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EFFECT OF PLANTING DATE, IRRIGATION LEVEL AND FOLIAR SPRAY WITH CALCIUM AND/OR BORON ON POTATO CROP PERFORMANCE
2. YIELD AND ITS COMPONENTS, CRACKING PHENOMENON AND TUBER QUALITY

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ABSTRACT

A filed experiment was carried out during the two successive seasons of 2016/2017 and 2017/2018 at the experimental farm of El-Gemmeiza, Agric Res. Station, ARC, Gharbiya Governorate (Middle Nile Delta, Egypt) to study the effect of planting date (20th September (Sep) and 10th October (Oct), irrigation water level at 50, 75 and 100 % of filed capacity (FC) and two foliar spray with Ca (1%) as calcium chloride and/or boron (60 ppm) as boric acid besides unsprayed treatment (control), and their interactions on yield and its components, tuber cracking and tuber quality under clayey soil conditions using flood irrigation system. The adopted treatments were arranged in a split - split plot design with three replicates. The planting dates were arranged in the main plots, irrigation water quantities were arranged in the sub plots, while Ca and/or B foliar sprays were randomly distributed in sub - sub plots.

***The obtained results indicate that**, the tertiary interaction of planting on 10th Oct. , irrigation at 100% FC and sprayed plants with Ca + B resulted in higher values of total tuber yield, average tuber weight , number of tuber № plant-1 , tuber yieldplant-1 ,N, K, Ca and B contents and DM percentages in 1st and 2nd seasons. Total carbohydrates were the highest with the interaction of planting on 10th Oct. and irrigating at 100 %FC and sprayed plants with B. The increases in total tuber yield were about 253.75 and 177.82 % for tertiary interaction of planting on 10th Oct , irrigation at 100% FC and sprayed with Ca + B over the interaction of planting on 20th Sep , irrigation with 50%FC and unsprayed plants, in the 1st and 2nd*

seasons, respectively. As for tuber cracking %, the lowest values were obtained with the tertiary interaction of planting on 10th Oct, irrigation with 75 %FC and sprayed with Ca + B (11.37 and 10.41 %) in the 1st and 2nd seasons, respectively, while the highest values were obtained with the tertiary interaction of planting on 20th Sep, irrigation at 100 %FC and without Ca and B (25.38 and 26.57 % in the 1st and 2nd seasons, respectively).

***Conclusively**, under similar conditions it could be concluded that , the tertiary interaction of planting on 10th Oct , irrigation at 100 % FC and sprayed plants with Ca + B was superior for enhancing both total tuber yield and quality. Furthermore, on reducing tuber cracking, combination of planting on 10th Oct, irrigation at 75% FC and spraying the plants with Ca + B is recommended.*

Key word: Potato tuber yield & its attributes, planting date, irrigation level, tuber quality, Ca and B foliar sprays, tuber cracking phenomenon.

INTRODUCTION

The increase in human population is stimulating the increase in demand for good quality potato tubers. In addition to quantity, potato quality is an important factor based on consumer demand. Potato quality is determined by tuber size, tuber weight and cracking- free etc. All these parameters collectively determine the marketable tuber yield.

Planting date is considered very important to take the full advantage of the short growing period. Since tuberization rate in potato declines above a temperature of 17°C, increasing temperature may lead to reduced yields. Determining the optimum date of planting is not only important for yield but also to ensure better tuber quality (Dash *et al*. 2018). In natural environment plants are subjected to many stresses that have a great impact on development and finally yield of the crops. In this respect, Sandhu *et al*. 2013, Thongam *et al*. 2017 and Dash *et al.* 2018 stated that planting date had significant effects on yield and tuber quality of potato.

