

**RESPONSE OF THREE ONION (*Allium cepa* L.) CULTIVARS GROWN UNDER IRRIGATED AND NON-IRRIGATED CULTIVATION TO POLYETHYLENE MULCHING**

**2- PRODUCTION OF DRY ONION BULBS IN FALL SEASON\***

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**ABSTRACT**

This study was carried out at horticultural research fields, Mosul University, Mosul, Iraq, during 2004-2005 growing season to investigate the influences of polyethylene mulching, supplementary irrigation and rainfall incidences on the production of dry bulb of three onion cultivars grown in spring season. Results showed that supplementary irrigated onions resulted in significant increases bulb fresh weight, bulb size, bulb bulk density, number of storage leaves per bulb, plant dry weight and yield of dry onion bulbs, as compared to these of rainfalls onions. Production of dry onions on bare soil under rainfall incidences in mosul are possible in fall season. Polyethylene mulching substantially improved growth and yield of onions, as compared to un-mulched treatment, particularly these grown under rainfalls. Therefore the ability of producing dry yield of onions under rainfalls was confirmed. Clear polyethylene mulching appeared to be the most effective treatments. It displayed significant increases in area per plant, leaf area index, individual bulb size, single bulb fresh weight, bulb bulk density, and dry yield of onion bulbs. Moreover, it significantly lessen the water requirements and weed eradication labor cost. However, it increased onions bolting. Local Red was the paramount cultivar. It showed the highest responses to supplemental irrigation, rainfalls and polyethylene mulching, as it showed the highest values in bulb size, bulb fresh weight, , and yield of dry onion bulbs. Furthermore, it resulted in the lowest stalk numbers per plant, and dry weights of flowering stalks. On the other hand local white cultivar displayed controversial results. Bashiqi cultivar manifested moderate responses as it occupied the gap spared between Local Red and Bashiqi cultivars. Finally, the highest yield ( $3.59 \text{ kg.m}^{-2}$ ) and yield quality of dry onion bulbs was concomitant to supplementary irrigated Local Red onion cultivar grown on clear polyethylene mulched soil.

**INTRODUCTION**

Onion (*Allium cepa* L.) local cultivars namely Bashiqi, Local Red and Local White are very familiar and heavily consumed in Iraq. These cultivars are purchased as dry bulbs and are kept to be consumed during the ensuing winter (Abdel, 1995). Commercial production of onions in New Mexico in 1996 was 365700 tons and was valued at more than \$ 45 million. Ninety percent of the crop was produced in Dona Ana and Luna counties ( USDA, 1996). Doorenbos and Kassam (1986) reported that seasonal water requirement for onion vary between 35 and 55 cm to

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obtain yield between 35000 and 45000 kg.h<sup>-1</sup>, they estimated a maximum crop coefficient Kc of (1.1) , using furrow irrigation. Whereas, furrow irrigation water requirements for onion in the San Joaquin valley of California were estimated at 51 to 87cm. Their seasonal Kc ranged from 0.78 to 0.98 ( Synder, 1989 & Al-Jamal *et al.*,1999) reported that the simulated Kc curve for non-soil moisture stressed yield level of 73000 kg.h<sup>-1</sup> . They found that onion evapotranspiration was 80 cm and seasonal Kc for onion ranged from 0.6 to 0.8. In Mosul north Iraqi province Abdel, (1990) found that onion required daily supplementary irrigation during April (0.69 mm), May(2.1 mm) for bare soil and only (0.69 mm ) in May for clear polyethylene mulched soil. An attempt was made to investigate the growth and yield responses of three local cultivar to supplementary irrigation, rainfall incidences and polyethylene mulching.

### MATERIALS AND METHODS

This study was conducted at research fields of Horticulture Department, Mosul University, Mosul, Iraq, during 2004-2005 fall growing seasons. Experiment was proposed to investigate the influences of polyethylene mulching on the production of dry onion bulbs of three irrigated and non-irrigated local onion cultivars grown in fall season.

A Split Split Plot within Factorial-Randomized Complete Block Design (Split Split F-RCBD) trail was used for each of the three experiments. The main plots were supplemental irrigation (A1) and rainfall incidences (A2). The sub plots were un mulched soil (B1), clear polyethylene mulched soil (B2) and black polyethylene mulched soil(B3). Whereas, the sub sub plots were Bashiqi cultivar (C1), Local Red cultivar (C2) and Local white cultivar (C3). Therefore, each experiment contained 18 treatments and each was replicated 3 times. Each replicate was represented by a furrow of (0.75 X 5m) planted on both sides with 15 cm intra plant space.

