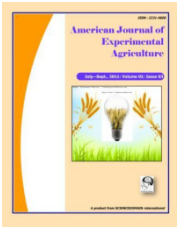

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A Greenhouse Study on Growth, Yield and Anatomical Parameters of Three Pea Cultivars: under Different Irrigation Levels and Growth Regulators

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ABSTRACT

This experiment was carried out during the fall season 2009-2010 in the vegetable greenhouse, Horticulture Department, Dohuk University. Three pea cultivars namely Local crinkle, Local Smooth and Canadian were subjected to three irrigation levels where plant irrigated whenever 25, 50 or 75% of pot available water capacity were depleted, besides plants were sprayed with either 100mgl^{-1} gibberellic acid (GA_3), 100mgl^{-1} indole-3-butyric acid (IBA), 2.5gl^{-1} micronutrient and distilled water as a check treatment. The objective was to evaluate the cultivar performance under adequate and inadequate irrigation during flowering, pod swelling and seed filling stages to find out which is the best, particularly under moderate and severe drought, besides that we intended to evaluate the possibility extent of boosting drought resistance of these cultivars by the aid of GA_3, IBA and micronutrients. The obtained results exhibited that irrigating pea plants whenever 25% 0f pot available water capacity was depleted appeared to be the paramount irrigation treatment followed by that of 50% depletion and irrigation level of 75% are not advisable. 25% irrigation level manifested the highest leaf number per plant (26.33), plant height (141.15 cm), root dry weight (0.16g), flower number per plant (6.48), individual pod fresh weight (3.56g), seed number per pod (3.47), green pod yield per plant (14.53g), weight 100 seeds (23.02g), seed fresh weight per pod (1.44g), pericarp fresh weight (2.05g), aperture length of upper leaf stomata (4.38µm), stomata length of leaf lower surface (6.23 µm), stomata aperture length of leaf lower surface (4.75 µm), smallest vessel width (3.72 µm), protein content of dry seed (25.3%), GA_3 (346.63 mgkg^{-1} dry seeds), and IAA (4109.72 mgkg^{-1} dry seeds). The best plant response was confined to these sprayed with micronutrient, then IBA and the lowest was GA3-treated pea. Pea sprayed by 2gl^{-1} micronutrients manifested the highest root dry weight (0.16g), leaf dry matter percentage

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(26.36%), stem dry matter percentage (35.77%), flower number per plant (6.43), pod number per plant (4.49), individual pod fresh weight (3.01g), seed number per pod (3.64), yield of fresh pods per plant (13.33g), total pod number per plant (4.11), weight of 100 seeds (23.51), fresh weight of pericarp (1.6g), stomata length at upper leaf surface (6.05µm), stomata length at lower leaf surface (6.6 µm), stomata width at lower leaf surface (3.78 µm), stomata aperture length at lower leaf surface (4.61 µm), stomata aperture width at lower leaf surface (2.38 µm), stomata population at lower and upper leaf surface (5971.88 and 3792.19 stomata mm^{-2}, respectively), chlorophyll percentage out of gross pigments (40.05%), proline content (0.0062 $\mu g g^{-1}$ dry seeds), ABA (713.31 $mg kg^{-1}$ dry seeds) and IAA (3725.23 $mg kg^{-1}$ dry seeds). Crinkle pea appeared to be the potent cultivar it gave the highest yield of green pod (14.6 $g plant^{-1}$), plant height (119.8cm), leaf dry weight (0.27g), root dry weight (0.25g), leaf dry mater percentage (28.79%), stem dry matter percentage (36.39%), flower number (6.75), pod number per plant (4.62), individual pod dry weight (1.21g), pod fresh weight (2.72g), seed number per pod (2.95), pericap fresh weight (1.51g), dry pericarp (0.57g), upper leaf surface stomata width (3.7µm), upper leaf surface stomata length (6 µm), stomata aperture length of upper leaf surface (4.32 µm), stomata aperture width of upper leaf surface (2.2 µm), aperture length of lower leaf surface stomata (4.64 µm), aperture width of lower leaf surface stomata (2.32 µm), stomata length at lower leaf surface (6.4 µm), stomata width at lower leaf surface (3.96 µm), the widest and lowest vessels width (10.37 and 3.8µm, respectively), vessels number per bundle (12.46) and chlorophyll percentage related to gross pigments (34.74%). Local smooth comes next then the worst cultivar was Canadian. Therefore, crinkle was most drought resistant pea cultivar.

Keywords: Pea; anatomy; irrigation; cultivar, gibberellic acid; indole-3-butyric acid; micronutrients;

1. INTRODUCTION

Pea grows best in cool weather and should be planted in early spring or late summer. The ideal mean temperature for growth is (13–18°C). Young pea plants can with stand a little frost, though frost may damage the flowers and pods. As a winter crop, peas tolerate temperatures down to (-2°C) in the seedling stage, but top growth may be damaged when the temperature falls below (-6°C) (Slinkard et al., 1994). Peas are important in human nutrition. Consumed mostly as green peas, total production worldwide is around 8.3 million tons and it is the fourth leading legume in terms of consumption in the world (FAO, 2008). Pea has high levels of the amino acids, lysine and tryptophan which are low in cereal grains and grain protein in pea can range from 19 to 27 percent but is most commonly 22 to 24 percent. Pea also contains high levels of carbohydrates and is low in fiber and contains 86 to 87 percent total digestible nutrients. These feed characteristics, combined with high palatability make pea an excellent livestock feed pea. Dry pea is often cracked or ground and added to cereal grain rations and researches have shown that dry pea is an excellent protein supplement in swine cow feeder calf dairy and poultry rations (Miller et al., 2005).

Irrigation is not necessary for a spring or fall pea shoot crop, but it is necessary for peas grown from June through August. Irrigation rates and frequency depend on soil conditions and air temperatures. Heavy soil will request less irrigation than lighter soils (Hemphell,

2002) Supplementary irrigation was found to be beneficial to the pea yields when the temperature increased. Indeed, application of 60 mm of supplementary irrigation during the complete growth stages of crops that were subjected to an increase in mean daily temperature of 0.6–2.2°C resulted in crop yields improving by 8.3%–12.8%. Consequently, in this region, supplementary irrigation may play an important role in maintaining pea yields that would otherwise be affected by climate warming. However, the results also show that application of 60 mm of supplementary irrigation does not decrease the number of stems with root-rot sickness and that the In/Out ratio of pea crops subjected to the same temperature conditions will increase (Xiao et al., 2009). Field irrigation requirements to achieve maximum yields in vegetable crops are highly dependent on the active root zone where water and nutrients are absorbed. Subsequently, the more occupied soil by roots the more efficient water use, unfortunately most vegetable crops are of shallow root systems including legume crops and their abilities to adapt with moisture changes are poor, particularly at latter stages of growth where pod swelling and seed fillings are synchronized with such moisture changes which resulted in drastic reductions in yield quality and quantity (Abdel, 1993 and Al-Rawi, 2011). Maximum root depth varied from 0.88m to 1.06m,with the root penetrating to greater depths for February sowing than for November sowing in very cold winters, the earlier the crop was sown , the sooner maximum root depth was reached (Vocanson et al., 2006). Limited or no irrigation was required in March, whereas the rainfall in the April–June period was far below the evapotranspiration demand for pea in this region. The maximum daily ET values of pea varied from 4.1 to 4.8mm per day in the 4 experimental years and they occurred in mid or late May during the pod formation stage of the crop. The low rainfall and high ET demand in the April–June period of all experimental years shows the importance of irrigation. It is estimated that a total of 175–316mm of irrigation would be required in this period to stabilize and improve seed yield (Uzun et al., 2005). Supplementary irrigation was found to be beneficial to the pea yields when the temperature increased. Indeed, application of 60 mm of supplementary irrigation during the complete growth stages of crops that were subjected to an increase in mean daily temperature of 0.6–2.2^{0}C resulted in crop yields improving by 8.3%–12.8%. Consequently, in this region, supplementary irrigation may play an important role in maintaining pea yields that would otherwise be affected by climate warming.

A time-course analysis of the 10 days, 30% soil field capacity treatment showed a decrease in leaf water potential from -0.5 to -0.87 MPa by 8 days, with a cessation of dry weight increase after 3 days, when leaf water potential was -0.65 Mpa (Ramos et al., 1999). Measurements of relative leaf water content and leaf water potential revealed a remarkably similar physiological response to water stress among the pulse crops that was fundamentally different from spring wheat. In particular, as leaf water content decreased, the leaf water potential of the pulse crops did not decrease as rapidly as that of spring wheat. This suggests that pulse cell walls have additional elasticity, which helps maintain turgour under water stressed conditions (Miller et al., 2005). The smaller final size of the mature cells and organs produced under water deficit conditions require smaller quantities of essential solutes (such as sugars) to maintain turgour, at a time when solute availability for growth and respiratory activity may already be limited (Sharp et al., 1990).

Significant differences in stomata conductance between watered and stressed plants were first detected at day 4 after withholding water. The relationship between photosynthetic rate and stomata conductance was linear during the stress period (Chartzoulakis *et al.,* 2002). Stomata conductance was linearly correlated with leaf specific conductivity (k_l) at low stress levels, suggesting a concerted regulation of water flow, while at higher stress levels stomata conductance decreased with no changes of k_l (Lovisolo and Schubert, 1998). This required

lower stomata conductance (gs) to compensate for the lower leaf specific conductivity (k_l) in the stressed plants. When water stress was more severe, this balance was not maintained, presumably gs was not reduced sufficiently to balance the ψ gradient, and embolism occurred. Changes in leaf anatomical characteristics can alter the CO_2 conductance diffusion components from the sub stomata cavities to sites of carboxylation and thus contribute to maintenance of photosynthetic rates despite the low stomata conductance (Evans et al., 1994). Albeit, a decline in the photosynthetic rate under water stress conditions could be attributed either to a decrease in stomata conductance and/or to non-stomata limitations (Cornic and Massacci, 1996).

Abd El-Wahed et al. (2006) observed significant decrease of GA_3 treatments for chlorophyll concentration. Foliar spray of fababean with GA_3 increased the polysaccharides which form the predominant fraction in the carbohydrate pool in the yielded seeds and thereby increased significantly the total carbohydrates (Gaber et al., 2000). Chhun et al. (2004) indicated that the increase in yield and its components by IBA treatment could be due to the stimulation in dry matter production resulted from the enhancement of cell division as well as chlorophyll accumulation which leads to higher photosynthetic activity and accumulation of dry matter and in turn reflected on the increasing in translocation and accumulation of certain microelements in plant organs and this in turn on their yield and its components. Amin et al. (2007) have found that foliar application of indole-3-butyric acid with different concentrations led to significant increases in vegetative growth, plant height, number of leaves per plant, fresh and dry weight per plant, leaf area per plant. The application of GA_3 at 50 and 100mgl^{-1} on pea (*Pisum sativum* L.) showed significant decrease in carbohydrate and sugar in seeds in both season, total soluble protein and decreased chlorophyll concentration (El- Shraiy and Hegazi, 2009). They also found that application of IBA at 50 and 100mgl^{-1} significantly increased the total chlorophylls in leaves, total soluble proteins, praline, phenol, total soluble carbohydrates and sugars in seeds, and significant increase in length of pod plant, number of pod per plant, number of seed, per pod, 1000 seeds weight and pods fresh and dry weights of pea plants (*Pisum sativum L.*). ABA is synthesized in plant roots in response to stress (Shashidhar et al., 1996). Thus Abscisic acid (ABA) is widely believed to be a major contributor in the signaling pathway of water deficit and in the controls of plant transpiration and leaf growth. This view is reinforced by experiments in which the ABA biosynthesis pathway was affected (Borel et al., 2001) or in which artificial ABA was fed to plants (Zhang and Davies, 1989).

The accumulation of osmolyte compounds has long been proposed as an adaptative mechanism for drought and salt tolerance, it has received increasing interest during the last 20 years. In response to drought and/or high salinity stresses, which disturb the intracellular water balance, many plants and bacteria synthesize and accumulate several kinds of compatible osmolytes, such as proline (Kavi Kishor et al.,1995), mannitol (Tarczynski et al., 1993), glycinebetaine (Huang et al., 2000), trehalose (Garg et al., 2002), fructan (Pilon-Smits et al., 1995). Proline is one of osmolytes which increase faster than other amino acids in plants under water stress and help the plants to maintain the cell turgour (Valentovic et al., 2006). Therefore increasing proline concentration can be used as an evaluating parameter for irrigation scheduling and for screening drought resistant varieties (Gunes *et al*., 2008). Alexieva et al. (2001) have found that proline content increased under drought stress in pea plants. However, Serraj and Sinclair (2002) suggested that osmolyte accumulation and crop yield have no consistent benefit, with probably no link with osmotic adjustment. The accumulation of proline in plant tissues is a clear marker for environmental stress, particularly in plants under drought stress (Routley, 1966).

Iron is one of the ions usually supplied as mineral nutrients from the soil and known to be essential for plant growth (Hearin, 1981). Iron plays an important role in the activation of chlorophyll and in the synthesis of many heme proteins such as different cytochrome, which participate in different functions in the plant metabolism (Bhandari an Randhawa, 1985). Iron-deficiency induced chlorosis is a widespread nutritional problem, this disorder becomes evident as a typical yellowing of young leaves of plants in many crops and affects leaf and flower mineral composition and is responsible for significant decreases in yield, crop size and the quality of many species (Tagliavini and Rambola, 2001). Amar (2003) stated that iron is involved as an active factor in the structure of catalase, peroxidase, oxidase and cytochromes enzymes which facilitate the activation performance of many physiological processes in plant cells. Mishra et al. (2003) have found that application of Fe significantly increased the yield components and they showed that the foliar spray with Fe^{2+} caused increases in seed yield of chickpea. These increases might be due to the role of iron in chlorophyll synthesis (Al-Taai et al., 1994) who found that iron is implicated as a Co-enzyme in the synthesis of the chlorophyll, chlorophyll biosynthesis and assimilate accumulation (Naguib and Ali, 2002) they mentioned the role of Fe in chlorophyll biosynthesis and in turn on increasing the photosynthetic rate which is followed by an accumulation of soluble sugars and soluble nitrogen in the plant tissues. The excess of these metabolites were mobilized to the different yield components and participation in enzymes.

