4.21                     | Site1 (AlGubba) | Site2 (AlMazaree) |
| Site2   | 2.67    | 4.72  | 47.2        | 7.42              | 7.42              | 7.77              | 7.14                     | Site1 (AlGubba) | Site2 (AlMazaree) |

| Textural properties of the two sites soils |
|------------------------------------------|
| Location | Texture | Soil particles | Soil conductivity cm.h⁻¹ | Infiltration | Porosity % | Bulk density g.cm⁻³ | Clay | Silt | Sand | Texture | Location |
|----------|---------|----------------|------------------------|-------------|------------|---------------------|------|------|------|---------|----------|
| Sw       | 0.0164  | 0.0082         | 1.29                   | 1.20        | 2.2        | 42.5                | 1.40 | 490  | 305  | 145     | Clay     |
| S        | 0.013   | 0.0065         | 1.63                   | 1.578       | 2.62       | 47.0                | 1.314| 230  | 470  | 300     | Loam     |
|          |         |                |                        |             |            |                     |      |       |       |         |          |

Table. 1 Some chemical properties of the two sites soils

| Site    | Sw | S | constant | Falling | Potosity | Bulk density | Soil particles | Texture | Location |
|---------|----|---|----------|---------|----------|--------------|---------------|---------|----------|
| Site1   | 0.0164 | 0.0082 | 1.29 | 1.20 | 2.2 | 42.5 | 1.40 | 490 | 305 | 145 | Clay | Site1 |
| Site2   | 0.013 | 0.0065 | 1.63 | 1.578 | 2.62 | 47.0 | 1.314| 230 | 470 | 300 | Loam | Site2 |

Table. 2 Some physical properties of the two sites soils
Table 3. Moisture content of the soil with various matrix potential in the two sites

| Available water | Moisture matrix potential (Kpa) | Texture | Location |
|-----------------|---------------------------------|---------|----------|
| 10              | 30.44                           | Clay    | Site1    |
| 12.035          | 25.48                           | Clay    | Site2    |

Randomized complete design (RCBD) was used (2 irrigation treatments \*4 polymer treatments \*3 animal amendment treatments \*3 replicates = 72 experimental units for each site. The area of each strip = 12 m² \* number of units 72 = 864 m², except for the separating borders between the treatments. With the separators, the area \( \approx 950 \) m² for each experiment in each location).

Irrigation levels (two levels):
The first treatment I1 = the full irrigation treatment and irrigation is performed when 50% of available water is lost and 50% of water is added to obtain 100% water.
The depth of the water added was calculated according to the following equation:

\[
d = \frac{(\theta_{\text{mfc}} - \theta_{0.5\text{Aw}}) Zr \times Pb}{Pw}
\]

The second treatment I2 = the short irrigation treatment. Irrigation is performed when 75% of available water is lost and 25% of water is added to obtain 50% water.

\[
d = \frac{0.75 \text{Aw} - \theta_{0.5}}{Pw} Zr \times Pb
\]

\( \theta_{\text{mfc}} = \) moisture content at the field capacity %.
\( \theta_{0.5 \text{Aw}} = \) moisture content when losing 50% of available water.
\( \theta_{0.75 \text{Aw}} = \) moisture content when losing 75% of available water.
\( Zr = \) Depth of the root group (m).
\( Pb = \) Soil bulk density (mega g.m\(^{-3}\)).
\( Pw = \) Water density (mega g.m\(^{-3}\)).

\( V = A \times d \)
\( d = \) depth of the water added.

The two time (periods) of irrigation for each depth in the experimental units depending on the moisture depletion for each treatment (control treatment) through the following equation:

\[
Q = V \times \frac{t}{Q}
\]

\( Q = \) discharge of the pump (m\(^3\).h\(^{-1}\)) or (m\(^3\).min\(^{-1}\)) or (l.sec\(^{-1}\)).
\( V = \) volume of the water added (m\(^3\)) or liter (l).
\( t = \) time (hour) or (minute) or (second).
\( A = \) area of the treatment that ought to be irrigated (experiment unit area). m\(^2\).

Polymer treatments: Four levels of polymers were used:
1- The first treatment (control) P0 = 0 without adding any polymer.
2- The second P1 = 10 kg.donum\(^{-1}\) of Polymer (PAM) added to when planting inside the furrows.
3- The third treatment P2 = 20 kg.donum\(^{-1}\) of Polymer (PAM) added to when planting inside the furrows.
4- The fourth treatment P3 = 40 kg.donum\(^{-1}\) of Polymer (PAM) added to when planting inside the furrows.

Animal amendment treatments: Three levels of animal amendments were used as follows:
1- The first treatment (control) O0 = without adding animal amendments.
2- The Second treatment: \( O_1 = 4 \text{ tons.donum}^{-1} \) of animal amendment are added before planting and blended and mixed with the soil. The farm is left until the time of planting. It was added in 16/12/2011.

3- The Second treatment: \( O_2 = [2 \text{ tons.donum}^{-1} \) of animal amendment are added before planting (16/12/2011), blended and mixed with the soil. The farm is left until the time of planting. \( \text{tons.donum}^{-1} \) is added in 20/2/2012 as lines and mixed with the furrows.

The quantity consumed by the plant is the quantity that is added as volume in a certain time in the consequent irrigation to maintain the required moisture level by detecting the depth of the root group from the soil surface. It was observed that there were significant differences between the depth of the root group during the various stages of the plant growth. The values of \( Z_r \) varied between (0.15 – 0.35 m) beginning from the germination stage and through the vegetative stage, tuber formation, tubers bulging and ending with the peel maturity and stiffness. From the other hand, the values of bulk density \( Pb \) were determined before adding any treatment, and after adding the treatments before planting in 15/2/2012. Also, its values were measured after planting in 27/4/2012 and it was observed that their values were different during the different growth stages, especially the stages of tubers formation, bulging and peel stiffness and maturity compared to the treatments in which there were no additions of animal amendment in particular. The values of \( Pb \) of the control treatment were depended on the mass basis of the soil layer for a depth (0-0.2 m) for the period from the planting until the harvest. The quantities of water to be added to each treatment were recorded as affected by adding the treatments.