Egypt suffers from the limited natural water resources for irrigation the cultivated area besides the other water – consuming activities. Furthermore, irrigation water quantity is considered as one of the main factors that greatly affect plant growth and yield. So, efforts should be directed to optimize water

requirements and improved water productivity for all crops including potato. In addition, yield response to irrigation of different crops is of major importance in production planning where water resources are limited. Levy *et al*. 2013 reported that abiotic stress factors, such as drought, have severe, adverse effects on potato growth and yield, and regular water supply is necessary to achieve a high quality yield.. In connection, Erdem *et al*. (2006) reported that furrow and drip irrigation methods had no significant effect on tuber yield. Irrigation regimens influenced tuber yield ($P < 0.05$) and the highest tuber yield was registered for 30% irrigation regimen comprised 35.13 - 44.56 t ha^{-1}, comparable with irrigating as 50 or 70% of the available soil water was consumed. In Egypt, Farrag *et al*. (2016) found that different irrigation levels *vis* 50, 75 and 100% of irrigation requirements, under drip irrigation, significantly affected potato vegetative growth, tuber yield and nutrients content (N, P and K), and Increasing irrigation requirements for potato crop from 50% to 100% enhanced total and marketable yield. Furthermore, Badr *et al.* (2012) Irrigated potato under drip irrigation with different levels e.g. 40, 60, 80, 100% evaporation) resulted in a significant increase in the growth parameters, yield of tubers in particular, by increased irrigation level. In addition, Cantorea *et al*.(2014) reported that Water stress due to 50% irrigation level, significantly affected yield response, and the marketable yield decrement of 25.9% was observed, compared with 100% full irrigation level.

Calcium plays an important role in tuber quality by forming part of the membrane cell wall structures (Kleinhenz and Palta 2002). In connection, Palta (1996) reported that potato tuber quality can be enhanced by increasing Ca content of the tubers. Gumede (2017) found that yield and quality of potatoes will be affected by the Ca application level. In this regard, Chowdhury 2017, Simango and Walls 2017, Tantawy *et al.* 2017 and Singh *et al*. 2018 indicated that sprayed potato plants with calcium and/or boron increased tuber yield and improving quality as well.

Therefore, the aim of the present work is to study the proper planting date, irrigation level, and foliar spray with calcium or/and boron for enhancing potato productivity, mitigating tuber cracking disorder and improving tuber quality of potato grown on a clayey soil at Gemmeiza area under furrow irrigation system.

MATERIALS AND METHODS

A filed experiment was carried out in the successive winter seasons of 2016/2017 and 2017/2018 at the experimental Farm El- Gemmeiza, Agric Res.

Station, ARC, Gharbiya Governorate (Middle Nile Delta, Egypt) to study the effect of planting date, irrigation water level and foliar sprays of Ca and/or B and their interactions on potato productivity, yield components, tuber cracking phenomenon and other tuber quality traits under furrow irrigation. The soil in the experimental site is clayey in texture with bulk density, field water capacity and available water values, in the 60 cm depth of the soil profile, comprised 1.25(gcm^{-3}), 43.01 and 17.92% by mass, respectively.

The mechanical and chemical analysis of the used soil are presented in Table (A). Particle size distribution was carried out using the method of Piper (1950). Calcium carbonate was determined using Collins calcimeter according to Wright (1939). Organic matter was assayed according to method of Walkley (1947). Total available nitrogen was determined using the microkjeldohl and Phosphorus was determined according to methods as described by Chapman and Pratt (1961). Potassium was determined using Flam photometeric method described Piper (1938). Available B was determine by Bingham (1982). pH value was measured in the soil past using Bechman pH meter.

Table (A). The mechanical and chemical analysis of the experimental soil

Parameters	**Values**	
1. *Mechanical analysis*	**First season**	**Second season**
Corse sand (%)	1.60	1.50
Fine sand (%)	12.91	14.4
Silt (%)	37.23	35.9
Clay (%)	40.82	43.0
$CaCO_3$ (%)	3.90	3.20
Organic matter (%)	1.57	1.98
Texture class	Silty clay loam	
2. ***Chemical analysis***		
Available nitrogen (ppm)	33	35
Available phosphorus (ppm)	8	8.8
Available potassium (ppm)	420	440
Available boron (ppm)	0.10	0.12
Soluble calcium (Ca^{++})	6 meq/l	
Soil reaction (pH) in 2.5 soil suspension	8	8