Zinc deficiency include chlorosis on young leaves, reduced leaf size and shortened internodes length on the branches .The reduced size of leaves is usually associated with bright yellowing between the vines (Crowly and Smith,1994). Zinc deficiency also can result in die back of leaders or shortened internodes and small leaves at shoot extremities, resulting in a bushy appearance to shoot tips (Goldspipink and Sutton, 2001). Boron deficiency has been reported to be most pronounced on leguminous crops such as Lucerne, red clover and alfalfa and cruciferous crops such as cabbage, cauliflower, rutabagas, turnips and radish (Murphy and Walash, 1972). Boron is involved in several cellular processes as protein synthesis, sugar and hormone translocation membrane transport, and nucleic acid, (Schon and Blivins, 1990). Bolanos et al. (1996) showed lower number of developed nodules and capacity to fix N_2 in legumes under B deficiency; their results were attributed to the possible role of B in Rhizobium-legume cell surface interaction. Boron is needed for the targeting of nodule-specific plant derived glycoprotein (Bolanos et al., 2001), that are crucial as signals for bacteroid differentiation into a N_2-fixing form (Bolanos et al., 2004).

The objective of this investigation was to discriminate pea drought resistance cultivar from susceptible ones and to find the extent of improving drought resistance by the application of micronutrients, Gibberellic acid and Indole-3-butyric acid. Therefore, three irrigation levels were used to detect the level where water commences to reduce yield which was confirmed by anatomical, growth and yield parameters.

2. MATERIALS AND METHODS

This experiment was carried out during the grown season of 2009 inside controlled green hose, Horticulture Department, Agricultural College, Duhok University, Dohuk which is located at (36°51˝38˙) North Latitude and (42°52˝02˙) East Longitude, and with Altitude of 473m. Seeds of three pea cultivars namely Canadian, Local smooth and Local crinkled were purchased from agricultural shop, Mosul.

Split split plot within factorial randomized complete block design was chosen where the main plot is factor (A) the irrigation level which included; (a_1) irrigating the pots whenever 25% of

soil available water capacity is depleted, (a_2) irrigation the pots whenever 50% of soil available water capacity is depleted (a_3) irrigation the pots whenever 75% of soil available water capacity is depleted. Whereas, the Sub plot was dedicated to spraying factor (B); in which spraying pea plant with distil water (control = b_1), (b_2) spraying pea plants with Gibberellic acid (GA_3 = b_2) at 100mg-l^{-1}, spraying pea plants with indole-3- butyric acid at 100mg-l^{-1} (IBA= b_3), and (b_4) was spraying pea plants with micronutrient mixture at 2.5g-l^{-1}). Pea cultivars were represented by factor (C): Where c_1= Canadian pea cultivars and c_2 local smooth pea cultivar and c_3 local crinkled pea cultivar. Therefore 36 treatments were included in this excrement and each treatment was reiterated five times, one replicate was represented by one pot.

A mixture of sandy soil to Patmos (2:1) was prepared to fill pots of 22cm diameter and 20cm depth each with weight (5 kg) of the above prepared mixture then these pots were distributed to fit the selected experimental design. Gypsum blocks were salted at the mid pot depth in order to truck the soil moisture fluctuation during plant reproductive growth. Thereafter, pots were brought up to field capacity and five seed were sown in each pot on October 25th, 2009 then plants were thinned to two plants per pot.

Soil moisture was monitored by the use of Avometer brother YH-395B and subsequently, irrigation at 25% (14 times), 50%, (7 times) and 75% (1 time) was given. Irrigation was experienced during the flowering, pod swellings and seed filling development stages. Pots were fertilized with fertilizer (N-46%) urea on December 28th, 2009. Plant was protectively sprayed by Benomyl fungicide at 0.5g-l^{-1}. Plants were also sprayed by either distilled water, l00 mgl^{-1} gibberellins, 100mgl^{-1} indole-3-butyric acid or 2.5gl^{-1} micronutrients on December 29th, 2009 and spraying was repeated after two weeks on January 12th, 2010, and finally plants were harvested on March 28th, 2010.

10 pots were filled with the growing mixture, each pot was provided by one gypsum block which was positioned at the mid pot depth. Pots were irrigated and then sealed by plastic bags to bring about moisture homeostasis to field capacity. Pot weights and their corresponding electrical resistances (Avometer brother YH-395B) were recorded periodically until the soil being completely dried where the Avometer is being reached constancy. Recorded data were analyzed by a computer Minitab Program to obtain an equation that would be used latter in the greenhouse for determining when to irrigate plants. Soil available water capacity (AWC) was calculated from the mean of pot weight at field capacity minus pot weights at soil drying phase. AWC depletion percentage was calculated from the following equation:

Soil weight at field capacity – soil weight at any given time/ soil weight at FC- dry soil weight x100.

This equation was applied after each reweighing and table of resistance in ohm column versus AWC depletion percentage were emerged. Finally, recorded data was analyzed by computer Minitab Regression programmer (Figure 1).

Leaf number per plant, pod number per plant aborted ovule number per pod, aborted seed number per pod, seed number per pod, were counted. Plant height was measured by roller. Leaf fresh weight, stem fresh weight, mature seed fresh weight, seed coat fresh weight and pod fresh weight , were weighted by metric balance of three decimals. Leaf dry weight, stem dry weight, pod dry weighted, seed dry weight, seed coat dry weight, root dry weight, were weight and oven dried at 70°C for 24 hours then samples were taken out from the oven and

left for 2 hours then reweighted in order to calculate the dry matter percentage. Leaf area was calculated by weighting the whole fully expanded (4^{th} down order from the apical meristems) leaf of pea and then one centimeter was cut out including the midrib leaf and weighted. The area was calculated from the following equation: LA = leaf weight/weight of $1cm^2$ of leaf cut. Samples were oven-dried at 65^0C for 24 h then samples were left in the laboratory for 2hrs and thereafter were weight with 2 decimal meteler balance.

Full expanded leaves were sampled from pea plants on February 23^{rd}, 2010 at early morning, sample were weighted and kept in the refrigerator at $5^{\circ}C$. Fresh leaf epidermis was pealed and mounted on the slide drops of distilled water were added and the sample was slightly covered by cover slip, then the slide was examined under 40X objective lens and grade eye lens 7x. Then stomata was magnified 7x40= 280 times (Abdel, 2006a). Stomata populations were determined by counting the stomata number in the micron area of examined leaf sample under the microscope and then converted to square millimeter, referring to micrometric slide dimensions of sample area. Permanent slide preparation was concluded from Berlyn and Miksche (1976).

Chlorophyll was determined in the green house using (chlorophyll meter, model spade 502 manufactured by Minolta company Japan. Total nitrogen was determined by micro Kjeldahl method (A.O.A.C., 1980). Proline was measured at 520 nm by UV- Spectrophotometer type (JENWAY) Model 6300) (Bates et al., 1973). Finally, ABA, GA_3 and IAA determination were made according to procedure adopted by Unyayar et al. (1996).

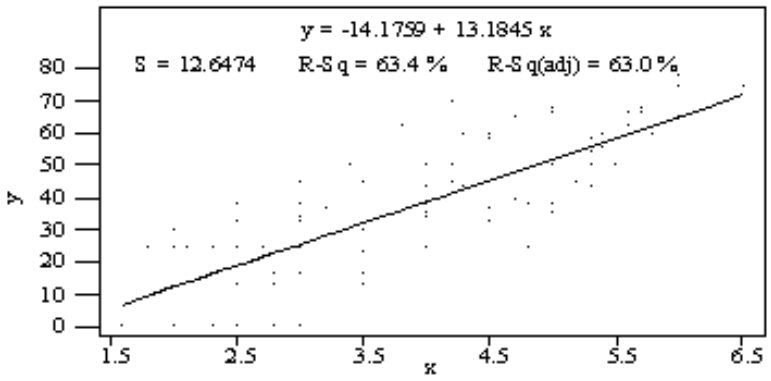

Fig. 1. Soil AWC depletion (Y) versus Avometer reading ohmx 1000 (X)

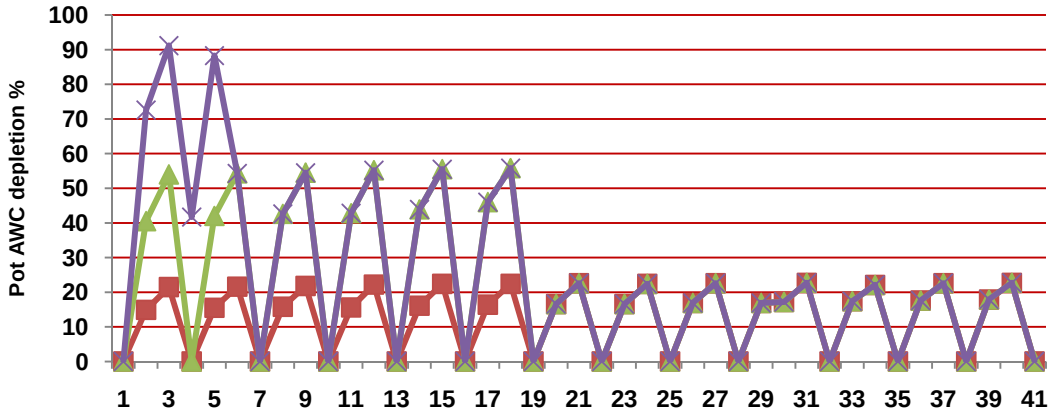

Fig. 2. Irrigation frequencies for 25, 50 and 75% pot AWC depletion during 86 days from flowering to harvesting (x-x 75%); (triangle, 50%) and square 25%

3. RESULTS AND DISCUSSION

3.1 Vegetative Growth Responses to Watering

The obtained results (Table 1) revealed that irrigating pea plants whenever (25%) soil available water capacity was depleted appeared to be the most effective treatment. It substantially exceeded that of (50%) level in leaf number per plant (19. 6%) and plant height (22%). Moreover, this treatment also manifested superiority over that of 75% level in terms of leaf number per plant (33.5 %) and plant height (53.7%). Irrigating pea plants whenever (50 %) of soil AWC was depleted came next to (25 %) level. It significantly surpassed that of (75 %) level in terms of leaf number per plant (11.6%) and Plant height (26%) and also exceeded that of (25%) in terms of dry matter percentage (21.9%),stem dry percentage (79.4%) and leaf area (44%). Irrigating pea plant whenever (75 %) of soil AWC was depleted manifested the lowest values in most vegetative growth parameters. However, this level exceed that of (50 %) level in leaf dry matter percentage (64.1%), stem dry matter percentage(94.8%) and leaf area (13.8%) and also exceeded that of (25%) level in term of leaf dry matter percentage (100.8%), stem dry matter percentage(249.6%) and leaf area (63.8%). Very close results were reported on faba beans (Abdel and Al-Hamadany, 2010), cowpea (Abdel and Al-Salem, 2010). The adverse effects of water shortages were attributed to the role of drought on leaf senescence where the first detected leaf senescence event was an increase in the mRNA encoding a Cysteine-proteinase homologous to *Arabidopsis* SAG2. This happened at early stages while the photosynthesis rate, chlorophyll and protein contents were still high. The 2-fold variability in life span of leaves was closely linked to the duration from leaf unfolding to the beginning of accumulation of this mRNA. In contrast, the duration of the subsequent phases was essentially conserved in all studied cases, except in plants with excised flowers, where the degradation processes were slower (Pic et al., 2002). These results suggest that senescence in water deficient plants was triggered by an early signal occurring while leaf photosynthesis was still active, followed by a program similar to that of monocarp senescence. They also suggest that reproductive development plays a crucial role in the triggering of senescence. The obtained results might be attributed to the role of water stress on acceleration leaf senescence of plants subjected to water shortage, because it reduces the water demand cumulated over the whole plant cycle, thereby

avoiding water deficit during seed filling, and it allows recycling of scarce resources to the reproductive sinks. However, in crop species, early leaf senescence usually correlates with lower yield because cumulative photosynthesis is reduced (Wolfe et al., 1988). Comparison of pea leaves senescence under varying moisture availabilities revealed that the time course of leaf senescence in pea (*Pisum sativum* L. cv Messire) plants subjected to a mild water deficit to that of monocarpic senescence in leaves of three different ages in well watered plants and to that of plants in which leaf senescence was delayed by flower excision (Pic et al., 2002). They found that mild water deficit (with photosynthesis rate maintained at appreciable levels) sped up senescence by 15^0C/ day (200°Cd). Whereas, the range of life spans in leaves of different ages in control plants was 25 d (340°Cd).

3.2 Vegetative Growth Responses to Gibberellic Acid (GA_3)

The obtained results (Table 1) manifested that foliar application of $100mgl^{-1}$ GA_3 on pea plants was the most potent treatment it significantly exceeded that of untreated check in terms of leaf number per plants (26.5%), plant height (105.7%), stem dry matter percentage (5.4%). It also exceeded that of micronutrient in leaf number per plant (18.7%), plant height (92.5%) and leaf area (6.8%) moreover it highly surpassed pea plant treated with IBA in terms of leaf number per plant (22.8%) and plant high (82.6%). The role of GA_3 in well irrigated crops is well established. However, improving the growth and yield of crops under water shortages required interpretations. Abdel (2005) has reported superiority of GA_3 over IBA in improving lettuce yields under inadequate rainfalls. He attributed his paradox results to the beneficial role after every rainfall incidence where plants capable to extract water before they inter the drought episode between rainfall incidences which sometimes these drought episodes were not severe enough to abrogate GA_3 roles. Subsequently, Abdel (2007a) found that spraying of faba bean plants by GA_3 at rate of $150mgl^{-1}$ significantly improved growth and yield of green pods; however, it delayed pod maturation as the treated plants produced 46% of their accumulative yield during the first 4 harvests. When a comparison was made with check, this GA_3 rate manifested the highest plant height (140.9 cm), branches number per plant (5.5), leaflet numbers per branch (135), leaflet area (25.3 cm^2),leaf area index (28.3), plant fresh weight (4 $kg.m^{-2}$). Leite et al. (2003) showed that foliar spray of GA_3 increase in plant height , first internodes length stem diameter, leaf area and dry matter production of soybean plants. Emongor (2007) reported that exogenous application of GA_3, 7 days after emergence at 30, 60 or 90 mg L^{-1} significantly increased cowpea plant height, first node height, leaf area and leaf number/plant, nodulation, plant dry matter accumulation.