| Treatments | \( P_1 \) | \( P_2 \) | \( P_3 \) | \( P_4 \) | \( P_5 \) | \( P_6 \) | \( P_7 \) | \( P_8 \) | \( P_9 \) | \( P_{10} \) | No. |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-----|
| Site1      | b1.276 | b1.263 | a1.400 | b1.272 | b1.264 | a1.403 | b1.275 | b1.266 | a1.403 | b1.27 | 2012 |
|            | d1.131 | b1.213 | a1.343 | d1.136 | b1.215 | a1.354 | d1.142 | b1.218 | a1.382 | cdf1.148 | 2012 |
|            | b1.195 | b1.183 | a1.315 | b1.193 | b1.185 | a1.315 | b1.192 | b1.183 | a1.317 | b1.193 | 2012 |
|            | c1.115 | b1.13 | ab1.287 | c1.117 | b1.134 | a1.292 | c1.119 | b1.137 | a1.30 | c1.119 | 2012 |

The process of adding water (irrigation scheduling) was conducted by monitoring the measurement of soil moisture content after depleting 50% of the available water and adding 50% to reach 100% of available water for the irrigation level II (full irrigation). As for the irrigation treatments I2, they were conducted when the moisture content reached 25% of available water and 25% was added to reach 50% available water. In each irrigation, the quantities of water were calculated depending on the soil moisture content using the weighting method by taking samples from the soil at depths (0-20), (20-40) and (40-60) cm using auger. The effective root depth was adopted from the beginning of the study until the harvest. The quantities of water to be added to the experimental units were determined on the mass basis of the soil layer for a depth (0-0.2 m) for the period from the planting until the vegetative growth stage. Then the calculation of changed to the soil layer (0-0.4m) for the period ranged from the vegetative growth until the stage of peel stiffness and maturity as the root zone (\( Z_r \)) depth was changed. Moreover, the differences of bulk density values in terms of the stage and treatments were taken into consideration. The quantity of water added to the experimental unit differed according to the difference of the treatments, which changed the soil moisture content from a treatment to another due to the differences in the levels and the way in which the improvements were added. Water drainage quantity with time was calculated and at the same time observing the soil moisture content in the duration of the growth season to determine the time of irrigation and the added water quantity and this was done by taking sample continuously before each irrigation by the auger for various depths mentioned earlier and drying them in an electrical oven (105° degree temperature) for 24 hours. By knowing the values of moisture content and weight for each sample of the control unit and by applying equation (1) for the irrigation level I (100%), and equation (2) for the for the irrigation level II (50%), the quantity of water added was calculated from knowing the capacity of the pump discharge using the equations (3) and (4).
Investigated properties of the yield

Vegetative growth properties

Plant height: The height of the plants was measured from the soil surface to the plants were taken randomly from the middle furrows for each experimental unit and then the mean was extracted.

Number of aerial stems: they were calculated for five random plants from the middle furrows for each experimental unit and the

\[
\text{Number of aerial stems} = \frac{1}{5}
\]

Dry weight of the root: The roots of five randomly selected plants were detached and cleaned from dirt and weighted while they were wet. Then they were put in an oven at 70°C until the weight is confirmed and then the dry weight of the root was determined[31].

Yield properties: The following stage indicate the maturity of the potato crop: (cessation of the vegetative growth, yellowing of leaves, spread and stiffening of aerial stems and stiffening the tubers peel) when the water was halted 6-7 days before harvest. After that the vegetative parts are cut from the area they touch the soil so that the tubers can be plucked after 2-3 days. The plucking process was conducted in 12-17/6/2012 using manual tools.

Number of plant tubers: The tuber number was estimated by taking five random plants according to the total number of the tubers except for the impaired and tiny ones. Then they were divided by five and the number of a plant tubers was calculated:

\[
\text{Number of tubers in one plant} = \frac{\text{Number of tubers in the experimental unit (less than 10 g)}}{\text{No. of plants tubers taken from (5 plants) for each experimental unit}}
\]

Average weigh of a tuber: The average weigh of a tuber was calculated according to the following equation:

\[
\text{average weight of a tuber} = \frac{\text{Plant yield}}{\text{Number of tubers}}
\]

Average yield of each plant: It was estimated according to the following:

\[
\text{Average of one plan} = \frac{\text{Yield in the experimental unit (g)}}{\text{No. of plants the yield was taken from}}
\]

Total yield or total production (ton.donum-1): The total yield of tubers was estimated from the experimental unit yield taking into consideration the losses, by applying the below relation:

\[
\text{Average of one plant} = \frac{\text{Yield of the experimental unit (ton)}}{\text{Area of the experimental unit}} \times 2200\text{m}^2\text{ (Actual area of donum)}
\]

considering the actual area of the donum is (2200) m², and the rest is canals and passages.
Seed production (ton. donum⁻¹): after plucking five plants from each experimental unit, the yield of each plant was graded embraced well, then the tubers with sizes (35-55 mm) were weighted and the mean seed production was calculated using the same method of calculating the total production.

The non-marketable crop (ton. donum⁻¹): It included the infected, distorted which less than (25 g) in weight and they were estimated with the total seed production average.