The present experiment included 24 treatments, which were the combination of two planting date e.g. planting on 20th Sept and 10th Oct, three irrigation water level *vis* 50, 75 and 100 %FC and three foliar spray treatments *i.e.* Ca(1%, wt/vol) as calcium chloride and/or boron (60 ppm as boric acid), besides the control (unsprayed treatment). The assessed treatments were arranged in a split - split plot design with three replicates. The planting dates were represented in the main plots, sub plots were assigned for irrigation levels and Ca and/or B foliar sprays and control treatments were randomly distributed in the sub - sub plots.

The experimental unit area was 14.7 m^2 containing three ridges with 7m length and 70 cm apart, and the potato seeds (*Solanum tuberosum* L. Mondial cv) were sown at 20 cm in between. One ridge was used to measure the morphological and physiological traits and the other two ridges were left for yield determinations. In addition, one ridge was left as buffer zone between each two experimental units to avoid lateral seepage of irrigation water. All the agronomic practices recommended for potato production in the area e.g. seed – bed preparation, N, P &K fertilization, weed and pest control etc., were executed. Calcium chloride and boric acid were sprayed three times in two 2- week interval, and started 45 days after planting using a manual atomizer.

The irrigation water was added each three weeks intervals beginning at 10th and 30th October (20 days after planting) and ended 5th and 25th Jun. (15 days before harvesting) in the 1st and 2nd seasons, respectively. Under the adopted irrigation treatments, four irrigation events plus the planting one were applied throughout the entire growing season. To determine water quantity required under each adopted irrigation level, a soil sample (up to 60 cm depth) was taken before each irrigation from 100% FC treatment, and soil moisture content (%,wt/wt basis) was calculated. The water quantity required to refill the 60 cm of soil profile to field capacity could be determined as follows:

$$\text{Water required, mm} = \text{FC} - \text{MC} \times \text{Bd} \times \text{soil layer depth (600 mm)} / 100$$

Where: FC = Soil field capacity% by weight(g), MC = Soil moisture content% by weight before irrigation(g), Bd = Bulk density of 60 cm depth, gcm^{-3} , 600 = depth of root zone, mm.

Then, multiplying water quantity required for 100% FC level by 0.75 and 0.50 to attain water quantities required for 75 and 50%FC, respectively.

On applying the pre-determined water quantity, a plastic tube (spile) with internal diameter of 3 inches was used to apply and calculate the water quantity according to Michael (1987) as follows:

$$\text{Water quantity, } cm^3sec^{-1} = 0.61 \times A \sqrt{2 \times 981 \times h}$$

Where: A = sectional tube area, cm^2 and h = Effective water head over the tube, cm.

Data Recorded

Yield determinations were recorded at harvesting time.

1. ***Yield and its components*:** It included of tubers №plant^{-1}, tuber yield plant^{-1} (kg), average tuber weight (g), total tuber yield (ton fed^{-1}) and the relative yield increase (%).
2. ***Cracking percentage*:** was calculated as number of cracking tubers per plot
3. ***Tuber quality*:** Tuber quality included: Nitrogen, P and K% were determined according to AOAC (1990). Boron was determined calorimetrically using azomethine –H method as described by Bingham (1982), soluble calcium was determined according to Cottenie *et al.* (1982), and Total Hydrolysable Carbohydrates (THC) was determined using picric acid method according to Thomes and Dutcher (1924).
4. ***Dry matter (%)*** : It was determined by drying 100 g of grated tuber tissues at 70 ^{0}C till the constant weight, and then DM % was calculated.

The collected data were subjected to statistical analyses of variance according to Snedecor and Cochran (1980), and means separation was done using LSD at 5 % probability level.