Experimental soil was clay , it contained 56.4% clay, 31.3 silt and 12.3 sand. It possesses field capacity, wilting point and bulk density of 21.8%, 12.9% and 1.6 g.cm<sup>-3</sup>, respectively. The soil was plowed twice, dissected to furrows ,one gypsum block was settled at 25 cm depth from the top of each furrow to track soil moisture fluctuations throughout the growing seasons (Greenwood, 1982 and Sanders, 1997), then NPK fertilizer was broadcasted at rate of 30 g.m.<sup>-2</sup>, thereafter mulching sub plots were covered by either clear or black poly ethylene . Two slits 2m apart were cut in the polyethylene at the bottom of each furrow to facilitate rainfall seepages to furrows, then soil was placed on slits and on the outermost polyethylene edges in plots to reduce soil evaporation and to fix the polyethylene. Holes of 15 cm apart were made on the upper third of each furrow by fork like steel bar of two teeth . Bulb sets of 1-1.5 g and diameters of 1-2 cm were sown through the holes and on furrows of bare soil treatments on December, 4, 2004.

Supplemental watering was applied whenever 50% depletion of soil available water capacity is recorded by gypsum blocks. Subsequently, onion plants required 1,1,1 and 1 irrigation times on March, April, May and June, respectively, for polyethylene mulched treatments ,however, bare soil treatments required 2, 2,1 and 1 irrigation times, respectively, on March, April, May and June ( Table and

Figure,1). Supplementary irrigation was ceased 2 weeks before harvesting to prevent the resumption of new leaf differentiations and to confirm the inducement of bud dormancies (Kelley and Granberry, 2000). Polyethylene was torn to ventilate bulbs in order to reduce risks of overheating and fungus infection incidences.

Weeds were manually eradicated during both growing seasons and a protective spray of benomyl fungicide at rate of  $1 \text{ g.l}^{-1}$  was applied on March, 15, 2005. Rate of  $30 \text{ g.m}^{-2}$  of NPK fertilizer was broadcasted again on April, 1<sup>st</sup>, 2005. Finally, plants were harvested on June, 15, 2005. Plants were tied and hanged for one week on tree branches to cure them (Greer and Kuepper, 1999).

Data on plant height, leaf numbers per plant, numbers of storage leaves per bulb, bulb doubling percentage, percentage of unbolted plants, number of roots per plant, flowering stalk numbers per plant, leaf length and leaf width were recorded. Leaf area and leaf area index were calculated (Wien, 1997 and Faysal, 1999). Flowering stalks, fresh bulb, fresh root, samples of storage leaves, onion plants and onion dry bulbs were weighed to record their fresh weights then oven dried at  $65 \text{ c}^{\circ}$  for 72 h. to obtain their dry weights. Bulb size was measured by water replacement, bulb bulk density was calculated from the weight and volume of individual bulb, hand refractometer was used to measure total soluble solids of the storage leaves.

## RESULTS AND DISCUSSION

Supplementary irrigation highly increased plant height (19.8%), leaf area per plant (38.8%), leaf area index (87.5%), fresh weight of individual bulb (114.3%), number of storage leaves per bulb (58.3%), bulb size (111.2%), bulb bulk density (2%), plant dry weights (141.7%) and yield of dry bulbs (147.7%), as compared to these of corresponding rainfalls. However, non-significant differences were observed in fresh and dry weight of flowering stalks and stalk numbers per plant (table 2a). rainfalls were more than adequate for early growth of onion in fall season due to the low evapotranspirations caused by low temperature, high relative humidity and low leaf area index of onions. Accumulated rainfalls (327 mm) in this season were within the range of onion water consumptive use 305-402 mm (Imtiyaz, *et al.* 2002). The problem was in the random fluctuations of the rainfall incidences throughout the growing season and in the shallow small onion root devoid of root hairs (Esau, 1977). Onion plants are of very low growth rate which is resulted in weak competition to weeds (Zandestra, 2003). Maximum turgour pressure of onion cell is 0.4 Mpa which is equals half that of lettuce and cabbage winter crops (Millar *et al.*, 1971). Levy, *et al.*, (1981) stated that onion plants are sensitive to severe water stress which led to substantial growth and yield reduction. Stomata closure caused by water stress play major roles in CO<sub>2</sub> entrance to leaf mesophyll which is finally leaded to compensation point (Boyer and Youmis, 1983). Dehydration of leaf mesophyll tissue leads to substantial intercellular space reductions, increasing cytoplasm viscosity and distortions of mesophyll cells which serves as barriers for CO<sub>2</sub> fixation and assimilate translocations (Kaiser, 1983).