3. Results and Discussion

Quantity of water added: The quantities added to irrigation in the germination and the vegetative stages for both sites and for the irrigation levels (I1, I2) were equal as no water was added during this period and the dependence on rainwater only which was recorded at the forecast station in AlRashediyah for both sites. The quantity of rain for this period was calculated after the time of planting until the plants are fully grown with a height of 10-15 cm. In the tuber formation stage in which the size of vegetative growth increases (in size), and this period is considered sensitive and optimal moisture should be available near the root zone because low moisture affects the number of tubers produced and thus affect the yield. It was noticed that the least water quantity added at the level I1 was for the two treatments (P3O2 and P1O2) (904 and 894 liters) compared to the largest quantity of the control treatment which was (1217 liters) (table 5). The reason behind that is the roles of the polymer and the animal amendments at the two levels (O2 and O1) in terms of maintaining the soil moisture and preserving it near the root zone and low loss of water by evaporation outside the domain of the root zone. For the rest of treatments, the irrigation water quantities varied according to the levels of polymer and animal amendments added. As for the irrigation level I2, differences in the water quantities observed as the least value of irrigation water in the treatments (P3O2 and P1O1) were (411 and 418 liters) compared to the control treatment which was (6033 liters) (table 5). It was observed that the difference in moisture content between the treatment (P1O0) and the treatment (P3O2) was (313 liters) in level I1 and (192 liters) for the the irrigation level I2, because the full irrigation (irrigation level I1) for the treatments that contained high concentrations of polymer and animal amendments could keep the water by suction and storing it and didn't lose it by evaporation – transpiration or deep infiltration outside the root zone in comparison to the irrigation level I2 (incomplete irrigation) for the same treatment and repeating the irrigation process was (5) times which lasted for (25) days. For the second site (site2), results indicate the variation in water quantities added for each treatment and this variation is due to the difference in the soils moisture content as a result of the difference in the polymer and animal amendments levels. The lowest water quantities recorded for (P3O2 and P3O1) were (702 and 709 liters respectively) and the control treatment needed the highest quantity during this period which was (970 liters) for the irrigation level I1. The reason behind that is the same reason above at the first site. In addition to that the control treatment recorded the highest quantity of irrigation water (499 liters) for the level I2 and the lowest quantity for (P3O2) was (323 liters). It was noticed that the differences in the quantity of the water added for the highest and lowest quantity for the levels I1 and I2 were (268 and 176 liters) respectively. This is because the polymer could suck and preserve larger quantity in level I1 compared to level I2. This indicates that the polymer granules and animal amendments preserved the water, retained it and prevented it from infiltrating outside the root zone, and it was also observed that the repetition in this period was (5) times and that with the older age of the plant, it demands larger amounts of water to survive and avoid drought and thirst. The stage of tuber bulging when the age of the plant became (6-70) days is highly sensitive to the lack of water as it affects the size of tubers and in the case where there is a shortage or deficiency in the soil moisture content, this leads to producing small tubers (less than 25 cm. in diameter). When the water is optimally available, this will enable the production of optimal tuber size although this is associated with the type of the species planted. So, when the plant gets the sufficient amount of water, then it gives the best productivity (involves big and middle-sized tubers). Therefore, the plants shouldn't suffer drought in this period and the subsequent stage to get good-sized production. Also, it is observed that the highest quantities of the water added for all the growth stages were in the control treatment and was (2097 liters), but for the interference treatment it was (1628 liters) for the irrigation level I2. From the other hand, the rest of treatments varied in terms of irrigation quantities according to the variation in the polymer and animal amendment levels and results showed that the highest water quantity was in the control treatment (1087 liters) and the lowest quantity was for the treatment (P3O2).
as it was (853 liters) for the irrigation level I2 at site1 (table 5). It was found that the values of the control treatment and (P3O2) was (469 liters) and (234 liters) respectively for I1 and I2 levels. So, repeating the irrigation and increasing the irrigation between each irrigation and water quantity was (6) times. The results of site2 indicated in this stage that there has been a need to the highest quantity of irrigation water added compared to other stages. The quantities for control treatment were (1951 liters) and (988 liters), while the lowest quantities for treatment (P3O2) were (1456 liters) and (730 liters) for I1 and I2 irrigation levels respectively. This is due to the availability of polymer granules and the organic matter near the root zone, which could keep the soil moist compared with the other soils that didn't contain improvements. The difference between the control treatment and (P3O2) treatment, it was found that the difference in I4 level was (495 liters), whereas the difference in I2 level was (258 liters) and this is because the quantity of irrigation water in the case of full irrigation (100% available water is higher than the incomplete irrigation quantity (50% available water). So, it was noticed that the number of irrigation times in this stage is 6 and added water between each two irrigation was increased. At the stage of peel stiffness, which is regarded as the last stage for plant maturity and it is indicated by the halting of leaves growth, turning into yellow and the spread of stems on the ground and between the furrows, excess irrigation should be avoided as it might cause spoilage or loss in the tubers. This stage is considered less sensitive than the formation and bulging of tubers, but the lack of water in this stage results in a change in the peel stiffness (the tubers are soft and unacceptable as marketable yield or a crop to be stored). Eventually, we should take into consideration that the lack of water in this stage harms the plant in terms of its peel and consequently affects the quality and quantity of the yield (the yield becomes non-marketable due to the softness of tubers). Therefore, attention should be paid to the added water to preserve the shape, appearance and the peels of tubers. It was observed that low compared to the previous two-stage and that the highest treatment in terms of need of water depending on the moisture content near the root zone took into account the depths (0-20 cm) and (20-40 cm) when samples were taken to determine the soil moisture according to which irrigation is performed and calculating the available water for each treatment for site1 (table 5). The highest added irrigation water quantities were for the were control treatment (751 and 373 liters), while the lowest was for the treatment (P3O2) with values (575 and 283 liters) for the levels I1 and I2 respectively. With the difference of polymer levels added and the method in which animal amendments were added, we see that there was a difference in moisture preservation by the treatment soil near the root zone. Also, there was a difference between the control treatment, to which the highest quantity of water was added compared with quantity of the treatment (P3O2) as values were (176 and 90 liters) respectively for the levels I1 and I2 respectively. So, it was found that irrigation for this stage was repeated twice and last irrigation and the yield harvest time was 7-10 days. Results indicated in site2 that the quantity of irrigation water added during this stage was lower than the previous stages similarly as the behavior of site1. The control treatment recorded the highest water quantity (713 and 337 liters), whereas (P3O2) treatment needed the lowest quantity of water (537 and 258 liters) for the levels I1 and I2 respectively. (table 5). This difference is attributed to the addition of polymer and animal amendment which caused a difference in the moisture preservation of the treatment soils. Therefore there was a superiority for the difference at the irrigation levels I1 and I2 in terms of the quantity of the water added and the values were (176 and 69 liters) respectively and the number of irrigation times was two and the difference between the last irrigation and the time of harvest was 7-8 days.
Table 5. shows the quantity of the water added to the plant during the growth season for the two sites.