3.3 Vegetative Growth Responses to Indole-3-Butyric Acid (IBA)

IBA treatment comes next to GA_3 treatment in potency particularly that of pea plants treated with $100mgl^{-1}$ IBA it showed superiority over control in term of plant height (12.7%), stem dry matter percentage (5.2%) and leaf area (5.3%). In addition to that, IBA treatment exceeded micronutrient treatment in term of plant height (5.4%) and leaf area (9.8%). Amin et al. (2007) found that foliar application of indole-3-butyric acid with different concentrations led to significant increases in vegetative growth; plant height, number of leaves per plant, fresh and dry weight per plant, leaf area per plant. Abdel (2007) confirmed that gradual increases in IBA rate were concomitant by gradual improvement in detected traits in faba bean growth. Thus positive correlations were observed in plant height (r=0.16), branch numbers per plant (r=0.60*), leaflet numbers per leaf (r=0.68*), plant fresh weight (r=0.49*), leaf area (r=0.57*), leaf area index (0.72*) and percentage of leaf dry matter (r=0.72*). Moreover, IBA treated plants showed the highest leaf water content after 2 weeks period of drought episode which

was confirmed by the negative correlation that observed in leaf water saturation deficit (r=-0.66*) and leaf water potential (r=0.79*). These results suggested that IBA possesses the ability of reducing the adverse effects of drought through sustaining enough moisture in the plant tissues, cells and even cellular organelles, if would otherwise occurs these organelles will be disintegrated to their initial macro building units. Turner (1986) reported that signal of drought for the shoots would come from root ABA/cytokinin ratio, thus giving the root the role of drought sensor, this mechanism probably added to phytohormone which is build up very rapidly during the establishment of drought stress. There is some evidence that turguor can be maintained even when some symptoms of drought are observed, such as growth reductions (Zang and Daves, 1990). Yield of carrot roots was highly improved by IBA foliar application, particularly at 40mgl^{-1} rate (Abdel, 2011).

3.4 Vegetative Growth Responses to Micronutrient

The third treatment i.e., the foliar spraying of pea plant by 2.5g.l^{-1} micronutrients exceeded the untreated control in leaf number per plant (6.5%), plant height (6.9%) and stems dry matter percentage. Therefore untreated pea was the inferior treatments as it gave the lowest detected trait values. Micronutrient especially iron, boron, copper, magnesium are urgently required for crop productions in Kurdistan owing to the calcareous soils of high pH which embodied in the deficiencies of such element. Iron is the most demanded for improving of vegetable crops. Abdel (1991) showed that foliar spray of micronutrient iron and Boron profoundly improved the growth and marketable yield of Texas Grano onion cultivar. The benefit gained from Fe-EDDHA application could be referred to the role of ferrous in plant metabolism and its deficiency resulted in a weak plant stature. The potency of iron could be due to their role in many metabolic aspects in plant cell. Goodwin and Mercer, (1985) stated that iron prophyrins are prosthetic groups of cytochromes, hemoglobin in root nodules and enzyme such as catalase. Sometimes nitrogen application desperately required iron to cure yellowing owing to the role of iron in chlorophyll synthesis. Thus, Improvements in growth and yield of faba bean that achieved by Fe-EDDHA application were expected. Additionally, iron can substitute Mo as the metal cofactor necessary for the functioning of nitrate reductase the most effective growth enzyme (Prasad and Power, 1997).

3.5 Vegetative Growth Responses to Cultivars

The highest response to varying irrigation levels was observed in local crinkled pea cultivar (Table 1). This cultivar apparently exceeded Canadian pea cultivar in terms of plant height (4.4%), root dry weight (150%) and leaf dry matter percentage (20.9%). Furthermore this cultivar showed superiority over local smooth in term of plant height (5%), root dry weight (108.3%) and leaf dry matter percentage (20.9%). The second cultivar in the significance order was local smooth cultivar. Since this starchy cultivar was preponderance over Canadian in term of leaf number (4.4%). moreover, local smooth cultivar was exceeded to local crinkled pea cultivar in leaf number (3.3%) and leaf area (4.7%).The inferior cultivar was Canadian as it revealed the lowest values in most detected parameters . However, it exceed crinkle cultivars in leaf area (7.2%). Variations in cultivar responses might be referred to the capability of any given cultivar in expression it's inherited with the prevailing ambient condition, the prevailing ambient condition where the mother plants were grown (for instance pollination, temperature, photoperiods water and nutritional availabilities), and techniques had been used in seed productions of these cucumber cultivars (Abdel, 2009).

3.6 Vegetative Growth Responses to Irrigation and Spraying Interaction

Pea plant irrigated whenever 25% of soil AWC was depleted and sprayed with 100mgl^{-1} GA_3 (Table 1) appeared to be the supreme treatment. This dual interaction revealed the highest value in term of leaf number per plant (31.13) and plant height (212.53cm). Moreover, this treatment showed no significant difference with that gave highest values in other detected traits, especially in term root dry weight (0.15g). Abdel (2007a) found that spraying of faba bean plants by GA_3 at rate of 150mg l^{-1} significantly improved growth and yield of green pods; however, it delayed pod maturation as the treated plants produced 46% of their accumulative yield during the first 4 harvests. When a comparison was made with check, this GA_3 rate manifested the highest plant height (140.9 cm), branches number per plant (5.5), leaflet numbers per branch (135), leaflet area (25.3 cm^2),leaf area index (28.3) and plant fresh weight (4 kg m^{-2}).

3.7 Cultivar Vegetative Growth Responses to Irrigation

Local smooth Pea plant irrigated whenever 25% of soil AWC was depleted (Table 1) was best interaction treatment. This interaction revealed the highest value in term of leaf number per plant (28.5) and plant height (165cm). Moreover, this treatment, significant differences were not observed between this treatment and treatments that gave the highest values in root dry weight (0.15g). The obtained results might be attributed to the role of water stress on acceleration leaf senescence of plants subjected to water shortage, because it reduces the water demand cumulated over the whole plant cycle, thereby avoiding water deficit during seed filling, and it allows recycling of scarce resources to the reproductive sinks. However, in crops species, early leaf senescence usually correlates with lower yield because cumulative photosynthesis is reduced (Wolfe et al., 1988). Comparison investigation of pea leaves senescence under varying moisture availabilities revealed that the time course of leaf senescence in pea (*Pisum sativum* L. cv Messire) plants subjected to a mild water deficit to that of monocarpic senescence in leaves of three different ages in well watered plants and to that of plants in which leaf senescence was delayed by flower excision (Pic et al., 2002).

3.8 Cultivar Vegetative Growth Responses to Spraying

Local smooth cultivar sprayed by distilled water (Table 1) appeared to be the most potent interaction treatment. This interaction exhibited the highest value in term of leaf number per plant (31.13), plant height (212.53cm) and root dry weight (0.15g).

3.9 Cultivar Vegetative Growth Responses to Irrigation and Spraying Interaction

Canadian cultivar Pea irrigated whenever 25% of soil AWC was depleted and sprayed with 100mgl^{-1}GA_3 (Table 1) appeared to be the paramount triple interaction treatment. This interaction showed the highest value in term of leaf number per plant (32.2) and plant height (216cm).

Table 1. The influence of irrigation levels, GA_3, IBA and micronutrients on vegetative growth of Canadian, local smooth and local crinkle pea cultivars

Detected traits		LN	Ph	R Dwt	LDM%	SDM%	LA
Irrigation levels	25%	26.33a	141.15a	0.16a	18.06c	17.09c	6.5c
	50%	22.02b	115.68a	0.16a	22.10b	30.66b	9.36b
	75%	19.73c	91.83c	0.15a	36.27a	59.74a	10.65a
	Cont.	20.82c	88.51d	0.16a	26.36a	34.63b	8.76b
Sprayed Treatment	GA_3	26.33a	182.07a	0.14a	24.18b	36.49a	8.97ab
	IBA	21.44bc	99.71b	0.17a	24.1ab	36.44a	9.22a
	Micro	22.18b	94.60c	0.16a	26.36a	35.77a	8.40c
Canadian (Ca)		22.28b	114.77b	0.10b	23.81b	34.95a	9.11a
Local smooth (Ls)		23.27a	114.10b	0.12b	23.81b	36.16a	8.90a
Local crinkle (Lc)		22.53b	119.80a	0.25a	28.79a	36.39a	8.50b
25% AWC depletion	Cont	24.2d	105.93f	0.17ac	17.95de	17.57ef	6.4e
	GA3	31.13a	212.53a	0.15ac	16.51e	18.64e	7.05d
	IBA	24.4cd	127.93d	0.17ac	18.27de	15.46f	6.81de
	Micro	25.6c	118.2e	0.16ac	19.5ce	16.71ef	5.762f
50% AWC depletion	Cont	19.33gf	88.07i	0.21a	24.18b	28.31d	9.178c
	GA3	27b	181.67b	0.10bc	20.12cd	31.46c	9.493c
	IBA	20.6ef	99.67g	0.12ac	22.13bc	30.94cd	9.49c
	Micro	821.13e	93.33h	0.19ab	21.97bc	31.91c	9.293c
75% AWC depletion	Cont	18.933g	71.53j	0.10c	36.96a	58.01b	10.71b
	GA3	20.87e	I52.c	0.17ac	35.9a	59.37b	10.38b
	IBA	19.33g	71.53j	0.20a	34.59a	62.9a	11.35a
	Micro	19.8gf	72.27j	0.12ac	37.62a	58.69b	10.14b
25% AWC depletion	CA	26.2b	133.45b	0.16 ab	17.05d	19.14d	6.44d
	LS	28.5 a	165.a	0.15 ab	17.55cd	16.57d	7.44c
	LC	24.75 c	125.c	0.19 ab	19.58bd	15.56d	5.64e
50% AWC	CA	21.70 e	113.25d	0.17 ab	22.85b	26.18c	9.54b
	LS	23.10 d	134.1b	0.11 ab	21.03bc	32.51b	9.19b

depletion		LC	21.25 e	99.7f	0.19 a	22.41b	33.29b	9.36b
		CA	19.40 f	96.40f	0.09 b	36.67a	60.64a	10.74a
75% AWC		LS	19.30 f	106.65e	0.18 ab	35.35a	59.13a	10.87a
depletion		LC	20.5ef	72.45g	0.16 ab	36.78a	59.46a	10.33a
		CA	24.20c	105.93f	0.17a	17.95cd	17.57c	6.4ef
Untreated		LS	31.13a	212.53a	0.15a	16.51d	18.64c	7.05e
Control		LC	44.4c	127.93d	0.17a	18.27cd	15.46c	6.81e
		CA	25.6bc	118.2e	0.16a	19.5cd	16.71c	5.76f
100 mgl^{-1}		LS	19.33de	88.07h	0.2a	24.18b	28.31b	9.18d
GA_3		LC	27b	181.67b	0.11a	20.12bd	31.46b	9.49c
		CA	20.6de	99.67fg	0.12a	22.13bc	30.94b	9.49d
100 mgl^{-1}		LS	21.13d	93.33gh	0.19a	21.97bc	31.93b	9.29d
IBA		LC	18.93e	71.53i	0.10a	36.96a	58.01a	10.71ab
2.5 $g.l^{-1}$		CA	20.86d	151c	0.17a	35.9a	59.38a	10.38b
Micronutrient		LS	19.33de	71.53i	0.2a	34.59a	62.90a	11.35a
		LC	19.80de	72.27i	0.12a	37.61a	58.69a	10.14bc
		CA	24ej	97ij	0.11di	17.73lo	15.29mo	7.67i
	Cont	LS	23.8ej	100.8i	0.24be	17.27lo	21.42ik	5.83lm
		LC	24.8eh	120fh	0.16ci	18.84jo	16lo	5.69lm
		CA	32.2a	216a	0.12di	14.33o	23.87hj	6.57jl
	GA_3	LS	30.2ac	216.6a	0.1di	15.2no	15.19mo	6.99ik
		LC	31ab	205b	0.24bf	19.99in	16.85lo	7.59ij
		CA	25.6df	115h	0.09di	16.86mo	11.49o	7.25ik
25%	IBA	LS	25.4df	123.4f	0.17ci	18.14ko	22.77ik	7.91hi
AWC		LC	22.2hm	145.4e	0.25bd	19.81io	12.13o	5.26m
		CA	25.2dg	116.2gh	0.11di	19.22io	17.92kn	5.18m
	Micro	LS	26.2de	116.8gh	0.07hi	18lo	12.67no	6.46kl
		LC	25.4df	121.6fg	0.3ac	21.28hm	19.54jm	5.64lm
	Cont	CA	19.8mn	82.4m	0.1di	23.95hj	26.42hi	9.32eg
		LS	20.4lm	87.8l	0.1di	21.95hm	25.55hi	9.45eg

		LC	17.8no	94jk	0.41a	26.63fh	32.98fg	8.76gh
		CA	28.8bc	188.8c	0.07hi	18.87jo	19.79jm	10.61bo
50% AWC	GA_3	LS	27.8cd	190c	0.08fi	18.89jo	33.65fg	9.02fg
		LC	24.4ei	166.2d	0.18ci	22.59hl	40.94e	8.85fh
		CA	20.6km	90.8kl	0.09di	20.4in	29.28gh	9.58dg
	IBA	LS	19.6mn	89.4kl	0.08gi	22.24hm	26.16hi	9.32eg
		LC	21.6jm	118.8fh	0.2ci	23.75hk	37.39ef	9.57dg
		CA	22.2hm	88L	0.09di	22.05hm	29.57gh	9.22fg
	Micro	LS	20.6km	92jl	0.1di	22.02hm	32.13fg	9.41eg
		LC	20.6km	100i	0.38ab	21.84hm	34.07fg	9.25fg
		CA	16.4o	66.8p	0.05i	31.25df	59.84bc	10.83bc
	Cont	LS	20.8km	68.8Op	0.07gi	34.61d	49.97d	10.87bc
		LC	19.6mn	79mn	0.19ci	45.02ab	64.22ab	10.43be
		CA	20.8km	171d	0.08ei	35.8cd	68.55a	10.81bc
	GA_3	LS	21.8im	144e	0.22bh	24.79gi	57.73c	9.44eg
		LC	20lm	141e	0.3i	47.11a	51.84d	10.88bl
		CA	16O	71.2Op	0.22bh	29.31eg	58.85bc	11.04bl
75% AWC	IBA	LS	19.4mn	70.4Op	0.07gi	40.19bc	68.08a	12.12a
		LC	22.6gl	73O	0.3ac	34.27de	61.78bc	10.89bc
		CA	15.8O	74no	0.05i	35.94cd	58.51c	11.29ab
	Micro	LS	23.2fk	69.2Op	0.07hi	32.53de	68.63a	9.96cf
		LC	20.4lm	73.6n0	0.23bg	44.38ab	48.93d	9.17fg

*Note: LN=Leaf number per plant, Ph =Plant height, RDwt=root dry weight, LDM %=leaf dry matter percentage and LA=leaf area; **Means of unshared letters are signification 0.05 level according to Duncan's Multiple Range test, ad=abcd.*

3.10 Pod Component Responses to Irrigation

The obtained results (Table 2) revealed that irrigating pea plants whenever (25%) soil available water capacity was depleted appeared to be the most effective irrigation treatment. It profoundly exceeded that of (75%) levels in term of flower number (23%), pod number (23.6%), pod fresh weight (100%) and seed number per pod (35%). Moreover, this irrigation level was also overwhelming that of 50% level in term of individual pod fresh weight (43.5%) and seed number per pod (29.5%). However, it gave (72.1%) higher aborted seeds per pod, as compared to 50% level. Irrigating pea plant whenever 50% soil AWC was depleted occupied the second order after 25% level. This treatment showed superiority over that of 25% level in terms of pod number (19.3%) and pod dry weight (67.4%). However, it manifested 80% aborted ovule higher than that of 25% Furthermore, 50% level exceeded that of 75% in flower number per plant (30%), pod number per plant (18%), pod dry weight (24.2%) and pod fresh weight (16.6%). However, it showed higher aborted ovules by 35%, as compared to 75% level. These results suggested that irrigating pea plant whenever (75%) of soil AWC was depleted was the feeblest treatment, as it exhibited the lowest values in most detected parameters. The duration of pod swelling and seed filling is crucial where plants should not be subjected to drought (Al-Hamadany, 2005; Abdel, 1982). Previous studies revealed that pods should not be harvested until complete seed maturity is ensured in cowpea (Abdel and Al-Salem, 2010) and in faba bean (Abdel and Al-Hamadany, 2007), if which otherwise yield is drastically reduced besides bad seed quality. Pea plant adaptation was recorded by Wery et al. (1993) they stated that pea plant is able to shorten its flowering period according to the amount of water available. Gregory (1988) also found significant correlations between evapotranspiration and flowering duration in accumulative (degree. day). For an improvement in seed yield and nitrogen fixation, increased water uptake is more interesting if it occurs during flowering and seed filling. A drought episode was coincided during the pod development and seed filling physiological stage which is the most drought sensitive stage (Abdel, 2007). During this drought episode soil moisture depletion reached its maximum that profoundly affected yield and yield quality.