RESULTS AND DISCUSSION

1. Yield and its components

1.1 Effect of planting date

Data in Table 1 clear out that planting dates had significant effect on potato yield and its components and tuber cracking% as well, except tubers №plant^{-1} in 1st and 2nd seasons. Planting potato on 10th Oct gave higher total tuber yield than that attained with 20th Sep by 18.14 and 9.81%, respectively, in 1st and 2nd seasons. Similar trends were observed for yield components i.e. average tuber weight and tuber yieldplant^{-1}, where the increases under planting at10th Oct reached to (22.54 and 18.32%) and (17.04 and 16.82%)

for the abovementioned traits higher than those recorded with planting at 20th Sep, respectively, in 1st and 2nd seasons. In this concern, Lerna and Mauromicale (2006) stated that potato tubers yield and quality are affected due to several factors including environmental conditions. As for tuber cracking%, the trend was reversed, where cracking% were increased under planting at 20th Sep by 5.28 and 9.16% in 1st and 2nd seasons, respectively, comparable with planting at 10th Oct. The present results are referred that the prevailing weather conditions of 10th Oct planting date may be encouraged potato vegetative growth, which reflected on higher figures of average tuber weight and tuber yieldplant^{-1} and total tuber yield as well, comparable with 20th Sep planting date. Perumal (1981) stated that temperature is the most dominating factor in yield contribution of potato, and the required temperatures during vegetative as well as reproductive growth phase might have contributed towards getting better vegetative growth and higher yield. In connection, Khan *et al*. (2011), Sandhu *et al*. (2013), Thongam *et al*. (2017) and Dash *et al.* (2018) reported that there were significant differences between planting dates regarding yield and its components of potato. Data reveal that the relative yield increases were higher and comprised 18.14 and 9.81% with planting at10th Oct as compared with planting at 20th Sep.

1.2. *Effect of irrigation level*

Data in Table 1 reveal that the assessed irrigation levels significantly affected yield and its components and tuber cracking as well in 1st and 2nd seasons. Irrigation at 100 % FC exhibited the highest values of tuber yield fed^{-1}, average tuber weight, tuber №plant^{-1}, and tuber yieldplant^{-1}. The increases in the abovementioned traits, under 100 % FC level, were (68.97 and 22.40%), (25.36 and 10.94%), (40.08 and 17.26%) and (72.96 and 30.40%) in 1st season and (60.52 and 19.11%), (21.98 and 9.84%), (42.11 and 17.82%) and (71.20 and 29.29%) in 2nd season, compared with 50 and 75% FC, respectively. It evident from the obtained results, that the abovementioned traits were gradually reduced as irrigation level decreased and vice versa. In this regard, Belanger *et al.* (2002) registered a reduction in tubers bulking rate by 40% under water stress than normal irrigation condition, which causing a decline in tuber average weight. Furthermore, Badr *et al*. (2012), Al-Janaby (2012) , Abubaker, *et al*. (2014) and Dash *et al*. (2018) found that increasing water quantities up to the highest levels enhanced potato yield and its components. In addition, data illustrate that

irrigating potato crop at 75% FC resulted in lower figures of tuber cracking disorder reached to 11.87 and 26.65% in 1st season, and 14.79 and 24.43 in 2nd season, than with 50 and 100%FC levels, respectively. In this concern, it is well known that the main reason for the development of deep cracks is irregular irrigation of the crop during the tuber enlargement stage. Following irregular growth due to drought, watering will bring about rapid rehydration of the vascular tissues. The resulting internal pressure will be greater than the resistance of the skin, which breaks and then heals. The obtained results proved that optimum irrigation conditions resulted in higher relative yield increases values under 75 and 100%FC irrigation levels comprised 38.05 and 68.97% in 1st season and 34.76 and 60.52%, respectively, comparing with 50% FC irrigation level.