| Total quantity of water added M3/ha | Total quantity of water added l.m | Peel stiffness stage 6/12-5/29 15 days | Tubers bulging stage 5/28-4/29 30 days | Tubers formation stage 4/28-4/4 25 days | Stage of germination and vegetative growth 4/3-2/ 42 days22 |
|-------------------------------------|-----------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| I2                                  | I1                                | I2                                  | I1                                | I2                                  | I1                                |
| 2282.5                              | 3950.8                            | 2739                                | 4741                               | 373                                 | 751                               |
| 2068.3                              | 3505.8                            | 2452                                | 4207                               | 321                                 | 649                               |
| 1985                                | 3374.2                            | 2382                                | 4049                               | 304                                 | 609                               |
| 2233.3                              | 3861.7                            | 2680                                | 4634                               | 360                                 | 734                               |
| 2005.8                              | 3435.8                            | 2407                                | 4123                               | 314                                 | 640                               |
| 1937.5                              | 3319.2                            | 2325                                | 3983                               | 293                                 | 599                               |
| 2128.3                              | 3704.2                            | 2554                                | 4445                               | 352                                 | 709                               |
| 1953.3                              | 3353.3                            | 2344                                | 4024                               | 306                                 | 625                               |
| 1890.8                              | 3230.8                            | 2269                                | 3877                               | 288                                 | 589                               |
| 2074.5                              | 3575.8                            | 2489                                | 4291                               | 343                                 | 685                               |
| 1919                                | 3275.2                            | 2303                                | 3930                               | 303                                 | 613                               |
| 1852.5                              | 3144.2                            | 2223                                | 3773                               | 283                                 | 575                               |
| 2083.5                              | 3592.5                            | 2500                                | 4310                               | 337                                 | 713                               |
| 1882.5                              | 3233.5                            | 2258                                | 3880                               | 293                                 | 619                               |
| 1856.5                              | 3178.5                            | 2227                                | 3814                               | 288                                 | 601                               |
| 2018.5                              | 3502.5                            | 2422                                | 4202                               | 332                                 | 702                               |
| 1806.5                              | 3100.5                            | 2167                                | 3720                               | 283                                 | 590                               |
| 1782.5                              | 3037.5                            | 2138                                | 3644                               | 280                                 | 574                               |
| 1923.5                              | 3317.5                            | 2308                                | 3980                               | 324                                 | 657                               |
| 1746.5                              | 2968.5                            | 2095                                | 3562                               | 274                                 | 564                               |
| 1723.5                              | 2914.5                            | 2068                                | 3497                               | 268                                 | 574                               |
| 1859.5                              | 3193.5                            | 2231                                | 3831                               | 314                                 | 638                               |
| 1682.5                              | 2855.5                            | 2018                                | 3426                               | 264                                 | 553                               |
| 1656.5                              | 2809.5                            | 1987                                | 3371                               | 258                                 | 537                               |

Also, results showed the difference water quantity added for the two sites (site1 and site2). The highest quantity of the water added was for the control treatment (4741 and 4310 liters) for the irrigation level I1 and at the irrigation level I2 they were (2739 and 2500 liters) (table5), for the two sites respectively. It was noticed that the lowest water quantity added was for the treatments (P2O5) (894 and 1217 liters) at the level I1 compared to the level I2 (2223 and 1987 liters) for both sites. The difference in the quantities of the water added is due to the variation in the soil capacity to preserve the moisture with the treatments of the soil in terms of the levels of polymer and animal amendments and this is what was confirmed by several researchers. [15]; [6]; [18 ]; [22] indicated that adding polymers to the soil played a great role in improving its capacity to preserve moisture and increasing the positive effect of soil to keep the water with the increase of polymer concentration. Also, [4] showed polymer to the soil and then irrigate led to increasing the soil capability to preserve moisture and this is because each dry gram becomes 200-500 grams after suction of water. [33]; [9] indicated that adding the organic material increases the soil capacity to retain the water and prevents losing it.

Plant properties: Vegetative growth properties

Plant height: The treatment (P2O5) achieved the best values for plant height (100 cm) and (119 cm) for the level I1 compared to the lowest values for the control treatment for the irrigation level I2 with values (50.3 cm) and (50-66 cm) for both sites respectively (table 6). The treatments of level I1 were
superior due to the major role of the water in affecting this property, because the quantity of the water added to the level I1 is more than the quantity at the level I2 (table 5). Treatments of the level I1 differed significantly due to the influence of animal amendments in two levels (O2 and O1) on this property through their role in improving the physical and fertile properties of the soil like providing the necessary nutrients to the plant compared to the level O0. These results were agree with [2], as it was observed that a significant increase took place in the plant height for the two subsequent seasons when using various irrigation levels.

Number of aerial stems The values of numbers of aerial stems were significantly different in the levels I1 and I2 for the two sites due to the direct effect and positive role of the water for this property. It was observed that the treatment P3O2 for the irrigation level I1 achieved the best values (4.86 stem/plant) and (5.8 stem/plant) for the two sites respectively. Also, the animal amendments two positive roles in terms of the soil physical properties and secondly, increasing the rate of the necessary nutrients that the plant needs. Adding the polymer led to increasing the moisture preservation and thus provide the two essential factors, namely water and nutrients, which encourage the increase of aerial stems number. The lowest values for aerial stems number for I2 were achieved by the control treatment P0O0 (2.37 stem/plant) and (2.37 stem/plant) (table6) for the two sites respectively. These results come in conformity with what [28] concluded: potato exposure to levels of moisture matrix potentials results in a significant decrease in the average number of aerial stems.

Property of root weight The root values for the two sites showed significant differences between the level I1 irrigation level and the I2 level treatments, because the available water (100% available water) played a vital role in enhancing the growth of roots and created this significant difference. The values of P3O2 for I1 level were (27.7 g) and (29.0 g) and was significantly superior over the I2 level treatments. The control treatment of P0O0 for the level I2 the lowest values (10.3 g) and (21.3 g) for the two sites (tables 6). These values are in conformity with what Walworth and Carling mentioned; that the plant root dry weight significantly increases with the irrigation treatment compared to the case when no irrigation water is used.

Average weight of the tuber property: The results of the two sites demonstrated significant differences between the treatments in terms of the values of the average weight of the tuber. The treatment P3O2 of level I1 gave the highest values (84 g) and (86.5 g) for the two sites respectively due to the water positive role in the plant growth and this effect was reflected in the plant properties including the average tuber weight in addition to the high capacity of the polymer in providing the water portion needed by the plant by means of increasing moisture preservation and decreasing the lost water either by evaporation – transpiration or the deep infiltration outside the domain of the root zone as well as the effects of the organic amendments in improving the physical and fertility properties of the soil. It was that the best values were for the level O2 of the animal amendments at the level I1. It was also observed that the level I2 treatments did not differ significantly because the water didn't meet the plant water requirements at this level and the lowest values were achieved by the treatment P0O0 (55.6 g) and (55.3 g) for the two sites respectively (table 6). This is what [13] explained that there was a significant decrease in the tuber average passes through matrix potential compared to the treatment of the ordinary irrigation. Also, [36] concluded that the tuber average weight increases when using animal amendments.