3.11 Pod Component Responses to Micronutrient

The obtained results (Table 2) manifested that foliar spray of micronutrient 2.5g.l^{-1} on pea plants was the most potent treatment, since it substantially exceeded that of 100 mgl^{-1} IBA treatment in terms of pod number (12.3%), pod dry weight (57.7%) and pod fresh weight (11.1%). it also exceeded that of 100 mgl^{-1} GA_3 in term of pod fresh weight (88.1%) and seed number per pod (586.8%). Vegetable yield reductions in Kurdistan were mainly due to micronutrient deficiencies in particular iron which confined to high pH soils. Prasad and Power (1997) reported that iron is an immobile nutrient, its deficiency distinctly seen on young leaves of plant grown in neutral and alkaline soils. This is the perfect description for Iraqi soils. They recommended the use of Fe-EDDHA salts on alkali soils to overcome the problem, and on long day plants to sustain vegetative growth and boosting earlier flower initiation in short days (Kinet et al., 1985). Vegetable crops are very sensitive to low iron availability, in addition to that drought imposes additional adverse effects combined with those of iron deficiency (Kozolowski, 1980).Therefore, Fe -EDDHA foliar sprays substantially improved faba bean yield components grown under inadequate rainfall (Abdel, 2006a). Since, yield components were linearly responded to Fe-EDTA rates in terms of pod length (r=0.082), seeds per pod (r=0.12), pod dry weight (r=0.17), weight of 100 seeds (r=0.12) and yield of dry seeds (r=0.19). Furthermore, drought enhancement was reinforced by the negative correlations obtained in aborted ovules per pod (r=-0.28) and aborted seeds per pod (r=-0.28). Iron may intermingled with many metabolic aspects related to cellular membrane as it

has been mentioned by Varanini et al. (1993) they found that soluble complexes between iron and humic acid molecules might conceivably contribute to iron nutrition by acting as natural substances for inducible Fe (III) chelae reductase. Additionally, they could enhance the activity of other membrane associated enzymes, namely H^+ ATPase involved in the rhizosphere acidification.

3.12 Pod Component Responses to IBA

The next treatment in potency seems to be that of untreated pea plants, as it showed superiority on IBA treatment in term of pod number (14%), pod dry weight (53.8%) and pod fresh weight (14.8%). Cauliflower sprayed with 40mgl^{-1} IBA strikingly increased the accumulation of assimilates in curds as compared to check which embodied in yield increases (Abdel, 2009a). Interpretation of these results might be inferred from the role of IBA on cell division which is the base of leaf generation at the apices of the plant. The analysis of leaf cells in tobacco lines over expressing auxin binding protein (ABP1) indicate the presence of twice as many nuclei in G2 phase compared to the wild type, suggesting an involvement in cell cycle regulation. Moreover, a tobacco BY-2 cell line generated that expressed an antibody ABP1. This antibody bonded ABP1 block its activity in vivo. Cells from this line arrested at G1, further indicating that ABP1 might function in cell cycle checkpoint regulation (Ringo, 2006).

3.13 Pod Component Responses to GA_3

The third treatment in the sequence order was the foliar spraying of pea plant with 100mgl^{-1} GA_3 (Table 2). It substantially exceeded that of untreated pea in term of individual pod dry weight per plant (20%) and aborted ovule number per pod (40%). And also this treatment exceeded that of 100mgl^{-1} IBA and micronutrient 2.5g.l^{-1}, respectively, in term of individual pod dry weight per plant (84.6%) and (17.1%). In addition to that control treatment exceeded that100mgl^{-1} GA_3 treatment in term of individual pod fresh weight (94.4%) and seed number per pod (571.1%). Untreated pea revealed superiority over GA_3-treated pea owing to the reductions in yield components that caused by GA_3 foliar sprays. These results were special case and can be interpreted on the following basis: a. GA_3 was applied at the commencements of flowering where pea plants were grown in green house of higher temperature and thus GA_3 rate was sustained in plant tissues during the flower generation which resulted in parthenocarpy setting, ovule and seed abortion because there was not enough time for GA_3 oxidation and conjugation in plant tissues. However, if GA_3 was applied in the field results might highly differ where, GA_3 can be gradually vanished during the longer duration where shoots and flower generation were synchronized. b. Cooler field environments accompanied with short day shift the hormonal balance for the favour of growth inhibitors (Abdel, 2009a). Spraying determinate black cumin (*Nigella sativa* L.) with GA_3 especially, 360mgl^{-1} boosting parthenocarpy which reflected in high number of seedless capsules (Adnan Salih and Abdel (1994). Additionally, Emongor (2002) found that GA treatments had no significant effect on seed yield of bean plants and significantly reduced 1000 seed weight, seed yield, seed number/ pod and number of pods/plant of common beans (*Phaseolus vulgaris*). The role of GA_3 in the development of parthenocarpy fruits in pea plants was confirmed by Bonde (2008). He found that gibberellic acid caused the formation of seedless pods.

3.14 Pod Component Responses to Cultivars

Local crinkled pea cultivar manifested the highest responses to different irrigation levels and varying spraying treatments (Table 2). This cultivar apparently exceeded Canadian cultivar in terms of flower number (10.1%), pod number (9.2%) and individual pod fresh weight (11.9%). Furthermore, this cultivar showed superiority over local smooth in term of flower number (18%) and pod number (13.5%). The second cultivar in the significance order was local smooth, since this starchy cultivar was preponderance over Canadian in term of pod fresh weight (9.9%). However, local smooth cultivar exceeded that of local crinkled pea cultivar in term of aborted seed number (110.3%). The feeblest cultivar was Canadian as it revealed the lowest values in most detected parameters. Cultivar discrepancies were recorded by several workers and they referred them to genome expression and cultural practices. Differences within the same cultivar namely Ramshorn produced by three different seed production companies were found in their performance under the same field (Abdel and Al-Salem, 2010). They attributed the intra cultivar variation to the techniques that had been adopted by the producing companies. In our results the superiority of both local cultivars, particularly, Local crinkle over Canadian might be due to the adaptation of the former cultivars to prevailing conditions of Kurdistan.

3.15 Pod Component Responses to Watering and Spraying Interaction

Pea plant irrigated whenever 25% of soil AWC was depleted and sprayed with 2.5 $gm.l^{-1}$ micronutrient (Table 2) was overwhelmed other dual interaction treatments. This interaction displayed the highest value in terms of flower number per plant (7.07) and individual pod fresh weight per plant (4.38g). Moreover, this treatment showed no significant difference with that gave the highest pod number per plant (4.87) and seed number per pod (4.2). These results suggested that moisture availabilities are dominated the pea plant responses to micronutrients where higher response was revealed providing the presence of higher moisture. Similar results were reported by Abdel and Rahi (1992). They found that copper sulphate can only improve onion yield under adequate irrigation and moderate drought, however, under severe drought copper sulphate lost its benefits. The adverse role of drought was attributed to reactive oxygen species generation which resulted in cell organelles destructions. Drought stress invariably leads to oxidative stress in the plant cell due to higher leakage of electrons towards O_2 during photosynthetic and respiratory processes leading to enhancement in Reactive Oxygen Species (ROS) generation (Asada, 1999). Tohidi-Moghadam et al. (2009) suggested that drought stress leads to production of oxygen radicals, which results in increased lipid peroxidation and oxidative stress in the plant. In conclusion of present study, Application of super absorbent polymer could reserve different amounts of water in itself and also increases the soil ability of water storing and preserving and at last in water deficiency, produce plant water need and approve its growth under post anthesis water deficiency.

3.16 Cultivars Pod Component Responses to Irrigation

Local crinkled cultivar Pea plant irrigated whenever 25% of soil AWC was depleted (Table 2) dominated other interaction treatments. This dual interaction manifested the highest value in terms of individual pod fresh weight per plan (4.05), seed number per pod (4.25). Moreover, this treatment showed no apparent difference with that gave the highest flower number per plant (6.9). Deduction obtained from these results was that exiguous competitions were emerged among cultivars under adequate watering and the competitions were gradually

increased with increasingly water depletions until plants were severely water stressed the competitions were completely vanished. These results were confirmed by Al-Hamadany (2005) and Al-Juboori (2005).

3.17 Cultivars Pod Component Responses to Spraying

Canadian cultivars spraying with 100mgl^{-1} GA_3 (Table 2) preponderated other interaction treatments. This interaction displayed the highest value in term of individual pod fresh weight per plan (4.38g), moreover, significant differences were not observed between this treatment and other treatments that gave the highest flower number per plant (7.06), pod number (4.86) and seed number per pod (4.2). GA_3 roles in plant developments are almost negated under severe water stress where plant creating new gene set expression to provide self defense system in order to sustain cell organelle integrities. The beneficial duration is located after irrigation and/or rainfall to the point of water depletion where drought started to be effective in disrupting cell metabolism (Drought Breaking Point). Subsequently, Mukhtar and Singh (2006) reported that GA_3 stimulated an increase in growth, flowering, pod maturity and grain yield of cowpea. Emongor (2007) reported that exogenous application of GA_3, 7 days after emergence at 30, 60 or 90 mgl^{-1} significantly increased cowpea plant height, first node height, leaf area and leaf number/plant, nodulation, plant dry matter accumulation, pod length, pod number/plant, seed number/pod, 100 seed weight, harvest index and seed yield ha^{-1}.

3.18 Cultivars Pod Component Responses to Watering and Micronutrient Interaction

Local Crinkled cultivar irrigated whenever 25% of soil AWC was depleted and sprayed with 2.5 gml^{-1} micronutrient (Table 2) appeared to be the supreme treatment. This triple interaction revealed the highest value in term of individual pod fresh weight per plant (5.2g), moreover, this treatment showed no significant difference with that gave the highest of pod number per plant (5.6) and seed number per pod (3.8). These results suggested that the best pea growing environment can be provided by the combination of adequate watering and micronutrient, particularly with Canadian cultivar and thus we can inferred the poor resistance of this cultivar. Since, it cannot express its potential unless suitable environments were overwhelmed, owing to its poor adaptability to Kurdistan region where, micronutrient are essential elements for plant growth and development in this province, since these elements perform many physiological function, including structural, enzymatic regulatory and ionic .They are required by the plants at low concentration less than 100mg/kg(100mg/ml). Boron, iron, zinc and molybdenum are essential Micronutrients (Jones, 1998).

Adequate Molybdenum is reported in Iraqi soils. However, under drought its availability is profoundly reduced and plants suffer obvious deficiency (Abdel, 2006a). Molybdenum is required for growth of most biological organisms including plants and animals. Molybdenum toxicity in plants under most agricultural conditions is rare. In tomato and cauliflower, plants grown on high concentrations of molybdenum will have leaves that accumulate anthocyanin and turn purple, whereas, in legumes, leaves have been shown to turn yellow (Bergman, 1992; Gupta, 1997).