1.3. Effect of Ca and/or B foliar sprays

Spraying potato plants with Ca and/or B significantly influenced yield and its components and tuber cracking as well, in 1st and 2nd seasons (Table 1). It is obvious, in general, all the assessed Ca and/or B treatments surpassed the control regarding total tuber yield and its attributes. In addition, spraying potato crop with Ca + B exhibited higher values of the tested traits, except tuber №plant^{-1} in 1st season, where the highest figure (3.21) was recorded due to spraying Ca, as compared with that recorded under spraying the crop with Ca + B (3.18), however, the difference did not reach the significance level. The relative increases in the studied traits, except tuber №plant^{-1}, due to spraying Ca+ B, comparable with the control comprised (53.62 and 60.52%), (58.34 and 47.82%) and (64.71 and 62.50%) in 1st and 2nd seasons for total tuber yield and yield attributes e.g. average tuber weight and tuber yieldplant^{-1}, respectively. The current results are in parallel with those reported by El -Dissoky and Abdel – Kadar ((2013), Chowdhury (2017) , Simango and Walls (2017) and Singh *et al*. (2018) whom reported that potato yield and its components were increased by spraying the plants with Ca and/or boron as compared with the control (unsprayed plants). Regarding tuber cracking phenomenon, it is clear that the assessed Ca and/or B treatments resulted in favorite figures as compared with the control, and Ca + B treatment was superior in this respect. The reduction in tuber cracking phenomenon, due to Ca + B treatment, were 38.44 and 41.01% lower than those recorded with the control, respectively, in 1st and 2nd seasons. Data in Table1 illustrate that Ca + B treatment still surpassed the other Ca and/or B treatments and the control as well to enhance relative yield increase parameter.

1.4. Effect of interactions

1.4.1. Effect of bi-lateral interaction of planting dates and irrigation levels

It is obvious that bi-lateral interaction of planting dates and irrigation levels reflected a significant effect on yield and its components and tuber cracking (%) in 1st and 2nd seasons, Table 2. Generally in 1st and 2nd seasons, bi-lateral interaction of planting on 10th Oct and irrigation at100 %FC level recorded the highest values of total tuber yield, average tuber weight, tuber yield plant^{-1}, except tuber №plant^{-1} trait in 2nd, where the highest figure (3.321) was obtained due to 20th Sep planting date as interacted with100 %FC irrigation level. In addition, relative yield increase values were enhanced due to bi-lateral interaction of planting on 10th Oct and irrigation at100 %FC level, in1st and 2nd seasons. Regarding tuber cracking%, desired figures were attained due to bi-lateral interaction of planting on 10th Oct and 75%FC irrigation level, in 1st and 2nd seasons.

4.1.2. Effect of bi-lateral interaction of planting date and Ca and/or B foliar sprays

The bi- lateral interaction of planting on 10th Oct and foliar spray with Ca +B significantly increased potato tubers yield fed^{-1}, average tuber weight and tuber yield plant^{-1}, 1st and 2nd ,Table 1. In addition, such interaction exhibited higher values of the abovementioned traits, except, tuber № plant^{-1} in 1st season, where higher values (3.37 and 3.02, respectively, 1st and 2nd) were recorded due to 20th Sep planting date as interacted with spraying Ca treatment, without significant differences in 1st and 2nd seasons. Favorite tuber cracking% and higher relative yield increase values were obtained under planting on10th Oct and Ca +B foliar spray, in 1st and 2nd seasons.

4.1.3. Effect of bi-lateral interaction of irrigation levels and Ca and/or B foliar sprays

Data in Table 3 exhibited that bi- lateral interaction of irrigation levels and foliar spray with Ca and/or B significantly altered potato yield and its attributes and tuber cracking%, in 1st and 2nd seasons. Bi- lateral interaction of irrigation at100 %FC level and Ca + B foliar spray exhibited higher figures of total tuber yield, average tuber weight and tuber yield plant^{-1}, and relative yield increase% as well, in 1st and 2nd seasons. Furthermore, it is observed that tuber № plant^{-1} and tuber cracking%, exhibited different trend to each other, and to the other studied traits as well. Tuber № plant^{-1} exhibited higher values under irrigation at 100 %FC

level as interacted with Ca spray, whereas lower tuber cracking% values were attained with interaction of irrigating at 75%FC and Ca + B foliar spray, in 1st and 2nd seasons.