Average yield of one plant: Values of the yield per plant significantly differed for treatments. The treatments values of animal amendment at levels O2 and O1 at the irrigation level I1 were significantly superior over the rest of treatment. The best values of P3O2 were (1048 g/plant) and (1282 g/plant), as the interaction between the polymer and animal amendments played a positive role in improving the values of this treatment. The least yield values were for the control treatment P0O0 for both sites (295 g/plant) and (333 g/plant) respectively for the level I2 (table 6), because the quantity of water added at level I2 was 50% of available water which didn't meet the plant requirements of water due to the matrix potential in the root group domain. This negative effect was reflected in the productivity properties including the average yield per plant.
The number of small tubers didn't directly affect the total number of tubers and eventually the total output of the crop. There was a significant difference concerning the number of tubers used as tubers for planting between the two levels I1 and I2 due to the major role of soil improvements especially the level of P3 and P2, and animal amendment for the levels O3 and O1. There was no significant difference between animal amendment levels O2 and O1 at the level I1. The best yield of tubers number for planting was achieved by the treatment P3O2 at the level I1 (7.3 tubers/plant) and (8.3 tubers/plant) for both sites respectively. The polymer played an important role in increasing the moisture preservation near the root as it decreases water by the plant and the availability of the nutrients necessary for the plant growth which result from the decomposition of amendments that encouraged the vegetative and root growth and this reflected on giving the best and highest tubers as tubers for planting. So, the high levels of polymer and animal amendments were superior when the irrigation water was available I1 (100% available water) so that the plant could suck the water and perform the vital and functional activities optimally. This effect reflected on the number of tubers and the yield productivity. Moreover, results demonstrated that there was no significant differences in all the treatments of level I2 (50% available water) as incomplete irrigation, and the lowest value for tubers number for planting achieved by the treatments P3O3 and P2O3 (1.3 and 1.3) tuber/plant) (table 7) for the two sites respectively. As for the number of large tubers, it was observed that there is a significant difference at the irrigation level I1 compared to I2 with values that equal zero. This is an explicit evidence that refers that the moisture content was affected at I2 due to the moisture matrix potential near the root zone and so the plant couldn't function normally. It was also noticed that the levels O2 and O3 of animal amendment were superior compared to the level O2 at the irrigation level I1. The highest number of large tubers for the treatment P3O2 were (1.7 tuber/plant)
and (2.3 tuber/plant) (table 7). While the treatments P$_0$, P$_3$, P$_2$ and P$_0$ were similar in the animal amendment level O$_2$, with a difference in the level of polymer and eventually a difference in the water quantity added. Therefore, the treatment P$_0$ needed the highest quantity of water added in the growth season, which positively reflected in the number of large tubers (table5). So that water plays a major role in affecting the number of large tubers, while polymer had a stronger effect on the number of small tubers used for planting only. For the total number of tubers represented by the (number of small tubers + number of small tubers for planting + number of large tubers) mentioned earlier, it was clear the superiority of the treatment of level I1 compared with the level I2 and the highest number of total number of tubers was achieved by the treatment P$_3$ (12.7 tuber/plant) and (15 tuber/plant) (table 7) for the two sites and at the level I1, which differed significantly from I2 and the level of animal amendment O$_0$ at the level I1, but didn't differ significantly from O$_2$ and O$_1$ at I1. This is attributed to meeting the plant need for water throughout the growth season and the availability of nutrients which result from adding the animal amendments and encouraging the vegetative growth and their reflection on productivity. Availability of the polymer, especially at the levels P$_3$ and P$_2$ led to the availability of water near from the root and so the plant could take the water and the nutrients. This interference led to a significant superiority for the treatment P$_3$ at I2. The lowest number of total tubers for the treatments P$_0$ and P$_0$ was (5.3 tuber/plant) and (6.0 tuber/plant) (table 7) for the two sites and for the irrigation level I2. The treatments of level I2 were not significantly different. Moreover, these results were in conformity with the results obtained by [29], that there was a significant increase in the total yield of tubers when increasing the quantity of irrigation water, and also were in conformity with [35], that when using animal amendments with the potato the highest number of tubers was obtained (7.54 tuber/plant) compared with the control (4.55 tuber/plant) and the results of [12], that the polymer in sand-loam soils had a positive effect on potato productivity. [37] achieved optimal results when adding the polymer to potato crop and obtained the best yield.

Table 7. shows the productivity properties for the two sites / total number of tubers (tuber/plant)