Polyethylene mulching highly improved growth and yield of both irrigated and rain fed onion, especially black polyethylene treatments which showed significant increases in plant height (11.1%), leaf area per plant (60.9%), leaf area index (49.3%), weight of single bulb (38.5%), size of single bulb (37.9%), plant dry

weights (16.7%), and yield of dry bulb (39%), as compared to bare soil treatments. Furthermore, they also significantly exceeded treatments of clear polyethylene in fresh weight of single bulb (14.7%), single bulb size (21.9%), bulb bulk density (3.2%) and yield of dry bulb (17.7%). Followed by clear polyethylene mulching which resulted in substantial increases in plant height (2.5%), dry matter percentage of storage leaves (13.5%), bulb fresh weight (20.8%), size of single bulb (21.9%), plant dry weights (22.2%) and dry bulb yield (21.3%), in comparison to un-mulched treatments. The worst treatments were these of bare soil they showed the highest stalk numbers per plant (1.98), fresh and dry weights of stalks (101.5 and 8.7 g.m<sup>-2</sup>, respectively). Polyethylene mulching highly improved onion growth and yield. However, fresh and dry weights of flowering stalks were also included in these improvements which constituted the major problem facing the production of marketable onions, particularly in fall season where extensive stalk formation occurred. There are so many disadvantages of bolting in onion productions for instance, the participation of stalks in source sink assimilate, elimination cost and after stalk removal, stalk traces serves as water and pathogens entrance to the most inner bulb sites. In addition to that, after stalk elimination the stalk base at the auxiliary of bladeless leaf continues growing, ultimately becomes hard, altering the bulb shape and when this stalk emerges at leaf bases very close to the main apical meristem, it alters the bulb to unmarketable one. The major polyethylene mulching advantages are its ability to prevent water evaporation from soil and sustains an adequate soil moisture at the outer soil surfaces, where most onion roots occur 0 to 30 cm (Shock *et al.*, 1998). Therefore, searching for moisture to further soil depths is not required which turn source sink assimilate for the favor vegetative growth and yield, ultimately water use efficiency is improved (Gupta and Acharya, 1993). Gases volatiles such as ammonia and nitrogen dioxide and others are also prevented by polyethylene which contributing in mineral nutrition, and reducing both nitrogen losses and ozone pollution.

Local Red cultivar manifested the highest growth and yield responses in relation to its corresponding local white cultivar. It significantly increased the plant height (10.2%), leaf area per plant (25.3%), leaf area index (31.2%), percentage of unbolted plants (87.6%), bulb bulk density (2.6%), percentage of tss (31.3%), and dry bulb yield (89.7%). Moreover, it exceeded these of Bashiqi cultivar in percentage of unbolted plants (87.6%), bulb fresh weight (46.9%), single bulb size (41.8%), bulb bulk density (2.6%) and yield of dry bulb (47%). This cultivar also showed the lowest bulb doubling percentage (25%), fresh and dry weights of flowering stalks (115.1 and 6.9 g.m<sup>-2</sup>, respectively) and stalk numbers per plant (1.6). However, it resulted in the lowest leaf numbers per plant and plant dry weight. The results confirmed Bashiqi to be next in the sequence, when it compared to local white, it exhibited substantial increases in plant height (12.8%), leaf area per plant (28.3%), leaf area index (27.9%), percentage of unbolted plant (113.8%), dry matter percentage of storage leaf (25.7%), weight of single bulb (43.3%), bulbing percentage (69.7%) and yield of dry bulb (29%). Besides, this cultivar displayed significant reductions in bulb doubling percentage (303.9%) and stalk numbers per plant (43.8%). On the other hand, local white cultivar had the lowest values in the favorable parameters for onion productions and the highest

with these of undesired for productions., The more frequent number, fresh weight and dry weight of flowering stalks were confined to the worst responded local white cultivar. Bulb doubling percentage was also prevailed in this cultivar, but bulbs generated from the doubled mother bulb were large enough to be marketable yields, especially these of onion grown on polyethylene mulched soil. Sets cultivations of some onion cultivars are very sensitive to bolting, especially when they survive more than 300degree. day<sup>-1</sup> of critical temperature below 10 c° (Brewster, 1982 and Zandestra *et al.*, 2003). Cultivars of high bolting resistance ability were recommended in areas of enough low temperature to achieve vernalization (Fact Sheet, 2003). Heavy bolting of local cultivar was apparent in fall season ,as compared to spring season. This results presumably due to the larger plant biomass accumulated before the ensuing winter which shortened the duration of low temperature required for vernalization induction. Similar results were reported by ( Home, 2002 and Horkan, 2003). This is the reason, why most onion growers prefer spring season on fall. However, in the case of production onions under rain fed, have no choice, but fall season. Bashiqi cultivar manifested moderate responses in all detected parameters. It occupied the gap created between Local Red and local white cultivars.