4.1.4. Effect of tertiary interaction of planting dates, irrigation levels and Ca and/or B foliar sprays

The tertiary interaction of planting dates, irrigation levels and Ca and/or B foliar sprays reflected a significant effect on potato yield and its components besides cracking percentage in 1st and 2nd seasons, however, the studied parameters exhibited different response, (Table 4). Higher total potato tubers yield values were attained with planting at 10th Oct, irrigation at75%FC level and sprayed potato plants with Ca + B interaction, in 1st and 2nd seasons. Average tuber weight exhibited the highest figure with planting at 10th Oct, irrigation at75%FC level and sprayed potato plants with Ca + B interaction in 1stseason, whereas in 2nd season the highest value resulted from planting at 10th Oct, irrigation at100%FC level and sprayed potato plants with Ca + B interaction. Tuber № plant^{-1} exhibited higher values under the interaction of planting on 20th Sep, irrigation at 100 %FC level and Ca spraying in1st and 2nd seasons. Tuber yield plant^{-1} shows higher values with planting at 10th Oct, irrigation at100%FC level and control(without spray) interaction in 1st season, and interaction of planting at 10th Oct, irrigation at100%FC level and sprayed potato plants with Ca + B in 2nd season. As for tuber cracking%, the highest values were obtained due to planting at 20th Sep, irrigation at100%FC level and sprayed potato plants with Ca + B interaction, in 1st and 2nd seasons. Relative yield increase%, in 1st and 2nd seasons, reveal higher values due to planting at 10th Oct, irrigation at75%FC level and sprayed potato plants with Ca + B interaction.

2. Tuber Quality

2.1. Effect of planting date

Planting dates had significant effect on tuber content of N, Ca, boron, total carbohydrates and DM percentages in 1st and 2nd seasons, Table 5. The increases in N, Ca, boron, total carbohydrates and DM%, due to planting at 10th Oct, were higher than those recorded under 20th Sep planting date by (4.10 and 6.54%), (29.20 and 27.71 %), (48.28 and 49.10%), (4.94 and 3.60%) and (10.39 and 8.12%) in 1st and 2nd seasons, respectively, comparing with 20th Sep planting date. Nevertheless, P and k contents exhibited reversed

trend, where higher values were recorded with 20th Sep planting date, however, the differences did not the significance level. In connection, Sandhu *et al*. (2013), Thongam *et al*. (2017) and Dash *et al.* (2018) found that differed planting dates induced variations with respect to potato tubers quality.

2.2. Effect of irrigation levels

Data in Table 5 show that, tuber contents of N, Ca, boron, total carbohydrates and DM percentages were significantly affected due to the adopted irrigation levels in1st and 2nd seasons. Higher figures for the abovementioned quality traits were registered under irrigation at 100%FC, compared to 50 and 75%FC, which reached to (7.84 and 5.10%), (29.44 and 11.67%), (75.00 and 24.66%), (4.00 and 0.21%) and (2.29 and 0.81%) in 1st season. The corresponding increases in 2nd season were (5.81 and 4.46%), (31.52 and 10.65%), (87.86 and 28.75 %), (2.07 and 2.97%) and (5.52 and 4.44%), respectively, comparing with 50 and 75%FC levels. In this concern, Ahmadi *et al*. (2010) stated that water stress at any growth stage leads to a considerable negative impact on potato tuber quality. In addition, El Saidi *et al*. (2010) and Dash *et al*. (2018) indicated that tuber quality of potato were improved with increasing irrigation water quantities up to the highest levels.