Table 2. Influence of irrigation levels, GA3, IBA and micronutrient on pod component responses of Canadian, local smooth and local crinkle pea cultivars**

Detected traits		Fn	Pn	PDwt	PFwt	Aon/p	Sn/p	Asn/p
	25%	6.48a	4.30b	0.89c	3.56a	1.35c	3.47a	1.17a
Irrigation levels	50%	6.85a	5.13a	1.49a	2.48b	2.43a	2.68b	0.68b
	75%	5.27b	3.48c	1.20b	1.78c	1.8b	2.57b	0.93ab
	Cont.	6.38a	4.56a	1.20b	3.11a	1.6b	3.56a	0.87a
	GA_3	6.11a	4.18ab	1.44a	1.6c	2.24a	0.53b	0.82a
Sprayed Treatment	IBA	5.96a	4.b	0.78c	2.71b	1.87a	3.89a	0.96a
	Micro	6.34a	4.49a	1.23b	3.01a	1.73ab	3.64a	1.07a
Canadian (Ca)		6.13b	4.23b	1.19a	2.43b	1.77a	2.77a	0.98ab
Local smooth (Ls)		5.72b	4.07b	1.18a	2.67a	1.82a	3a	1.22a
Local crinkle (Lc)		6.75a	4.62a	1.21a	2.72a	2a	2.95a	0.58b
	Cont	6.8ab	4.4be	1.05e	4.25a	0.67d	4.8a	0.93ab
25% AWC depletion	GA3	6.33ad	4.27cd	0.48g	2.31de	2 b	1.13e	1ab
	IBA	5.77cf	3.66de	0.76f	3.32b	1.8 bc	3.73bc	1.33ab
	Micro	7.07a	4.87ac	1.25ce	4.38a	0.93cd	4.2ab	1.4a
	Cont	6.47ad	3.13ab	1.88a	3.01bc	2.47ab	3.4bc	0.47b
50% AWC depletion	GA3	7.2a	5.2ab	1.14ed	1.49f	3.07a	0.00f	0.87ab
	IBA	6.67ac	4.67bc	1.46bc	2.75cd	2.67ab	3.93bc	0.6ab
	Micro	7.06a	5.53a	1.49b	2.66cd	1.93b	3.4bc	0.8ab
	Cont	5.87be	4.13cd	1.37bc	2.08e	1.67bc	2.47d	1.2ab
75% AWC depletion	GA3	4.8f	3.07e	0.71f	1.01g	1.67bc	0.47f	0.6ab
	IBA	5.47df	6.67de	1.45bc	2.06e	1.53bd	4bc	0.93ab
	Micro	4.93ef	3.07e	1.28bd	1.98e	2.33ab	3.33c	1ab
	CA	6.35ad	4.05bd	0.94e	3.64a	1.15c	3.6ab	1a
25% AWC depletion	LS	6.05cf	4.15bc	0.63f	3b	1.75bc	2.55c	1.3a
	LC	6.9ac	4.7b	1.09de	4.05a	1.15c	4.25a	1.2a
	CA	7.15ab	5.45a	1.61a	2.58bc	2.60ab	2.55c	0.55a
50% AWC	LS	5.55df	4.3bc	1.36bc	2.17cd	2.9a	1.7d	0.8a

depletion		LC	7.35a	5.65a	1.51ab	2.69b	1.80bc	3.80ab	0.7a
		CA	5.55df	3.85d	1.22cd	1.81de	1.5c	2.2cd	1.05a
75% AWC		LS	5.05 f	3.3d	1.13de	1.59e	1.45c	2.15cd	0.7a
depletion		LC	5.20ef	3.3d	1.26cd	1.95de	2.45ab	3.35b	1.05a
		CA	6.8ac	4.4bd	1.05d	4.25a	0.67d	4.8a	0.93a
Untreated		LS	6.33ad	4.26bd	0.48f	2.31de	2bc	1.13d	1a
Control		LC	5.73ce	3.66de	0.76e	3.32b	1.8bc	3.73d	1.33a
		CA	7.06ab	4.86ac	1.25cd	4.38a	0.93cd	4.2ab	1.4a
100 mgl^{-1}		LS	6.46ad	5.13ab	1.88a	3.01bc	2.47ab	3.4bc	0.47a
GA_3		LC	7.20a	5.2ab	1.14cd	1.49fg	3.07a	0.00E	0.87a
		CA	6.66ad	4.66ac	1.46d	2.75cd	2.27ab	3.93ab	0.6a
100 mgl^{-1}		LS	7.06ab	5.53a	1.49b	2.66cd	1.93bc	3.4bc	0.8a
IBA		LC	5.86be	4.13cd	1.37bc	2.08e	1.67bd	2.47c	1.2a
2.5 $g.l^{-1}$		CA	4.8e	3.06e	0.71ef	1.01g	1.67bd	0.47de	0.6a
Micronutrient		LS	5.46de	3.66de	1.45b	2.06e	1.53bd	4ab	0.93a
		LC	4.93e	3.06e	1.28bd	1.98ef	2.33ab	3.33bc	1.00a
		CA	5.2fi	4.2dh	0.88hl	4.56ab	0.2gh	5a	2.2ab
	Cont	LS	5.4fi	3.2hj	0.79km	3.28cd	1.8ah	4.8ab	0.4ce
		LC	9.8a	5.8ac	1.5be	4.9ab	0.0h	4.6ab	0.2de
		CA	5fi	3hj	0.59lm	1.82jm	2.6ad	0.0h	1.2be
	GA_3	LS	6.4ci	4.2dh	0.4bm	3.01df	1ch	3.4bf	1.2be
		LC	7.6be	5.6ad	0.42m	2.1fk	2.4ae	0.0h	0.6be
		CA	6di	3.6gj	4.86il	2.81di	2.2af	3cf	0.4ce
25%	IBA	LS	4.gi	3.2hj	0.81jm	4.09bc	1.4bh	3.8ad	3a
AWC		LC	6.4ci	4.2dh	0.62lm	3.07de	1.8ah	4.4ac	0.6be
		CA	6.8cg	4.4ch	1.4cg	3.47cd	1.2bh	4ad	2.2ab
	Micro	LS	6.8cg	4.6bh	1.07fk	4.46ab	1ch	4.8ab	1.2be
		LC	7.6be	5.6ad	1.29dg	5.2a	0.6eh	3.8ad	0.8be
	Cont	CA	6.6ch	4.2dh	1.41cg	2.62dj	2.8ac	3.4bf	0.2de
		LS	6.2ci	5.4ae	1.86b	2.93dg	2.6ad	3.4bf	0.6be

		LC	6.6ch	5.8ac	2.37a	3.48cd	2ag	3.4bf	0.6be
		CA	9.2ab	6.4a	0.81jm	1.3kn	3ab	0.0h	0.8be
50%	GA_3	LS	5.6ei	4.4ch	1.6be	1.38kn	2.6ad	0.0h	1.8ad
AWC		LC	6.8cg	4.8bg	1gl	1.81jm	3.6a	0.0h	0.0e
		CA	6.2ci	3.8fi	1.56be	2.57dj	2.8ac	4ad	0.4ce
	IBA	LS	5.6ei	4.2dh	1.28dh	2.9dh	2.6ad	2.8dg	1de
		LC	8.2ac	6ab	1.56be	2.77di	1.4bh	5a	0.4ce
		CA	7cf	5.6ad	1.75bc	2.73dj	2.2af	2.6dg	0.4ce
	Micro	LS	6.2ci	5.6ad	1.25di	2.56dj	1.8ah	3.6ae	1.2be
		LC	8bd	5.4ae	1.48bf	2.69dj	1.8ah	4ad	0.8be
		CA	7cf	5.2af	1.44cf	2.1fk	0.8dh	2.6dg	1.2be
	Cont	LS	5.6ei	3.8fi	1.42cg	2.16ek	2.6ad	2fg	1.2be
		LC	5fi	3.4gj	1.27dh	1.97ik	1.6bh	2.8dg	1.2be
		CA	4.6hi	3hj	0.76km	1.01mn	1ch	1.4gh	0.6be
	GA_3	LS	5.4fi	3.6gj	0.77km	1.12ln	0.4fh	0.0h	1.2be
		LC	4.4i	2.6ij	0.59lm	0.89n	3.6a	0.0h	0.0e
		CA	5.6ei	4ei	1.5be	2.18ek	0.4fh	5a	0.2de
75% AWC	IBA	LS	4.8gi	3.hj	1.65bd	2.15ek	1.4bh	3.6ae	1.4be
		LC	6di	4ei	1.2ej	1.85jm	2.8ac	3.4bf	1.2be
		CA	4.4i	3.4gj	1.34cg	2.03gk	2ag	2.2eg	2ac
	Micro	LS	5.8ei	3.6gj	1.23di	1.99hl	2.6ad	3.8ad	0.4ce
		LC	4.6hi	2.2j	1.27dh	1.92il	2.4ae	4ad	0.6be

*Fn= flower number per plant; pn=pod number per plant; PDwt= individual pod dry weigh (g); PFwt=individual pod fresh weight (g); Aon= aborted ovule number per pod; Sn/p=seed number per pod; Asn/p= aborted seeds per pod; ** Means of unshared letters are signification at 0.05 level according to Duncan's Multiple Range test, ad=abcd.*

3.19 Yield Component Response to Irrigation

The obtained results (Table 3) revealed that irrigating pea plants whenever (25%) soil available water capacity was depleted appeared to be the paramount irrigation treatments. It substantially exceeded that of (50%) levels in weight of 100 seeds (30.9%), seed fresh weight (25.2%), yield of green pods (18.8%) and pod envelope fresh weight (53%). Moreover, this treatment also exceeded that of (75%) level in terms of weight of 100 seeds (67.7%), seed fresh weight (56.5%), yield of green pods (171.1%) and pod envelope fresh weight (141.2%). Irrigating pea plants whenever (50 %) of soil AWC was depleted came next to (25 %) level come next in the sequence order. It significantly exceeded that of (75 %) level in terms of weight of 100 seeds (28%), seed dry weight (16.9%), seed fresh weight (25%), total pod dry weight (12.8%), yield of green pods (128.2%), pod envelope dry weight (27.3%) and pod envelope fresh weight (57.6%). In addition to that 50% irrigation level also exhibited superiority on 25% level in terms of seed dry weight (61.7%), total pod dry weight (31.6%) and pod envelope dry weight (66.7%). Therefore, irrigating pea plant whenever (75%) of soil AWC was depleted manifested the lowest values in most detected parameters. However, this level exceed that of (25%) level in terms of seed dry weight (38.3%), total pod dry weight (16.6%) and pod envelope dry weight (31%). Bulb length, bulb diameter and yield were significantly increased under adequate irrigation, as compared to onions grown under rainfall incidence in Erbil (Abdel, 1990). Reduction in yield components might be attributed to the role of drought on photosynthesis (Todd and Webster, 1965).

3.20 Yield Component Response to Micronutrient

The obtained results (Table 3) manifested that foliar spray of micronutrient 2.5gl^{-1} on pea plants was the most potent treatment, since it substantially exceeded that of 100 mgl^{-1} IBA treatment in terms of weight of 100 seeds (3.5%), seed dry weight (10.5%), yield of green pod (29%), and pod envelope fresh weight of pod (23.1%). Moreover this treatment showed superiority over 100mgl^{-1} GA_3 treatment in weight of 100 seeds (12.7%), seed fresh weight (1033.3%), total dry weight of pods (78.7%), and yield of green pods (104.8%). This treatment also exceeded that of untreated in yield of green pods (5.4%) and pod envelope fresh weight of pod (18.5%). The preponderance of micronutrient application over GA_3 and/or IBA in this investigation might be referred to the overwhelming sand content of soil mixture where pea plant grown, since sand lack the ability of adsorbing ions which might be leached out. Therefore, results would be varied than that of field. Most soils contain adequate total iron amounts that are available to plants. However, it might be inadequate dependent on various soil factors. Especially on calcareous soils, high pH and $CaCO_3$ content, ion imbalance and poor physical properties such as very high or low soil temperature, high humidity, poor soil aeration, and compaction can induce iron deficiency (Lucena, 2000). Mishra et al. (2003) found that application of iron significantly increased the yield components. Al-Hamadany and Abdel (2008) manifested that combination mixture of 20gm^{-2} + 10mgl^{-1} + 50mgl^{-1} GA_3 was the most effective treatment. It gave the highest values in term of plant height (47.35 cm), leaf numbers per plant (10.15), leaf fresh weight per plant (98.2g) and marketable yield (8.1$kg.m^{-2}$). Moreover, it substantially reduced the numbers of plants that failed to perform acceptable storage root. However, this treatment profoundly reduced swollen root numbers per m^2 and root fresh weight per m^2. Treatment of fertilizing radish plots by 20 $g.m^{-2}$ came next in the sequence of significance, as it displayed the highest value of leaf biomass productions (5.22 $kg.m^{-2}$), dry matter accumulation in leaves per plant (17.88 g), root fresh weigh per m^2 (4.41 $kg.m^{-2}$) and numbers of storage roots per m^2 (37.25). Untreated check was worst treatment. It manifested the lowest marketable yield

($5.21kg.m^{-2}$), leaves fresh weight per m^2 ($1.59kg.m^{-2}$). These results suggested that this mixture was more likely to be infavour of growth not for root swellings.

3.21 Yield Components Response to IBA

Pea plants treated by $100mgl^{-1}$ IBA followed micronutrient treatment in significance, where the former treatment exceeded that of 100 mgl^{-1} GA_3 in terms of weight of 100 seeds (8.9%), seed dry weights (3700%), seed fresh weights (1108.3%), yield of green pod (58.7%) and total pod dry weights (55.7%). IBA-treated onions showed yield increases by 11.2% in relation to untreated control (Abdel, 1995). Epstein et al. (1993) it has shown that IBAsp is even more active than free IBA in the promotion of adventitious roots in mungbeans. Riov and Yang (1998) found in *Vigna radiata* that induction of adventitious roots was observed after IBA, but not IAA application.

3.22 Yield Component Response to GA_3

Distilled water treated pea was categorized the third in the importance (Table 3). This treatment significantly exceeded that of $100GA_3$ treatment in 100 seed weights (11.7%), seed dry weights (4450%), seed fresh weights (1358.3%), total pod dry weights (80.4%) and yield of green pods (94.3%). Moreover, this treatment exceeded that of micronutrient in seed dry weight (8.3%) and seed fresh weights (28.3%); and also exceeded that of IBA treatment in weight of 100 seeds (2.6%), seed dry weights (19.7%), seed fresh weights (20.7%) and total dry weight of pods (21.3%). Subsequently, the feeblest treatment was $100mgl^{-1}$ GA_3, since this treatment revealed the worse results in most investigated characteristics. However, this treatment surpassed that of distilled water, IBA and micronutrients in term of pod envelope dry weight of pods by (50%), (69.6%) and (56%), respectively. These results were in accordance with that reported by Williams and de Mallorca (1984) they showed that GA_3 reduced 100 seed weight and seed yield of common beans (*Phaseolus vulgaris*). El-Shraiy and Hegazi (2009) stated that the application of GA_3 treatment at 50 and $100mgl^{-1}$ showed a significant reduction in yield parameters and increased plant height. Emongor (2002) mentioned that GA treatments had no significant effect on seed yield of bean plants and significantly reduced 1000 seed weight, seed yield, seed number/ pod and number of pods/plant of common beans (*Phaseolus vulgaris*).

3.23 Yield Component Response to Cultivars

The obtained results (Table 3) exhibited that Local crinkle pea was the supreme among other cultivar in its response to irrigation and spraying treatments. This cultivar hugely exceeded Canadian pea Local smooth pea cultivars in yield of green pods (50.9% and 33.8% respectively). Local smooth come next to crinkle, since it highly exceeded Canadian cultivar in weight of 100 seeds (11.2%), seed fresh weight (19%) and yield of green pod (12.8%), besides its superiority over crinkle in weight of 100 seeds (29.7%) . Thus, the worst cultivar was Canadian, as it manifested the lowest values in most studied parameters. However, this cultivar was preponderance on Local smooth in seed dry weights (13.6%). and over crinkle in weight of 100 seed (9.6%). Varying cultivar responses were well established, but in this investigation most differences could be referred to the cultivar adaption capabilities. Thus Local cultivars manifested preponderance on Canadian cultivar.

3.24 Yield Component Response to Irrigation and Spraying Interaction

Pea plant irrigated whenever 25% of soil AWC was depleted and sprayed with 2.5 gm.l^{-1} micronutrient (Table 3) appeared to be the most potent treatment. This dual interaction showed the highest value in term of weight of 100 seeds (27.89g), yield of green pods (18.76g) and pod envelop fresh weight (2.51g). These results might be attributed to the role of water stress on cell expansions. The smaller final size of the mature cells and organs produced under water deficit conditions require smaller quantities of essential solutes (such as sugars) to maintain turgour, at a time when solute availability for growth and respiratory activity may already be limited (Sharp et al., 1990). Pritchard et al. (1991) reported that turgour pressures in expanding cells situated 2 mm from the root tip of wheat *(Triticum aestivum* L.) seedlings recovered more rapidly than root elongation rates during exposure to growth inhibitory concentrations of mannitol at (-0.48 MPa) osmotic pressure.