The results of the interactions of irrigation and cultivars displayed that irrigated and non-irrigated Local Red cultivar was superior over other corresponding treatments. Thus supplementary irrigated Local Red cultivar gave the highest leaf area index (1.23), percentage of unbolted plants (30%), weight of individual bulb (242.2 g), single bulb size (247.7 cm<sup>-3</sup>), bulb bulk density (0.99 g.cm<sup>-3</sup>) and yield of dry bulb (3.15 kg.m<sup>-2</sup>). In addition to that, it showed the lowest fresh and dry weight of flowering stalks (106 g.m<sup>-2</sup> and 8.3 g.m<sup>-2</sup>, respectively) and numbers of stalk per plant (1.7). Non-irrigated Local Red was also superior cultivar over others which resulted in the highest percentage of unbolted plants (39.2%), fresh weight of individual bulb (99.3 g), bulb size (102.7 cm<sup>-3</sup>), bulb bulk density (0.96 g.m<sup>-3</sup>) and yield of dry bulb (1.29 kg.m<sup>-2</sup>). Moreover it displayed the lowest fresh and dry weight of stalks (59.7 and 5.4 g.m<sup>-2</sup>, respectively) and (1.5) stalk numbers per plant (table 2a). the results suggested that Local Red cultivar was paramount in resisting drought and also in racing its corresponding cultivars under irrigated condition. Bashiqi cultivar showed moderate responses to different soil moisture contents. It possessed the highest responses under complementary watering in dry matter percentage of storage leaves (20.3%), number of storage leaves per bulb (17.6), bulbing ratio (0.27) and bulb tss (16%). Moreover, it showed the lowest stalk numbers per plant (1.7). Mild responses of Bashiqi cultivar were also observed under drought conditions, its highest values obtained in dry matter percentage of storage leaf (20.7%), leaf area index (0.73), plant height (57 cm), bulbing ratio (0.29), and bulb tss (17.7%). Supplementary irrigated local white was inferior cultivar (table 3b), it resulted in the lowest plant height (59.7 cm), unbolted percentage of plants (6.1%),bulb fresh weight (120.4 g), bulbing ratio (0.14) bulb size (124.4 cm<sup>-3</sup>), bulb bulk density (0.94 g.cm<sup>-3</sup>) and yield of dry bulb (1.5 kg.m<sup>-2</sup>). Whereas, under inadequate rainfalls, this cultivar gave the worst significant reductions in plant height, leaf area index, doubling percentage, unbolted plant percentage, bulb fresh weight, bulb size and yield of dry

bulb. Onions of mulched soils under both irrigated and non-irrigated cultivations manifested the highest leaf area index, commenced earlier bulb formation and maturity. Speeding up onion growth by polyethylene mulching gave substantial leaf area index which resulted in earlier commence of bulb formation stage, despite the required photoperiod. Extensive leaf area index tends to prevail low R:FR light ratio at plant canopies, such microenvironments highly induce bulbing rates (Mondal, *et. al.* 1986).

Mulching and cultivar interactions results (table, 2b), confirmed that all cultivars displayed the lowest responses when grown on bare soils in relation to their responses when they were grown on mulched soils. Intra cultivar differences were detected, in which Local Red appeared to be the most responded cultivar. It showed the highest percentage of unbolted plants (31.5%), leaf area index (1.15), fresh weight on individual bulb (147.7 g), bulb size (150.7 cm<sup>3</sup>), bulb bulk density (0.9 g.cm<sup>3</sup>) and yield of dry bulb (1.92 kg.m<sup>-2</sup>). Mulching imposed apparent growth and yield improvements as it increased all parameters required for high yield quality and reduced the undesired ones, particularly with Local Red cultivar of black polyethylene mulch. This treatment combined the benefits of mulching and cultivar inheritances, and subsequently, this treatment resulted in the optimal values of unbolted plant percentage (33.6%), bulb doubling percentage (20.9%), stalk numbers per plant (1.7), fresh weight of single bulb (181.8g), bulb size (187.3cm<sup>3</sup>) and dry bulb yield (2.36 kg.m<sup>-2</sup>). Bashiqi cultivar displayed moderate responses to mulching next to Local Red, on the other hand the worst results were found with local white cultivar, especially when this cultivar grown on un-mulched soil. Obviously, mulching ameliorate the adverse effects of drought but, this cultivar could not utilize this amelioration in relation to its corresponding cultivars. Therefore, it showed the lowest percentage of unbolted plants (9.7%), leaf area index (0.9), dry matter percentage of storage leaf (15.2%), fresh weight of bulb (117.3 g), number of storage leaves per bulb (11.1), bulb size (120.3 cm<sup>3</sup>), bulb bulk density (0.95 g.cm<sup>-3</sup>) and yield of dry bulb (1.52 kg.m<sup>-2</sup>). The obtained results explained the disability of local white cultivar to match with its corresponding cultivars, under un-mulched, clear and black polyethylene mulched soils. Very close results were found by Abdel (1995) and Al-Juboori (2005).