2.3 . Effect of Ca and/or B foliar spray

Spraying potato plants with Ca and/or B significantly affected all the investigated parameters of potato tuber quality 1st and 2nd seasons, Table 6. The highest values of N(26.90 and 27.01%), P(34.42 and 33.07%), K(16.96 and 16.96%), Ca(35.65 and 28.90%) and B(34.00 and 38.20%) and DM%(19.45 and 20.04 %), respectively, in potato tubers were obtained due to spraying with Ca + B, in 1st and 2nd seasons, comparable with the control. The total carbohydrates increases were 12.07 and 10.10%, in 1st and 2nd seasons, due to spraying with B, comparable with the control. In connection, Follett *et al*., 1981 stated that enhancement in tuber quality by foliar application of boron may be attributed to stimulating plant biological activities such as photosynthesis, enzyme activities, nutrient uptake and rate of photo-assimilates translocation into the tuber. In addition, Awad *et al.* (2010), Jafari *et al*. (2013) and Tantawy *et al*. (2017) found that sprayed potato plants with Ca and / or boron resulted in higher tuber quality values more than unsprayed ones.

2.4. Effect of interactions

2.4.1. Effect of bi-lateral interaction of planting dates and irrigation levels

Data in Table 6 show that the bi-lateral interaction of planting dates and irrigation levels significantly influenced all the studied potato tuber quality parameters, except P% in 2nd season and K% in 1st and 2nd seasons. Planting on10th Oct date as interacted with irrigating at 100% FC exhibited higher figures of N, Ca, B and both total carbohydrates and DM percentages, 1st and 2nd seasons, whereas, P% reveal higher values with planting on 20th Sep and irrigating at 75% FC level bi-lateral interaction in 1st season, and under planting on 20th Sep and irrigating at 100% FC bi-lateral interaction, in 2nd season.

2.4.2. Effect of bi- lateral interaction of planting dates and Ca and/or B foliar sprays

The bi-lateral interaction of planting dates and Ca and/or B foliar sprays significantly altered all the studied potato tuber quality traits, in 1st and 2nd seasons, Table 6. Planting on10th Oct date as interacted with Ca +B foliar spray resulted in higher figures of the investigated potato quality traits, except total carbohydrates and DM percentages, which exhibited higher values due to planting on10th Oct date as interacted with Boron foliar spray and bi-lateral interaction of planting on10th Oct date and Ca +B foliar spray, respectively, 1st and 2nd seasons.

2.4.3. Effect of bi- lateral interaction of irrigation levels and Ca and/or B foliar sprays

Data in Table 7 reveal that bi-lateral interaction of irrigation levels and Ca and/or Boron foliar sprays significantly affected all the potato tuber quality traits under study, in 1st and 2nd seasons. Irrigating at 100% FC level and Ca + B foliar spray exhibited higher values of the investigated potato quality traits, except, total carbohydrates, which exhibited higher values with irrigating at 100% FC level and Boron foliar spray interaction, in 1st and 2nd seasons.

2.4.4. Effect of tertiary interaction of planting dates, irrigation level and Ca and/or B foliar sprays

The tertiary interaction of planting dates, irrigation levels and Ca and/or B foliar sprays significantly affected all the investigated potato quality traits, except tuber P% content, in 1st and 2nd seasons, Table 8. In addition, higher

values of N&, K%, Ca, B and DM% were obtained due to planting on 10th Oct, irrigating at 100 % FC and spraying potato plants with Ca + B interaction, whereas total carbohydrates% was the highest under interaction of planting on 10th Oct, irrigation levels at 100 % FC and sprayed plants with Boron, in 1st and 2nd seasons.

Conclusively, at similar experimental conditions it could be concluded that , the tertiary interaction of planting on 10th Oct , irrigation at 100% FC level and sprayed potato plants with Ca + B was the proper for enhancing tuber yield and improved quality. In addition, for reducing tuber cracking disorder, planting on 10th Oct, irrigation at 75% FC and spraying potato plants with Ca + B is the recommended interaction.