| Irrigation I2 | Total no. of tubers | Big tubers, less than 55 mm | Tuber s between 35-55mm | Small tubers, less than 35 mm | Irrigation I1 | Tuber s between 55-355mm | Small tubers, less than 35 mm | Treatm ent | Location |
|--------------|---------------------|---------------------------|-------------------------|-----------------------------|--------------|-------------------------|-----------------------------|------------|----------|
| P$_0$        | d5.3                | 0.0                       | b1.3                    | a4                          | e8.7         | e0.3                   | b3.0                        | P$_0$      | Site1    |
| P$_3$        | cd7.7               | 0.0                       | b2.3                    | a5                          | ab11.7       | abc1                   | a5.5                        | P$_3$      | Site1    |
| P$_2$        | d5.3                | 0.0                       | b1.3                    | a4                          | ab11.7       | abc1                   | a5.5                        | P$_2$      | Site1    |
| P$_0$        | cd7.7               | 0.0                       | b2.3                    | a5                          | ab11.7       | abc1                   | a5.5                        | P$_0$      | Site1    |
| P$_3$        | cd7.7               | 0.0                       | b2.3                    | a5.4                        | a12          | a1.7                   | a5.7                        | P$_3$      | Site1    |
| P$_2$        | d5.3                | 0.0                       | b1.3                    | a4                          | be9          | e0.3                   | b3                          | P$_2$      | Site1    |
| P$_0$        | cd7.7               | 0.0                       | b2.3                    | a5.4                        | a12          | a1.7                   | a5.7                        | P$_0$      | Site1    |
| P$_3$        | cd7.7               | 0.0                       | b2.4                    | a5.6                        | a12.3        | ab13                   | a6                          | P$_3$      | Site1    |
| P$_2$        | d5.3                | 0.0                       | b1.3                    | a4                          | be9          | e0.3                   | b3                          | P$_2$      | Site1    |
| P$_0$        | cd7.7               | 0.0                       | b2.4                    | a5.6                        | a12.3        | ab13                   | a6                          | P$_0$      | Site1    |
| P$_3$        | cd7.7               | 0.0                       | b2.4                    | a5.6                        | a12.3        | ab13                   | a6                          | P$_3$      | Site1    |
| P$_2$        | d5.3                | 0.0                       | b1.3                    | a4                          | be9          | e0.3                   | b3                          | P$_2$      | Site1    |
| P$_0$        | cd7.7               | 0.0                       | b2.4                    | a5.6                        | a12.3        | ab13                   | a6                          | P$_0$      | Site1    |
| P$_3$        | cd7.7               | 0.0                       | b2.4                    | a5.3                        | ab11.8       | abc1                   | a5.8                        | P$_3$      | Site1    |
| P$_2$        | d5.3                | 0.0                       | b1.3                    | a4                          | be9          | e0.3                   | b3                          | P$_2$      | Site1    |
| P$_0$        | cd7.7               | 0.0                       | b2.4                    | a5.3                        | a12          | ab11.7                 | a5.5                        | P$_0$      | Site1    |
| P$_3$        | cd7.7               | 0.0                       | b2.4                    | a5.3                        | a12          | ab11.7                 | a5.5                        | P$_3$      | Site1    |
| P$_2$        | d5.3                | 0.0                       | b1.3                    | a4                          | be9          | e0.3                   | b3.1                        | P$_2$      | Site1    |
| P$_0$        | cd7.7               | 0.0                       | b2.4                    | a5.3                        | a12          | bc0.7                  | a6.3                        | P$_0$      | Site1    |
| P$_3$        | cd7.7               | 0.0                       | b2.4                    | a5.6                        | a12.7        | abc1                   | a7.3                        | P$_3$      | Site1    |
| P$_2$        | d5.3                | 0.0                       | b1.3                    | a4                          | ab11.7       | abc1                   | a6.6                        | P$_2$      | Site1    |
| P$_0$        | cd7.7               | 0.0                       | b2.4                    | a5.6                        | a12.7        | abc1                   | a6.6                        | P$_0$      | Site1    |
| P$_3$        | cd7.7               | 0.0                       | b2.3                    | a6.0                        | a14.0        | ab13                   | a6.3                        | P$_3$      | Site1    |
| P$_2$        | d5.3                | 0.0                       | b2.3                    | a6.0                        | a14.3        | ab13                   | a6.3                        | P$_2$      | Site1    |
| P$_0$        | cd7.7               | 0.0                       | b2.3                    | a6.0                        | a14.3        | ab13                   | a6.3                        | P$_0$      | Site1    |
| P$_3$        | cd7.7               | 0.0                       | b2.3                    | a6.0                        | a14.3        | ab13                   | a6.3                        | P$_3$      | Site1    |
| P$_2$        | d5.3                | 0.0                       | b2.3                    | a6.0                        | a14.3        | ab13                   | a6.3                        | P$_2$      | Site1    |
| P$_0$        | cd7.7               | 0.0                       | b2.3                    | a6.0                        | a14.3        | ab13                   | a6.3                        | P$_0$      | Site1    |
Average total production: The values of the total production represented by producing the small tubers, producing the tubers for planting and producing the large tubers. It is clear from the two sites that there is no significant difference in terms of producing the small tubers at the levels I1 and I2 and there were significant differences for tubers between the irrigation levels I1 and I2. The animal amendments levels O2 and O1 at the level I1 differed significantly from the level O0 at the levels I1 and I2 in site1. The best yields of seed tubers in the two sites for the treatment P3O2 were (6.56 ton/donum) and (7.62 ton/donum), and the lowest in P3O0 at the irrigation level I2 were (1.33 ton/donum) and (1.38 ton/donum) respectively (table 8) due to water availability at I1 in addition to the positive effect of polymer and animal amendments. It was also noticed that there were no significant between I2 level treatments due to the lack of water in this level. While in terms of large tubers there was a significant superiority of I1 compared with I2 (as there was no production for the level I2).

The P3O2 at the level I1 for the two sites gave the highest values (2.59 ton/donum) and (4.13 ton/donum) because the quantity of water added used was sufficient for the plant need for water (table 5), while the lowest values for the treatment P3O0 (0.57 ton/donum) respectively (table 8), which were void of the amendments concentration. Water had a role in producing large tubers in addition to the role of amendments, while the most important cause behind producing the tubers for planting was the polymer. It was found that the final outcome exceeds the total production at I1 compared to I2 for both sites. The production values for the P3O2 treatment were (9.99 ton/donum) and (12.22 ton/donum) (table 8). This superiority was due to the level I1 (100% available water), which met the water requirements of the plant compared to the lowest yield of the level I2 of the P0O0 of the control treatment which were (2.81 ton/donum) and (3.17 ton/donum) respectively (table 8). Finally, for the ultimate outcome of the plant (vegetative + production), water had prominent and major role in affecting these properties. Also, adding improvements (polymer and amendments) played a vital role in improving the soil physical properties as increasing the moisture preservation and decreasing the moisture matrix potential, which leads to lack of moisture at the root zone and decreases the bulk density, increased the soil porosity and forming good soil structure, as well as providing the nutrients to the plant needs when amendments are decomposed. These results were in conformity with the findings of [34] in terms of using the polymer and blending it with the soil that led to increasing the moisture preservation and this reflected in increasing the yield and production. The findings of [16]; [32]; [7] confirmed that adding animal amendments gave the best potato yield. Also, the findings of [26] showed that the matrix potential is considered the most serious factor in terms of affecting the production and the formation and bulging of tubers until the maturity stage are considered the most critical stages in the plant life. Moreover, the lack of water leads to decreasing and lowering the quantity of the yield.
Table 8. shows the production properties for the two sites (ton.donum-1)