3.25 Cultivar Yield Component Response to Irrigation

Local crinkled cultivar Pea plant irrigated whenever 25% of soil AWC was depleted (Table 3) dominated other interaction treatments. This dual interaction manifested the highest value in terms of weight of 100 seeds (27.12g), seed fresh weight (1.67g) and yield of green pods (17.53g). Moreover, this treatment showed no significant difference with that gave the highest values in pod envelope fresh weight (2.28g). Resemble results were found by other research workers (Al-Hamadany, 2005 and Al-Juboori, 2005). Under drought conditions, plant tends to recruit the roots on the expanse of aerial. Neumann (1995) found that there was no obvious involvement of cell wall loosening events, however, increases in wall loosening in the tip tissues could facilitate root elongation even when severe water deficits have strongly inhibited cell expansion further behind the tip. This may help explain the fact that root growth is often more resistant to water deficits than shoot growth. Avoiding excessive loss of cell turgour pressure, associated wilting, and subsequent death of developing tissues is clearly a desirable trait for maintaining growth and survival of terrestrial plants exposed to water deficits.

3.26 Cultivar Yield Component Response to Spraying

Canadian cultivars spraying with 100mgl^{-1} GA_3 (Table 3) preponderated other interaction treatments. This interaction displayed the highest value in term of yield of green pods (18.76g). Moreover, this treatment showed no significant difference with that gave the highest values in total pod dry weight (4.31g) and pod envelope fresh weight (2.51g). Hooley (1994) has proposed that the types of responses of plant cells and tissues to GA_3 can be classified in to three categories: cell growth in vegetative tissues, seed reserve mobilization by aleurone cells, and flower and fruit development. Combination of adequate watering and GA_3 was found to give the best performance in growth and thereby yield (Abdel, 2009a).

3.27 Cultivar Yield Component Response to Irrigation and Spraying Interaction

Local crinkled cultivar irrigated whenever 25% of soil AWC was depleted and sprayed with distilled water (Table 3) appeared to be the supreme treatment. This triple interaction revealed the highest value in term of seed fresh weight (2.44g) and yield of green pod (25.71g). Moreover, this treatment showed no significant difference with that gave the highest values in pod envelope fresh weight (2.46g).

Table 4. Response of yield components of pea cultivars to irrigation and spraying of growth regulators and micronutrients

Detected traits		W100S	SDWt	SFwt	TPDwt	TPFwt	PeDwt	PeFwt
Irrigation levels	25%	23.02a	0.47c	1.44a	3.01c	14.53a	0.42c	2.05a
	50%	17.58b	0.76a	1.15b	3.96a	12.23b	0.70a	1.34b
	75%	13.73c	0.65b	0.92c	3.51b	5.36c	0.55b	0.85c
	Cont.	23.31a	0.91a	1.75a	4.15a	12.65b	0.52b	1.35b
Sprayed Treatment	GA_3	20.86c	0.02d	0.12c	2.3c	6.51d	0.78a	1.42ab
	IBA	22.71b	0.76c	1.45b	3.58a	10.33c	0.46b	1.30b
	Micro	23.51a	0.84b	1.36b	4.11a	13.33a	0.5b	1.60a
Canadian (Ca)		18.28b	0.67a	1.05b	3.58a	8.82c	0.51a	1.33a
Local smooth (Ls)		20.33a	0.59b	1.25a	3.59a	9.95b	0.58a	1.40a
Local crinkle (Lc)		15.68c	0.64ab	1.21a	3.3a	13.31a	0.57a	1.51a
25% AWC Depletion	Cont	28.241a	0.64e	2.24a	2.98d	17.56a	0.41de	1.99b
	GA3	8.572g	0.06g	0.37e	1.93e	8.44e	0.39e	1.79cd
	IBA	27.385b	0.41f	1.41c	2.85d	13.34c	0.36e	1.91b
	Micro	27.89a	0.75d	1.74b	4.31b	18.76a	0.49ed	2.51a
50% AWC Depletion	Cont	23.612c	0.22a	1.73b	5.06a	14.06c	0.67bc	1.26de
	GA3	0.00h	0.00g	0.0f	3.01d	7.53ef	1.11a	1.45cd
	IBA	23.03d	0.97b	1.68b	3.59c	11.63d	0.48de	1.18df
	Micro	23.51c	0.946b	1.21cd	4.16bc	15.68b	0.54cd	1.46cd
75% AWC Depletion	Cont	18.064f	0.87bd	1.28cd	4.4b	6.319fg	0.5de	0.79f
	GA3	0.000h	0.000g	0.00f	1.96e	3.56h	0.71b	1F
	IBA	17.703f	0.906bc	1.25cd	3.82bc	6.01g	0.54cd	0.81f
	Micro	19.137e	0.811cd	1.14d	3.84bc	5.54g	0.46de	0.82f
25% AWC Depletion	Ca	21.18b	0.48d	1.68a	2.48d	14.34bc	0.46de	1.9b
	Ls	20.76b	0.28e	0.97cd	2.79cd	11.71d	0.33e	1.97ab
	Lc	27.12a	0.64c	1.67a	2.79b	17.53a	0.46de	2.28ab
50% AWC	Ca	17.71c	0.91ab	1.3b	2.67a	12.44cd	0.69b	1.25cd
	Ls	12.02d	0.48d	0.8de	3.41bc	8.43e	0.87a	1.28c

Depletion		Lc	22.88b	0.96a	1.37b	3.79b	15.82ab	0.54cd	1.48c
		Ca	13.55d	0.65c	0.96cd	3.67b	5.33f	0.56bd	0.85e
75% AWC		Ls	9.26e	0.48d	0.66e	3.11bd	5.37f	0.65bc	0.92e
Depletion		Lc	18.37c	0.81b	1.12bc	3.75b	5.38f	0.44de	0.8e
		Ca	24.41ab	0.84b	1.76b	2.98c	17.56ab	0.41d	1.99b
Untreated		Ls	24.77a	0.81bc	1.53cd	1.93d	8.44e	0.39d	1.79bc
Control		Lc	20.73e	1.08a	1.96a	2.85c	13.34cd	0.35d	1.91b
		Ca	0g	0d	0g	4.31ab	18.76a	0.49cd	2.51a
100 mgl^{-1}		Ls	8.57f	0.06d	0.37f	5.06a	14.07cd	0.66bc	1.26de
GA_3		Lc	0g	0d	0g	3.01c	7.53e	1.11a	1.45cd
		Ca	24.12b	0.84b	1.43cd	3.59b	11.63d	0.48cd	1.18df
100 mgl^{-1}		Ls	23.36c	0.76bc	1.44cd	4.16b	15.69bc	0.54bd	1.46cd
IBA		Lc	20.64e	0.69c	1.46cd	4.4ab	6.32ef	0.50cd	0.79f
2.5 $g.l^{-1}$		Ca	24.57ab	0.99a	1.03e	1.96d	3.57f	0.70b	1f
Micronutrient		Ls	24.61ab	0.75bc	1.65bc	3.82b	6.01ef	0.54bd	0.81f
		Lc	21.35d	0.77bc	1.41d	3.84b	5.54ef	0.46de	0.82f
		Ca	31.25a	0.51h	2.5a	3.52dh	15.27cd	0.37ik	1.93bf
	Cont	Ls	28.65cd	0.47hi	1.77bc	1.31kl	11.71fg	0.31jk	1.59dl
		Lc	24.83eg	0.93be	2.44a	4.12cg	25.71a	0.56dj	2.46ac
		Ca	0.00m	0.00k	0.00i	0.97l	4.67oq	0.58di	1.62dk
	GA_3	Ls	25.72e	0.18jk	1.12fh	3.56dh	12.78ef	0.19k	1.89bg
		Lc	0.00m	0.00k	0.00i	1.25kl	7.89jl	0.41gk	1.86bh
		Ca	29.28bc	0.51h	1.3dh	3.11fi	11.05fg	0.34ik	1.52em
25% AWC	IBA	Ls	28.03d	0.44hi	1.47bg	3.25ei	15.11cd	0.39hk	2.61ab
		Lc	24.84eg	0.29ij	1.46bg	2.21ik	13.87de	0.34ik	1.6dl
		Ca	29.99b	1.01bd	1.11fh	4.53bd	15.09cd	0.37hk	2.37ad
	Micro	Ls	28.39d	0.63fh	2.29a	4.91ac	16.64c	0.45fk	2.17be
		Lc	25.27ef	0.62gh	1.81b	3.5dh	24.54a	0.67cg	2.99a
		Ca	25eg	1.05bc	1.52bf	5.69a	10.73fh	0.35ik	1.03im
	Cont	Ls	24.62fg	1.11b	1.45bg	4cg	10.14gi	0.74ce	1.47em

		Lc	21.21i	1.48a	2.21a	5.49ab	21.33b	0.89bc	1.27fm
		Ca	0.00m	0.00k	0.00i	3.48dh	7.54jm	0.77bd	1.23fm
50%	GA_3	Ls	0.00m	0.00k	0.00i	2.59hj	6.36lp	1.58a	1.34fm
AWC		Lc	0.00m	0.00k	0.00i	2.96gi	8.69hj	0.99b	1.79cj
		Ca	23.66h	1.05bc	1.61bd	3.92cg	8.46ik	0.51dj	0.94km
	IBA	Ls	24.43fh	0.86ce	1.58be	4.17cf	10.23gi	0.41gk	1.06hm
		Lc	21i	1be	1.84b	2.68hj	16.21c	0.53dj	1.53el
		Ca	24.22gh	1.1b	0.9h	4.92ac	12.15eg	0.64ch	1.83ci
	Micro	Ls	24.72fg	0.85cf	1.46bg	3.02fi	12.42ef	0.4hk	1.11gm
		Lc	21.58i	0.88be	0.00i	4.55bo	22.48b	0.6di	1.42em
		Ca	16.99k	0.96be	1.25dh	4.33ce	6.88jn	0.47fj	0.84km
	Cont	Ls	21.04i	0.82cg	1.37dg	4.87ac	7.2jm	0.58di	0.87lm
		Lc	16.17L	0.82cg	1.22dh	4.01cg	4.8nq	0.44fk	0.74m
		Ca	0.00m	0.00k	0.00i	1.46kl	2.36r	0.76bd	1jm
	GA_3	Ls	0.00m	0k	1.28dh	2.64hj	4.32pr	0.77bd	1.12gm
		Lc	0.00m	0.00k	0.00i	1.79jl	4.02qr	0.59di	0.88km
		Ca	19.42j	0.95be	1.38cg	4.1cg	7.34jm	0.54dj	0.8lm
75% AWC	IBA	Ls	17.61k	0.96be	1.27dh	3.9cg	5.8lq	0.68cf	0.87km
		Lc	16.08l	0.8dg	1.08gh	3.46dh	4.89nq	0.39hk	0.76m
		Ca	19.5J	0.85cf	1.08gh	2.99gi	4.32pr	0.49ej	0.9km
	Micro	Ls	20.72l	0.77eg	1.19eh	4.9ac	6.63jo	0.46fj	0.79lm
		Lc	17.2k	0.82cg	1.14fh	3.64dh	5.67mq	0.42fk	0.77m

Note: W100S=Weight of 100 seeds, SDwt=Seed dry weight, SFwt=Seed fresh weight, TPDwt=Total pod dry weight, TPFwt= Yield of green pod fresh weight, PeDwt= pod envelope dry weight, Pefwt= pod envelope fresh weight. Means of unshared letters are signification at 0.05 level according to Duncan's Multiple Range test, ad=abcd.

3.28 Anatomical Alterations in Response to Irrigation

Results of anatomical alteration to drought (Table 4, 4a, Figures 3, 4 & 5), revealed that irrigating pea plants whenever 75% soil AWC depletion appeared to be the most effective irrigation level. It substantially exceeded that of (25%) level in terms of upper stomata length (5.1%), upper stomata width (27.4%), upper stomata aperture width (20.5%), lower stomata width (19%), lower stomata aperture width (9.8%), stomata population at upper leaf surface (23.2%), vessel number (19.6%) and diameter of large vessel (19%). Moreover, this treatments also exceeded that of 50% level in terms of upper stomata length (5.2%), upper stomata width (27.7%), stomata aperture length at upper leaf surface (11.2%),stomata aperture width at upper leaf surface (26.5%), stomata width at lower leaf surface (20.1%), aperture length of stomata at lower leaf surface (9.6%), aperture width of stomata at lower leaf surface (15%), stomata population at lower leaf surface (8.4%), stomata population at the upper leaf surface (25.1%), vessel number (19%) and diameter largest vessel (27.1%).

Irrigating pea plants whenever 25% soil available water capacity is depleted showed lower response than the above treatment. It significantly exceeded that of 50% in term of aperture length of upper leaf surface stomata (6.6%) and aperture length of lower leaf surface stomata (8.7%). The third treatments in the sequence order was the treatment of irrigating pea plants whenever 50% soil AWC was depleted which appeared to be the worst irrigation level, since it gave the worst results. It was found that irrigating cowpea plants whenever 25% of soil available water capacity is depleted profoundly exceeded the other two irrigation levels 50 and 75% in terms of stomata lengths of leaf upper surface (20.2 and 41.5%, respectively), stomata lengths of leaf lower surface (13.4 and 36.2%, respectively), lengths stomata aperture at leaf upper surface (25.4 and 62.5%, respectively), lengths of stomata aperture at leaf lower surface (21.1 and 55%, respectively), stomata widths at leaf lower surface (20.2 and 56%, respectively), widths of stomata aperture at leaf upper surface (41.5 and 141.2%, respectively), stomata widths at leaf lower surface (42.3 and 131.8%, respectively). Moreover, 25% level significantly reduced stomata populations at leaf upper surface (24.8 and 53.4%, respectively) and at leaf lower surface (21.2 and 64.9%, respectively), as compared to 50 and 75% irrigation levels (Abdel and Al-Salem, 2010). These results might be attributed to the role of moisture availabilities on cell expansion in developing organs which is driven by water uptake into the central vacuole and involves a massive enlargement of the cell wall through biosynthesis and deposition of new wall material (Menand and Robaglia, 2004). During cell expansion process, the cell wall must be made extensible in a finely tuned manner to allow it to yield to the turgour pressure while maintaining its integrity. Members of the expansion family of proteins are prime candidates for controlling cell wall extensibility and ar presumed to act by breaking non covalent bonds between cell wall components to allow them to slide relative to each other (Cosgrove, 2005).