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تأثير ميعاد الزراعة ، مستويات الرى ومعاملات الرش الورقى بالكالسيوم والبورون على البطاطس

٢- المحصول ومكوناته - التشقق وجوده الدرنات

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أجريت هذه التجربة خلال الموسمين المتتاليين لعامي ٢٠١٦/٢٠١٧ ، ٢٠١٧/٢٠١٨ في مزرعة البحوث الزراعيه بالجميزة - محافظة الغربيه - مركز البحوث الزراعيه وسط الدلتا - مصر بهدف دراسة تأثير ميعاد الزراعة (الزراعة فى ٢٠ سبتمبر ، الزراعه فى ١٠ أكتوبر) ، مستويات الرى (الرى عند ٥٠ ، ٧٥ ، ١٠٠ % من السعة الحقليه) ومعاملات الرش الورقى بالكالسيوم (١ % في صورة كلوريد الكالسيوم) والبورون (٦٠ جزء فى المليون في صورة

حمض البوريك) ، بالاضافة الى عدم الرش والتفاعلات بينهم على المحصول ومكوناته – التشقق وجودة الدرنات تحت ظروف الارض الطينيه واستخدام نظام الرى بالغمر. وقد صممت التجربه فى قطاعات منشقه مرتين ، حيث وزعت مواعيد الزراعه فى القطع الرئيسيه ، مستويات الرى فى القطع تحت الرئيسيه ، ومعاملات الرش بكلوريد الكالسيوم والبوريك فى القطاعات تحت تحت الرئيسيه - **وكانت أهم النتائج المتحصل عليها كالتالى :**

سجلت التفاعل الثلاثى بين ميعاد الزراعة فى ١٠ أكتوبر والرى عند ١٠٠ % من السعه الحقليه ورش النباتات بالكالسيوم والبورون الى الحصول على أعلى القيم لمحصول الدرنات الكلي ،متوسط وزن الدرنه ، عدد الدرنات / نبات ، محصول النبات ، محتوى الدرنه من النتروجين والبوتاسيوم ، الكالسيوم والبورون ونسبه المادة الجافة فى كلا الموسمين ، بينما أزداد محتوى الدرنه من الكربوهيدرات الكليه مع التفاعل الثلاثى بين التفاعل الثلاثى بين ميعاد الزراعة فى ١٠ أكتوبر والرى عند ١٠٠ % من السعه الحقليه ورش النباتات بالبورون. وكانت مقدار الزيادة النسبيه فى المحصول الكلى للدرنات تتراوح بين ٢٥٣.٧٥ ، ١٧٧.٨٢ % بالنسبه لمعامله التفاعل الثلاثى بين ميعاد الزراعة فى ١٠ أكتوبر والرى عند ١٠٠ % من السعه الحقليه ورش النباتات بالكالسيوم والبورون عن التفاعل الثلاثى بين ميعاد الزراعة فى ٢٠ سبتمبر والرى عند ٥٠ % من السعه الحقليه و عدم الرش بالكالسيوم والبورون فى الموسم الاول والثانى على التوالى . اما بالنسبه لتشقق الدرنات فقد سجلت التفاعل الثلاثى بين ميعاد الزراعة فى ١٠ أكتوبر والرى عند ٧٥ % من السعه الحقليه ورش النباتات بالكالسيوم والبورون الى الحصول على أقل القيم (١١.٣٧ ، ١٠.٤٠ %) فى الموسم الاول والثانى على التوالى ، بينما لوحظ أعلى القيم لتشقق الدرنات (٢٥.٣٨ ، ٢٦.٥٧ %) مع التفاعل الثلاثى بين ميعاد الزراعة فى ٢٠ سبتميبر والرى عند ١٠٠ % من السعه الحقليه وعدم رش النباتات بالكالسيوم أوالبورون فى الموسم الاول والثانى على التوالى.

التوصيه : تحت الظروف المشابه لهذا البحث يمكن ان نستنتج أن أفضل تفاعل ثلاثى لزيادة المحصول وتحسين جوده الدرنات هى زراعة البطاطس فى ١٠ اكنوبر والرى عند ١٠٠ % من السعه الحقليه ورش النباتات بالكالسيوم والبورون ، بينما أدت معامله التفاعل الثلاثى بين زراعة البطاطس فى ١٠ اكنوبر والرى عند ٧٥ % من السعه الحقليه ورش النباتات بالكالسيوم والبورون الى تقليل النسبه المئويه لتشقق الدرنات.