| Total production (ton.donum) | Irrigation I2 | Irrigation I1 |
|------------------------------|--------------|--------------|
|                              | Producing big tubers (More than 35 mm) | Producing small tubers (35-55 mm) | Producing big tubers (More than 35 mm) | Producing small tubers (35-55 mm) |
|------------------------------|--------------|--------------|--------------|--------------|
| c2.31                        | 0.0          | 0.1.33        | 0.1.48        | 0.5.23        | 0.0.56        | 0.3.0         | 0.1.68        | P, O,     |
| h4.06                        | 0.0          | 0.1.81        | 0.2.25        | 0.8.35        | 0.1.80        | 0.5.18        | 0.1.37        | P, O,     |
| h4.43                        | 0.0          | 0.2.03        | 0.2.40        | 0.9.67        | 0.2.59        | 0.5.65        | 0.1.43        | P, O,     |
| c2.87                        | 0.0          | 0.1.38        | 0.1.49        | 0.5.42        | 0.0.48        | 0.3.1         | 0.1.84        | P, O,     |
| h4.19                        | 0.0          | 0.1.86        | 0.2.33        | 0.8.40        | 0.1.70        | 0.5.2         | 0.1.50        | P, O,     |
| h4.62                        | 0.0          | 0.2.10        | 0.2.52        | 0.9.72        | 0.2.24        | 0.5.91        | 0.1.57        | P, O,     |
| c2.90                        | 0.0          | 0.1.46        | 0.1.44        | 0.5.5         | 0.0.44        | 0.3.11        | 0.1.95        | P, O,     |
| h4.36                        | 0.0          | 0.1.91        | 0.2.45        | 0.8.5         | abc1.39       | 0.5.30        | 0.1.81        | P, O,     |
| h4.70                        | 0.0          | 0.2.13        | 0.2.57        | 0.9.83        | abc1.91       | 0.6.36        | 0.1.56        | P, O,     |
| c2.95                        | 0.0          | 0.1.52        | 0.1.43        | 0.5.54        | 0.0.41        | 0.3.16        | 0.1.97        | P, O,     |
| h4.40                        | 0.0          | 0.1.94        | 0.2.46        | 0.8.61        | abc1.18       | 0.5.61        | 0.1.82        | P, O,     |
| h4.73                        | 0.0          | 0.2.16        | 0.2.57        | 0.9.99        | abc1.91       | 0.6.56        | 0.1.52        | P, O,     |
| c3.17                        | 0.0          | d1.38         | 0.1.79        | 0.6.78        | 0.0.65        | 0.3.67        | 0.2.46        | P, O,     |
| h4.76                        | 0.0          | c2d.19        | 0.2.57        | 0.1.81        | 0.3.27        | 0.5.67        | 0.1.87        | P, O,     |
| c5.1                         | 0.0          | c2d.40        | 0.2.70        | 0.1.99        | 0.4.13        | 0.5.94        | 0.1.92        | P, O,     |
| h4.19                        | 0.0          | d1.48         | 0.1.71        | 0.6.83        | 0.0.62        | 0.3.77        | 0.2.44        | P, O,     |
| h4.89                        | 0.0          | c2d.25        | 0.2.64        | 0.1.91        | 0.2.73        | 0.5.76        | 0.2.42        | P, O,     |
| c5.17                        | 0.0          | c2d.38        | 0.2.79        | 0.1.24        | 0.3.58        | 0.6.22        | 0.2.24        | P, O,     |
| h4.97                        | 0.0          | c2d.31        | 0.2.66        | 0.1.26        | 0.2.61        | 0.5.97        | 0.2.68        | P, O,     |
| c5.27                        | 0.0          | c2d.43        | 0.2.84        | 0.1.27        | 0.2.68        | 0.6.27        | 0.2.22        | P, O,     |
| c5.36                        | 0.0          | d1.58         | 0.1.68        | 0.7.05        | 0.0.57        | 0.3.96        | 0.2.52        | P, O,     |
| h5.13                        | 0.0          | c2d.46        | 0.2.67        | 0.1.32        | 0.2.57        | 0.6.24        | 0.2.71        | P, O,     |
| h5.58                        | 0.0          | c2d.49        | 0.2.89        | 0.1.22        | 0.2.39        | 0.7.62        | 0.2.21        | P, O,     |

Reference

[1]Abdallah, S A M 1996, Studies on the application of antitranspirant and water regimes on potatoes grown in calcareous soils . MSc Thesis . Faculty of Agriculture ( Saba Basha),Alexandria University, Egypt.

[2]Abdel-Razik, A H 1996, Potato crop under semi-arid conditions with special references to irrigation and potassium fertilization in sandy soil. *Alex. J. Agric. Res.* 14(3): 329-341.

[3]Abdabobo, MAA, Hassanein ,MK and, Medany, MA 2007, Effect of irrigation regime and compost level on potato production in Northern Delta. Egypt. *African Potato Association Conference Proceedings.* 7:185-197. Alex. Egypt.

[4]Abedi-Koupai J and Ksadazemi, J 2006, Effect of hydrophilic polymer on the field performance of an ornamental plant under reduced irrigation regimes.*Iranin Polymer Journal 15*(9):715-725.

[5]Akolah, A 2013, Functionalized Polymeric Materials in Agriculture and the Food Industry, 65 DOI 10.1007/978-1-4614-7061-8-2, Springer Science +Business Media New York.

[6]Alessandro,S 2008,Application of Superabsorbent Hydrogels for The Optimization of Water Resources in Agriculture,The3rd International Conference on Water Resources and Arid Environments 2008 and the 1st Arab Water Forum.

[7]AlJawadi, LM 2007, The effect of adding animal amendments on some soil physical properties and the yield of potato, A master thesis – College of Agriculture and Forestry – Mosul University.

[8]Al Sahaf, FH1989, Applied Nutrition of Plant, Ministry of Higher Education and Scientific Research, Higher Education Press/IRQ.

[9]Arshad, MA , Lowery, B and, Grossman, B 1996,Physical tests for monitoring soil quality. P.123-142. In:J.W.Doran and A.J.Jones (eds.) methods for assessing soil quality. *Soil Sci.Soc.Am.Spec.publ.* 49.SSA, Madison.W.I.

[10]Authors, CS 2008, Climate change: precipitation and plant nutrition interaction on potato (Solanum tuberosum L.) yield in North-Eastern Hungary. *Geophysical Research Abstracts.* Vol. 11, EGU 1398, EGU General Assembly.

[11]Avdienco, VG and, Groshevo, TD 2003,The effect of growth divulgaters on potato .making pollutes of eating PP: 11.113 (in Russin).
[12] Bakass M, Mokhlisse, A, Lallemant, M 2002, Absorption and desorption of liquid water by a Superabsorbent polymer: Effect of polymer in the drying of the soil and the quality of certain plants, J.Appl.Polym Sci., 83:234-243

[13] Belanger, GW, Richards, JR, Milbum, JE and, Ziadi, PH 2001, Tuber growth and biomass partitioning of two potato cultivar under different nitrogen fertilization rates with and without nitrogen. Amer J.Potato Res 78:109–117

[14] Borisov, VA 2000, The Ecologically safe and Environmentally Friendly Fertilizing system. J. potato and Vegetables No5, 19-23.