3.29 Anatomical Alterations in Response to Spraying

The obtained results (Table 4, 4a, Figures 3, 4 & 5) manifested that foliar application of distil water on pea plants was the most potent treatment, since it substantially exceeded that of 100 mgl^{-1} GA_3 treatment in terms of stomata width at upper leaf surface (8.2%), aperture width of stomata at upper leaf surface (9.4%), aperture width of stomata at lower leaf surface (12%) stomata population at lower leaf surface (64.9%), stomata population at upper leaf surface (1219.7%) and vessel number (11.7%). It also exceeded that of 100mgl^{-1}IBA in term of aperture width of upper leaf surface stomata (10%), aperture width of stomata at lower leaf surface (12%), stomata population at upper leaf surface (12.4%), number of vessel(18.3%) and largest vessel diameter (16.7%).In addition to that this treatment exceeded to micro

nutrient in term of number of vessel (23%), smallest vessel diameter (6.5%) and largest vessel diameter (12.8%). These illusive results suggested that GA_3, IBA and micronutrients applications were not effective in exhibiting significant changes in the detected parameters.

3.30 Anatomical Alterations in Response to Cultivars

The obtained results (Table 4, 4a, Figures 3, 4 & 5) exhibited that Canadian pea cultivar was the supreme among other cultivar in its response to irrigation and spraying treatments. This cultivar hugely exceeded Local smooth pea cultivars in term of stomata length at upper leaf surface (5.8%), stomata width at upper leaf surface (12.3%), stomata aperture length at the upper leaf surface (7.6%), upper leaf surface stomata aperture width (9.5%), lower leaf surface stomata width (10.2%), lower leaf surface stomata aperture length (6.5%) lower leaf surface stomata aperture width (6.4%), lower leaf surface stomata population (7.7%), upper leaf surface stomata population (23.6%) and vessel number(7.7%). Additionally, this cultivar also exceeded Local crinkle in term of leaf lower surface stomata population (13%), upper leaf surface stomata population (29.8%). Local crinkle come next in the sequence order it exceeded Canadian cultivar in term of largest vessel diameter (10.8%) and it exceeded local smooth as well in term of upper leaf surface stomata width (11.4%), lower leaf surface stomata width (11.2%) and lower leaf surface stomata aperture width (5.9%). The inferior cultivar was local smooth as it revealed the lowest values in most detected parameters. However, it exceeded Canadian cultivars in term of largest vessel diameter (8.9%).

Variations at the anatomical levels between cultivars exposed to varying irrigation levels were well established in Kurdistan and Northern Iraq provinces, particularly in supplementary irrigation studies. Local red onion cultivar appeared to be the best in relation to other cultivars. It showed the highest stomata length (9.6%), stomata width (8.4%) and (13.4%), as compared to Bashiqi cultivar. Moreover, local red cultivar also significantly exceeded its corresponding local white in stomata length (5.7%) and stomata width (6.5%). Local white was the worst cultivar, as it significantly exceeded Bashiqi cultivar in populations of stomata and epidermal cells by 20.8 and 15.8%, respectively, and exceeded local red in the same traits by 24 and 16.5%, respectively (Abdel, 2009b). Recent study (Al-Rawi, 2011) on lentil cultivars also exhibited cultivar response discrepancies, where Baraka lentil cultivar revealed significant increases in stomata aperture 5.6% and 6.7%, as compared to Nineveh and Adlib, respectively. Baraka was also superior over Adlib stomata length (4%). However, Nineveh lentil cultivar exceeded Adlib in terms of palisade layer thickness (15.2%). It also surpassed Baraka in spongy layer thickness (36.6%). Adlib came next to Nineveh in superiority, as it exceeded Baraka in spongy layer thickness (37%), lower epidermis thickness (30.6%).

3.31 Anatomical Alterations in Response to Irrigation and Spraying Interaction

Pea plant irrigated whenever 25% of soil AWC was depleted and sprayed with distilled water (Table 4, 4a, Figures 3, 4 & 5) appeared to be the paramount treatment. This dual interaction showed the highest value in terms of Leaf lower surface stomata population (5792.19).). Moreover, non significant differences were observed between this treatment and others which showed the highest values in stomata length of upper leaf surface (6.23µm), stomata aperture length at upper leaf surface (4.37µm), leaf lower surface stomata length (6.47µm), stomata aperture length at lower leaf surface (4.83µm), lower leaf surface stomata aperture width (2.39µm), vessel number (15.56), largest diameter of vessel (11.22µm) and smallest vessel diameter (4.11µm). These results suggested that neither sprayed growth regulators nor micronutrients were capable to ensure substantial modifications on vessels and stomata behaviour. Subsequently, water availabilities were rolled the plant responses in anatomical

modifications. Similar results were confirmed the role of moisture availabilities where rainfalls results were completely shifted to that of supplemental watering by the aid of polyethylene mulching. Rainfalls onion plant substantially increased stomata numbers per unit area (17.6%), epidermal cell numbers per unit area (37.3%), as compared to these obtained from supplementary irrigated onions. On the other hand, adequate watering resulted in profound increase in stomata length (7.1%), width (9.4%), aperture length (8%), and aperture width (12.4%). However, stomata: epidermis cells ratio were slightly differed. Onion grown on black polyethylene mulched soil highly exceeded onions grown on bare soil and clear polyethylene mulched soils in terms of epidermal cell numbers per unit area (43.7%) and (34.7), respectively. However, onions of clear polyethylene mulches highly exceeded these of un-mulched treatment by (4.7%), (7%) and (34.1%), respectively, in reference to stomata length, length of stomata aperture and width of stomata aperture. Local red onion appeared to be the superior cultivar over the two investigated cultivars as it showed the lowest stomata population and the highest stomata dimensions, especially stomata aperture (Abdel, 2009b).

3.32 Cultivar Anatomical Alterations in Response to Irrigation

Local crinkle Pea plant irrigated whenever 75% of soil AWC was depleted (Table ,4, 4a) appeared to be the supreme treatment .This interaction revealed the highest value in term of stomata length at upper leaf surface (6.3µm), upper leaf surface stomata width (4.22µm), stomata aperture length at leaf lower surface (4.67) stomata length at lower leaf surface (6.62µm), stomata width at leaf lower surface (4.37µm), stomata aperture length at leaf lower surface (4.9µm), stomata aperture width at lower leaf surface (2.57µm), lower stomata population at lower leaf surface (5695.31), upper leaf surface stomata population (4523.44) and smallest diameter vessel (3.92). Moreover, non-significant differences were observed between this treatment and others that gave the highest upper leaf surface stomata width (2.52µm), stomata aperture length at upper leaf surface (4.37µm), leaf lower surface stomata length (6.47µm), lower leaf surface stomata aperture length (4.83µm), largest diameter of vessel (10.42µm) and largest diameter vessels (11.42). These results revealed that a higher drought resistance cultivar more likely possesses low lower stomata population, widest stomata aperture, and highest vessel number of widest cross sections. These results were confirmed by Abdel (2009b) and Al-Rawi (2011). Choat et al. (2003) reported that there is some evidence that the pit membranes may undergo further degradation with age, perhaps via the release of pectinase, increasing their porosity. As xylem vessels reach maturity, the protoplast is destroyed. At the same time, inter-vessel pit membranes are partially hydrolyzed, removing a proportion of the non-cellulosic substances (Butterfield and Meylan, 1982). There is also evidence that pit membranes might become more leaky, i.e., damaged or stretched, after cycles of cavitations and refilling (Hacke et al., 2001).

3.33 Cultivar Anatomical Alterations in Response to Spraying

Local smooth cultivars sprayed with $2.5gl^{-1}$ micronutrient (Table 4, 4a, Figures 3, 4 & 5) appeared to be the most effective dual interaction treatment. This interaction revealed the highest value in terms of upper leaf surface stomata length (6.43µm), leaf upper surface stomata width (4.29µm), leaf upper surface stomata aperture length (4.85µm) and leaf lower surface stomata population (5979.69). Moreover, this treatment showed no significant difference with treatments that gave the highest value in terms of leaf upper surface stomata aperture width (2.43µm), leaf lower surface stomata length (6.53µm), leaf lower surface stomata width (4.2µm), leaf lower surface stomata aperture length (4.77µm), leaf upper surface stomata population (4135.94). Symptoms of iron deficiency resulted in a marked decrease in dry matter accumulation, iron and chlorophyll contents. Similar results were

reported by Abdel (2009b) and Al-Rawi (2011). These results could be due to the role of micronutrients, especially iron. Amar (2003) stated that iron is involved as an active factor in the structure of catalase, peroxidase, oxidase and cytochromes enzymes which facilitate the activation performance of many physiological processes in plant cells. Additionally, Al-Taai et al. (1994) found that iron is implicated as a Co-enzyme in the synthesis of the chlorophyll. Effect of micronutrient was clearly due to the use by Fe-deficient plant of the endogenous iron bound to the humic fraction. They also found that, dry matter accumulation appeared to be greater than that expected on the basis of soluble iron supplied.

3.34 Cultivar Anatomical Alterations in Response to Irrigation and Spraying Interaction

Local crinkled cultivar irrigated whenever 75% of soil AWC was depleted and sprayed with 100mgl^{-1}IBA (Table 4, 4a, Figures 3, 4 & 5) appeared to be the supreme treatment. This triple interaction revealed the highest value in terms of leaf upper surface stomata width (4.66µm) and leaf lower surface stomata population (6593.75). Moreover, this treatment showed no significant difference with treatments that gave the highest value in term of leaf upper surface stomata length (6.66) leaf upper surface aperture length (5.1µm), leaf upper surface aperture width (2.6µm), leaf lower surface stomata width (4.5µm), leaf lower surface stomata aperture length (4.9µm), leaf lower surface stomata aperture width (2 µm) leaf upper surface stomata population (4593.75) and smallest vessel diameter (3.33µm). The obtained results manifested that there are many means to induce water stress mitigating under medium and severe degree through improving the performance of leaf tissues namely palisade thickness, vessels and stomata. Very close results were found by Abdel (2006b) and Al-Rawi (2011). They reported varying cultivar responses under adequate watering and growth regulators. However, they introduce different cultivar that has been introduced under suitable conditions.

3.35 Hormones and Proline Accumulation in Response to Irrigation

The obtained results (Table 5) displayed that irrigating pea plants whenever (25%) soil available water capacity was depleted appeared to be the paramount irrigation treatments. It substantially exceeded that of (50%) levels. in terms of seed protein (15.5%), seed GA_3 content (118%) and IAA content of seed (35.6%). Moreover, this treatment also exceeded that of 75% level in terms of seed protein content (20.2%), seed GA_3 content (436.6%) and IAA content of seed (171%). Irrigating pea plants whenever (50%) of soil AWC was depleted came next to (25 %) level. It significantly exceeded that of (75 %) level in terms of GA_3 seed content (146.1%) and IAA seed content (99.9%). Furthermore, this irrigation level was overwhelmed that of 25% level in seed proline content (27%), ABA content of seed (113.5%) and leaf chlorophyll (17.6%).

Table 4. Influence of irrigation levels, GA_3, IBA and micronutrients on stomata anatomy of Canadian, local smooth and local crinkle pea cultivars

Detected Traits		L1	W1	L2	W2	L3	W3
Irrigation levels	25%	5.92b	3.29b	4.38a	2.1b	6.23a	3.57b
	50%	5.91b	3.28b	4.11b	2b	6.36a	3.54b
	75%	6.22a	4.19a	4.57a	2.53a	6.47a	4.25a
Sprayed treatments	Cont	6.06a	3.71a	4.36ab	2.32a	6.19a	3.8a
	GA3	5.89a	3.43b	4.18b	2.12b	6.4a	3.86a
	IBA	6.07a	3.59ab	4.46b	2.11b	6.21a	3.71a
	Micro	6.05a	3.61ab	4.42ab	2.28ab	6.6a	3.78a
Canadian (Ca)		6.19a	3.73a	4.53a	2.31a	6.39a	3.88a
Local smooth (Ls)		5.85b	3.32b	4.21b	2.11b	6.26a	3.52b
Local crinkle (Lc)		6ab	3.7a	4.32ab	2.2ab	6.4a	3.96a
25% AWC Depletion	Cont	6.23ab	3.6b	4.37ac	2.25bd	6.47ac	3.77bc
	GA3	5.56c	2.87d	4.2bc	2de	6.2ac	3.62c
	IBA	6ac	3.37bc	4.43ab	1.97de	5.9bc	3.4c
	Micro	5.88ac	3.33bc	4.5ab	2.17ce	6.33ac	3.5c
50% AWC Depletion	Cont	5.97ac	3.33bc	4.27bc	2de	6.27ac	3.53c
	GA3	5.81bc	3.2bd	3.84c	1.9e	6.1ac	3.57c
	IBA	5.77bc	3.1cd	4.1bc	1.93de	6.2ac	3.57c
	Micro	6.11ac	3.43bc	4.24bc	2.17ce	6.87ab	3.5c
75% AWC Depletion	Cont	5.97ac	4.19a	4.42bc	2.7a	5.83c	3.07ab
	GA3	6.29ab	4.19a	4.49ab	2.47ac	6.9a	4.4a
	IBA	6.43a	4.29a	4.85a	2.43ac	6.53ac	4.2a
	Micro	6.17ab	4.08a	4.43ab	2.5ab	6.6ac	4.33a
25% AWC Depletion	Ca	5.99a	3.32b	4.32ac	2.24cd	6.32a	3.65bc
	Ls	5.9a	3.25b	4.3ac	1.88E	6.17a	3.61bc
	Lc	5.88a	3.3b	4.5ab	2.17cd	6.17a	3.45c
50% AWC Depletion	Ca	5.96a	3.3b	4.28ac	2.05de	6.3a	3.65bc
	Ls	5.81a	3.28b	3.9c	1.9e	6a	3.32c