Irrigation, mulching and cultivar interactions (Table,2) results revealed that supplementary irrigated Local Red cultivar grown on clear polyethylene mulched soil was the paramount treatment. It gave the highest plant height (68.3 cm), bulb fresh weight (276 g), bulb size (282 cm<sup>3</sup>), storage leaves per bulb (20.7) and yield of dry bulb (3.59 kg.m<sup>-2</sup>). Moreover, it manifested the lowest bulb doubling percentage (10.4%), fresh and dry weight of stalks (49.9 and 4.2 g.m<sup>-2</sup>, respectively) and stalk numbers per plant (1.3), as compared to other treatments. On the other hand non-irrigated local white of un-mulched soil resulted in the lowest plant height (45.3 cm), bulb weight (33.3 g), bulb size 36.3 cm<sup>3</sup>, storage leaves per bulb (8.7) and dry bulb yield (0.43 kg.m<sup>-2</sup>). Moreover, it possessed the highest bulb doubling percentage (96.7%) and stalk dry weights (15.1 g.m<sup>-2</sup>). These results were attributed to the advantages of the combination among favorable root growth condition such as temperature, nutrition and moisture which were mainly created by polyethylene

mulching and supplemental watering similar results were reported by Abdel, (1990).

## استجابة ثلاثة أصناف من البصل (*Allium cepa* L.) المروية وغير المروية للتغطية البلاستيكية ٢- إنتاج البصل الجاف في الفصل الخريفي\*

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### الخلاصة

أجريت هذه الدراسة في حقل أبحاث قسم البستنة ، كلية الزراعة والغابات ، جامعة الموصل خلال فصل النمو الخريفي ٢٠٠٤-٢٠٠٥ لدراسة تأثير التغطية البلاستيكية للتربة والري التكميلي والأمطار في نمو وحاصل البصل الجاف لثلاثة أصناف من البصل المحلي . أظهرت النتائج بأن ري البصل تكميلياً أدى إلى حصول زيادة مقارنة مع غير المروية في الوزن الطازج للبصلة وحجم البصلة والكثافة الظاهرية للبصلة وعدد الأوراق الخازنة للبصلة والوزن الجاف للنبات وحاصل الأصيل الجافة. وتؤكد النتائج إمكانية إنتاج البصل الجاف النامي في فصل الخريف تحت الأمطار المتاحة في الموصل . أدت التغطية البلاستيكية إلى تحسين النمو وحاصل الأصيل الجافة معنوياً مقارنة مع الأصيل النامية على التربة المكشوفة خاصة تلك الأصيل النامية تحت الأمطار . التغطية بالبلاستيك الشفاف كانت الأفضل خاصة حيث رافقتها زيادة معنوية في وحجم البصلة والوزن الطازج للبصلة والكثافة الظاهرية للبصلة وحاصل الأصيل الجافة ، والأبعد من ذلك أدت هذه التغطية إلى خفض معنوي في الاحتياجات المائية وكلفة مكافحة الأعشاب ويعاب عليها تحفيزها لنمو واضح للشماريخ الزهرية . صنف البصل احمر محلي كان أفضل الأصناف استجابة للتغطية والأمطار والري التكميلي حيث رافقته أفضل القيم في حجم البصلة ووزن البصلة الطازج للنبات والوزن الجاف للشماريخ الزهرية وحاصل الأصيل الجافة . أعطى صنف البصل ابيض محلي اقل القيم في الصفات المرغوبة في الإنتاج وأعلى القيم في الصفات غير المرغوبة اما الصنف بعثيقي كانت استجابته متوسطة بين الصنفين . أفضل حاصل للأصيل الجافة ( ٢ / . ) مرافقا للصنف احمر محلي المروي تكميلياً والنامي على تربة مغطاة بالبلاستيك الشفاف .

- تم تمويل هذا المشروع من قبل AHEAD ، مشروع اتفاق التعاون بين جامعات هاواي والموصل ودهوك

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