[15] Chan, KY and Sivapragasam, S 1996, Amelioration of adegarded hard setting soil using an anionic polymeric conditioner. Soil Technology 9: 91-100

[16] Davis, JR 1994, The influence of cover crops on the suppression of Verticillum wilt of potato. Advances in potato pest Biology and Management St. Paul, MN:APS press.

[17] Fatih, M Kiziloglu, U, Sahin., unc, T T and, Diler, S 2006, The Effect of Deficit Irrigation on potato Evapotranspiration and Tuber yield under cool season and semi arid climatic conditions. Journal of Agronomy 5(2): 284 – 288

[18] Fidelia N and Chris, B 2011, Environmentally Friendly super absorbent polymer. for water conservation in agricultural lands Journal of Soil Science and Environmental Vol.2(7),pp.206-211.

[19] Gardon, RDM Broun, A, Madan and, Dixon, MA 1999, An assessment of potato sap flow as affected by soil water status, solar radiation and rapour pressure deficit. Can.J Soil Sci. 79: 245-253.

[20] Geglarek, F, A Plaza. 2000, The consumption value of potato according to applied kind of organic fertilization. Proceedings of the conference table and food processing potato-geotechnical and storage factors conditioning quality, Radzikow, Poland. 23-25 February-1999.Biuletyn. Instytutu-Hodowli.i.Aklimatyzacji. Roslin 213,117.123

[21] Hartman, HT and, Kester. DE 2002, Plant propagation: principles and practices. 7th ed. Prentice-Hall. Inc, New jersey. U.S.A.

[22] Hossein,N, Mohammad , RZ, Reza , D, Solmaz, N 2010, The Effect of Water Stress and Polymer on Water Use Efficiency, Yield and several Morphological Traits of Sunflower under Greenhouse Condition, Print ISSN 2067-3205; Electronic 2067-3264, Not Sci Biol 2 (4), 53-58.

[23] Huttermann A, Zomorodnia, M, Reise, K, 1999, Addition of hydrogel to soil for prolonging the survival of Pinus halepensis seedlings subjected to drought. Soil Till. Res., 50:295-304.

[24] Javad. KM, Hossein, H SA, Gorban, N, Farrokh, D, Islam, MH, Ebraham, V 2011, Effect Of Superabsorbent Polymer (Tarawat A200) On Forage Yield and Qualitative Characters In Corn Under Deficit Irrigation Condition In Khoy Zone (Northwest Of Iran), Advances in Environmental Biology, 5(9): 2579-2587.

[25] Khaleel, M 1998, Water relationships and Irrigation Systems (Sandy lands – reserve agriculture – vegetable crops). AlMaarif Institution in Alexandria. Jalal Harbi and Partners. Egypt.

[26] Kijine, JW, Barker, R and, Molden, D 2003, Water Productivity in agriculture: Limits and opportunities , for improving. CAB international Wallingford. UK.

[27] Laszlo, DM 2009, Climate change : Precipitation and plant nutrition interactions on potato (Solanum tuberosum L.) yield in north-Eastern Hungary – Geophysical Research Abstracts. Vol. 11, EGU 2009 – 1398.

[28] Lynch, BR and, Tai, GCC 1989, Yield and yield component response of eight potato genotypes to water stresses. Crop Science 29 : 1207 –1211.

[29] Meyer , RD and, Marcum, DB 1998, Potato yield, petiole nitrogen , and soil nitrogen response to water and nitrogen. Agronomy. J., 90 : 420-429.

[30] Mhamed, A M 2001, Effect of organic, mineral fertilizers and bio-stimulants on growth, yield, quality and storability of sweet potato. Ph. D. Thesis, Fac. Agric. Cairo Univ. Egypt.

[31] Mohammed, A K 1984, Plant Physiology Practical, Directorate of Books House for Publication and Printing, Mosul University – Ministry of Higher Education and Scientific Research/Iraq.

[32] Moliavko, AA 2001, The optimal crop rotation and fertilization systems as the main constituent of an intensive technology.No:4-12

[33] Mooleki, S P , Schoenau, j j Charles, jl 2004, Effect of rate and frequency of feedlot manure on
Soil nitrogen availability. *Soil. Sci.* **84**:199 - 210.

[34] Orts, WJRE Soika, and G M Glenn 2000, Biopolymer additives to reduce erosioninduced soil losses during irrigation. *Indus. Crops Prod.*, **11** (1): 19-29.

[35] Othman, JY 2007, Studying the Effect of Using Organic Fertilizers on Growing and Producing Potatoes as a contribution to the Clean Organic Production. A master thesis, College of Agriculture – department of orchards – Teshreen University – Syrian Arab Rebublic.

[36] Plaza, AF, Ceglarek and D Buraczynska 2004, Tuber yield and quality of potato fertilized with intercrop companion crop and straw. Electronic Journal of polish Agricultural Universities, *Agronomy*. 7 (1).120-127 http://www.ejpau.media.pl.

[37] San J 1995, Sta-Moist (stockosorb) field trails-potato,pepper&anoin datain peru,Digahole.com an internet division of the resource management group,Inc.

[38] Shanini, V and LM Dudeley 2001, Field studies of crop response to water and salt stress. *Soil. Sci. Soc. Am. J. (65)*: 1522-1528.

[39] Shock, CCE, Feibert, and LD Saunders2009, Evaluation of stockosorb® as a soil conditioner for potato production. Malheur Exper. Station, Oregon State Univ., Ontario, OR. USA, 4 pp

[40] Shock, C 1998, Efficient irrigation scheduling. Malheur Experiment station. Oregon State University

[41] Tawfeeq, H A A 2006, Response of the white corn [Sorghum bicolor (L.) Moench] to the shortage of irrigation during the various stages of growth and the effect on roots distribution. A Ph. D. Thesis. College of Agriculture – Baghdad University.

[42] Thomas, F S 1999, Growing irrigated Potatoes. Agricultural Engineer, NDSU Extension Service (File internet).

[43] Walworth, J L and D E Carling 2002, Tuber initiation and development in irrigated and non-irrigated potatoes. *Amer. J. Potato Res.* **79** :387-396.

[44] Willem, R, Hart, A, Liu ,J and, Buell, CR 2005, Analyzing the potato a biotic stress transcriptome using expressed sequence tags. The Institute for Genomic Research. *Genome* **48**: 598-605.