	Lc	5.98a	3.24b	4.15bc	2.05de	6.77a	3.65bc
	Ca	6.15a	4.29a	4.53ab	2.67a	6.27a	4.32a
75% AWC	Ls	6.20a	4.05a	4.51ab	2.37bc	6.5a	4.05ab
Depletion	Lc	6.3a	4.22a	4.67a	2.52ab	6.62a	4.37a
	Ca	6.23ab	3.6b	4.36ac	2.25bd	6.47ab	3.78bd
Untreated	Ls	5.56c	2.87c	4.2bc	2de	6.2ab	3.62cd
Control	Lc	6ac	3.37bc	4.43ab	1.97de	5.9ab	3.4d
	Ca	5.88ac	3.33bc	4.5ab	2.17ce	6.33ab	3.5d
100 mgl^{-1}	Ls	5.97ac	3.33bc	4.27bc	2de	6.27ab	3.53cd
GA_3	Lc	5.81bc	3.24bc	3.84c	1.9e	6.1ab	3.56cd
100 mgl^{-1}	Ca	5.77bc	3.11bc	4.1bc	1.93de	6.2ab	3.56cd
IBA	Ls	6.11ac	3.43b	4.24bc	2.17ce	6.87a	3.5d
	Lc	5.97ac	4.19a	4.42ab	2.7a	5.83b	4.1ac
2.5 $g.l^{-1}$	Ca	6.29ab	4.19a	14.5ab	2.67ac	6.9a	4.4a
Micronutrient	Ls	6.43A	4.29a	4.85a	2.43ac	6.53ab	4.2ab
	Lc	6.17ab	4.08a	4.53ab	2.5ab	6.6ab	4.33a
Cont	Ca	6.4ad	3.60cf	4.5ae	2.2af	6.1bc	3.7di
	Ls	6ae	3.4eg	4.4ae	2.3ad	6.6bc	3.9ch
	Lc	6.3ae	3.8be	4.2bf	2.26ae	6.7bc	3.72di
GA_3	Ca	5.24e	2.5h	4.2bf	2.2af	5.9bc	3.3gi
	Ls	6.08ae	3.4eg	4.5ae	2.16af	6.2bc	3.9ch
25% AWC	Lc	5.36de	2.7gh	3.9df	1.66ef	6.5bc	3.66ei
IBA	Ca	6.08ae	3.5eg	4.2bf	2.1af	6.3bc	3.5fi
	Ls	6.06ae	3.4eg	4.6ad	1.62f	5.7c	3.4gi
	Lc	5.86ae	3.2eh	4.5ae	2.2af	5.7c	3.3gi
Micro	Ca	5.78ae	3.2eh	4.1cf	2bf	6.3bc	3.3gi
	Ls	6.16ae	3.3eh	4.8ad	2.3ad	6.4bc	3.5fi
	Lc	5.7be	3.5eg	4.6ad	2.2af	6.3bc	3.7di
Cont	Ca	6.4ad	3.6cf	4.5ae	2.1af	6.4bc	3.9ch
50%	Ls	5.66be	2.9fh	4.12cf	1.9cf	5.9bc	3i

AWC		Lc	5.86ae	3.5eg	4.2bf	2.2bf	6.5bc	3.7di
	GA_3	Ca	5.9ae	3.2eh	4.32ae	2.2af	6.4bc	4cg
		Ls	5.82ae	3.3eh	3.9df	1.8df	5.8c	3.3gi
		Lc	5.7de	3.22eh	3.3f	1.7df	6.1bc	3.4gi
	IBA	Ca	6.2ae	3.6cf	4.8ad	2.2af	6.2bc	3.3gi
		Ls	5.52de	3.02eh	3.6ef	1.9cf	5.9bc	3.3gi
		Lc	5.58ce	3.7gh	3.9df	1.7df	6.5bc	4.1cg
	Micro	Ca	6.36ad	3.3eh	4.66ad	2.1af	6.1bc	3i
		Ls	5.8ae	3.26eh	3.6ef	2.1af	8.4a	4cg
		Lc	6.16ae	3.72bf	4.46ae	2.3ad	6.1bc	3.5fi
	Cont	Ca	6.1ae	4.6a	4.4ae	2.7a	6bc	4.3bf
		Ls	5.9ae	3.56df	4.46ae	2.7a	5.8c	3.5fi
		Lc	5.9ae	4.4ab	4.4ae	2.7a	5.7c	4.4ae
	GA_3	Ca	6.7ab	4.6a	4.86ac	2.6ab	7.6ab	5.1a
		Ls	5.46de	3.26eh	3.9df	2.3ad	5.8c	3.1hi
75% AWC		Lc	6.7ab	4.7a	4.7ad	2.5ac	7.3ac	5ab
	IBA	Ca	6.86a	4.7a	5.16a	2.7a	6.7bc	4.6ac
		Ls	5.78ae	3.52eg	4.3ae	2bf	6.2bc	3.5fi
		Lc	6.66ac	4.66a	5.1ab	2.6ab	6.7bc	4.5ad
	Micro	Ca	6.26ae	4.32ad	4.66ad	2.6ab	6.7bc	4.6ac
		Ls	5.96ae	3.56df	4.3ae	2.3ad	6.4bc	3.8ci
		Lc	6.3ae	4.36ac	4.62ad	2.6ab	6.7bc	4.6ac

Note: L1=Leaf upper surface stomata lengths (µm), W1= Leaf upper surface stomata width (µm), L2= Leaf upper surface stomata aperture length (µm), W2= Leaf upper surface stomata aperture width (µm), L3=Leaf lower surface stomata length (µm), W3= leaf lower surface stomata width (µm). Means of unshared letters are signification at 0.05 level according to Duncan's Multiple Range test, ad=abcd

Table 4a. Influence of irrigation levels, GA_3, IBA and micronutrients on anatomy of Canadian, local smooth and local crinkle pea cultivars

Detected Traits		L4	W4	NO.S1	No.S2	No.V	VL	VS
	25%	4.75a	2.24b	4940.63ab	2707.81b	11.8b	9.58b	3.72a
Irrigation levels	50%	4.37b	2.14b	4676.56b	2667.19b	11.86b	8.97b	3.66a
	75%	4. 79a	2.46a	5067.19a	3335.94a	14.11a	11.4a	3.85a
	Cont	4.64a	2.42a	5517.19a	3979.69a	14.15a	10.81a	3.96ab
Sprayed	GA3	4.72a	2.16b	3346.88b	301.56c	12.67b	10.2ab	4.11a
treatments	IBA	4.57a	2.16b	5243.75a	3542.19b	11.96bc	9.26c	3.63bc
	Micro	4.61a	2.38a	5971.88a	3792 .19a	11.50c	9.58bc	3.27c
Canadian (Ca)		4.78a	2.33a	5218.75a	3376.56a	13.11a	9.36b	3.58a
Local smooth (Ls)		4.49b	2.19b	.4846.88b	2731.25b	12.17b	10.19a	3.86a
Local crinkle (Lc)		4.64ab	2.32a	4620.31b	2601.56b	12.46ab	10.37a	3.80a
	Cont	4.83ac	2.39ad	5792.19a	3875bc	15.56ab	11.2ac	4.11ab
25% AWC	GA3	4.82ad	2.1df	3479.69e	270.31e	12.56cd	9.56ce	4ab
Depletion	IBA	4.55be	2.1df	5000cd	3207.81d	9e	8.33e	3.44ac
	Micro	4.8ad	2.37ae	5489.06ac	3167.2cd	10.11cd	9.22d	3.33bc
	Cont	4.67ae	2.42ac	5082.81bd	3542.2d	13.11cd	8.78de	3.56ac
50% AWC	GA3	4.29ef	1.92f	3343.75e	448.44e	9.56e	9.11de	4.11ab
Depletion	IBA	4.4df	2.07ef	4750d	3281.25d	12.78cd	9.11de	4ab
	Micro	4.12f	2.13cf	5537.25ac	3395.31d	12d	8.89de	3c
	Cont	4.43cf	2.47ab	5676.56ab	4520.31a	13.78bd	12.44a	4.22a
75% AWC	GA3	5.07a	2.47ab	3218.75e	187.5e	15.89a	12ab	4.22a
Depletion	IBA	4.77ad	2.3be	5667.19a	4135.9ab	14.11ac	10.3ce	3.44ac
	Micro	4.91ab	2.63a	5395.31ac	4500a	12.22cd	10.4bd	3.44ac
25% AWC	Ca	4.82a	2.29bc	5031.25ac	2953.1bc	12.75bd	9.25cd	3.67a
Depletion	Ls	4.69a	2.12cd	4625bd	1875d	11.08d	9.42cd	3.83a
	Lc	4.74a	2.3ac	5164.06ab	3296.9bc	11.58cd	10.1bc	3.67a
50% AWC	Ca	4.6ab	2.31ac	4812.5bc	2859.38c	18.08cd	8.17d	3.58a
Depletion	Ls	4.31bc	1.94d	9085.94d	2046.88d	12.25cd	9.33cd	3.67a

		Lc	4.19c	2.15cd	5132.81ab	3093.8bc	11.25d	9.42cd	3.75a
		Ca	4.72a	2.52ab	5070.31ac	3429.69b	14.5a	10.7ac	3.5a
75% AWC		Ls	4.75a	2.3ac	4437.5cd	2054.69d	13.17ac	11.83a	4.08a
Depletion		Lc	4.9a	2.57a	5695.31a	4523.44a	14.33ab	11.4ab	3.92a
		Ca	4.83ac	2.39ad	5792.19ab	3875bc	14.22a	9.22cd	3.89ad
Untreated		Ls	4.82ac	2.1ce	3479.69d	270.31d	13.67ac	11.1ab	4ac
Control		Lc	4.55be	2.1ce	5000c	3207.81c	14a	12.1cd	4ac
		Ca	4.8ac	2.37ad	5489.06ac	3168.75c	12bf	9.22cd	3.89cd
100 mgl^{-1}		Ls	4.67ad	2.42ac	5082.81bc	3229.7bc	13.22ad	11ac	4.11ab
GA_3		Lc	4.29de	1.92e	3343.75d	448.44d	12.22be	10.4ad	4.33a
100 mgl^{-1}		Ca	4.4ce	2.07de	4750c	3281.25c	13.89ab	9d	3.22d
IBA		Ls	4.12e	2.13ce	5531.25ac	3395.31c	10.89e	9.56bd	4.11ab
		Lc	4.43ce	2.47ab	5676.56ab	4520.31a	11.11e	9.22cd	3.56bd
2.5 $g.l^{-1}$		Ca	5.1a	2.47ab	3187.5d	187.5d	11.78ce	10bd	3.33cd
Micronutrient		Ls	4.77ac	2.3bd	5979.69a	4135.9ab	10.89e	9.11d	3.22d
		Lc	4.91ab	2.63a	5395.31ac	4500a	11.67de	9.44bd	3.22d
	Cont	Ca	4.8bc	2.4ae	5906.25ae	4250cd	18.33a	10ch	3.47ac
		Ls	4.9ab	2.36ae	6625a	9093.8ce	13.33be	10.7bg	4.33ab
		Lc	4.8bc	2.4ae	4843.75ek	3281.3gi	15ad	13ac	4.33ab
	GA_3	Ca	4.8bc	2dg	2750n	189.06L	13bf	8.67dh	4ac
		Ls	4.9ab	2.1cf	3937.5jm	407.81L	12.67cg	10.3bg	4ac
25% AWC		Lc	4.76bc	2.2bf	3750kn	220.31L	12ch	9.67dh	4ac
	IBA	Ca	4.8bc	2.4ae	4562.5hk	3343.75fi	9.33fh	8.67dh	3.33ac
		Ls	4.3bd	1.8fg	6250ac	3531.3eh	9gh	8fh	3.67ac
		Lc	4.56bd	2.1cf	4187.5hl	2750ij	8.67h	8.33eh	3.33ac
	Micro	Ca	4.7bd	2.3af	6062.5ad	4031.25df	10.33ch	9.67dh	3.67ac
		Ls	4.8bc	2.4ae	5750af	3406.3ei	9.33fh	8.67dh	3.33ac
		Lc	4.9ab	2.4ae	4656.25fk	3000hi	10.67eh	9.33dh	3bc
	Cont	Ca	5ab	2.4ae	5906.25ae	4437.5bd	12.33ch	7h	3.67ac
50%		Ls	4.6bd	2.26bf	562.5bh	4250cd	14be	10.7bg	3.67ac

AWC		Lc	4.4be	2.6ac	4093.75hl	1937.5k	13bf	8.67dh	3.33ac
	GA_3	Ca	4.4be	2dg	4000il	814.06L	9.33fh	8fh	4ac
		Ls	4.4be	2.16cf	3220.31ln	345.31L	10.33eh	9.33dh	4ac
		Lc	4.06ce	1.6g	2812.5mn	189.06L	9gh	10ch	4.33ab
	IBA	Ca	4.5bd	2dg	5781.25af	4250cd	14be	8.33eh	3.67ac
		Ls	4.3bd	2dg	4531.25gk	3437.5ei	13.33be	10ch	4.33ab
		Lc	4.4be	2.2bf	3937.5jm	2187.5jk	11eh	9dh	4ac
	Micro	Ca	4.6bd	2.1cf	5843.75ae	3968.8dg	12.67cg	9.33dh	3bc
		Ls	3.76e	2.4ae	5593.75ag	3406.3ei	11.33dh	7.33gh	2.67c
		Lc	4de	1.9eg	5156.25ci	2812.5hj	12ch	10ch	3.33ac
	Cont	Ca	4.4be	2.5ad	656.25ac	5125ab	12ch	10.7bg	4.33ab
		Ls	4.6bd	2.4ae	.4312.5hl	3468.8ei	13.67be	12ad	4ac
		Lc	4.3bd	2.5ad	6437.5ab	4968.8ab	15.67ac	14.67a	4.33ab
	GA_3	Ca	5.6a	2.7ab	3251.56n	156.25L	15.33ac	11bf	3.67ac
		Ls	4de	2dg	3220.31n	218.75L	16.67ab	13.3ab	4.33ab
75% AWC		Lc	5.6a	2.7ab	3187.5mn	187.5L	15.67ac	11.7ae	4.67a
	IBA	Ca	4.9ab	2.4ae	6375ab	4750ac	18.33a	10ch	2.67c
		Ls	4.5bd	2.1cf	4968.75dj	3062.5hi	10.33eh	10.7bg	4.33ab
		Lc	4.9ab	2.ae	6593.75a	4593.8ad	13.67be	10.3bg	3.33ac
	Micro	Ca	4.86b	2.8a	5906.25ae	5250a	12.33ch	11bf	3.33ac
		Ls	4.86b	2.3af	4500gk	3156.3hi	12ch	11.3bf	3.67ac
		Lc	5ab	2.8a	5781.25af	5093.8ab	12.33ch	9dh	3.33ac

Note: L4= Leaf lower surface stomata aperture length (µm), W4 = Leaf lower surface stomata aperture width (µm), Nos1 = Leaf lower surface stomata population (Stoma/mm^2), Nos2 = Leaf upper surface stomata population (Stoma/mm^2, Nov = Number of vessel/bundle, VL= Largest diameter vessel (µm), Vs= Smallest diameter vessel (µm). Means of unshared letters are signification at 0.05 level according to Duncan's Multiple Range test, ad=abcd.

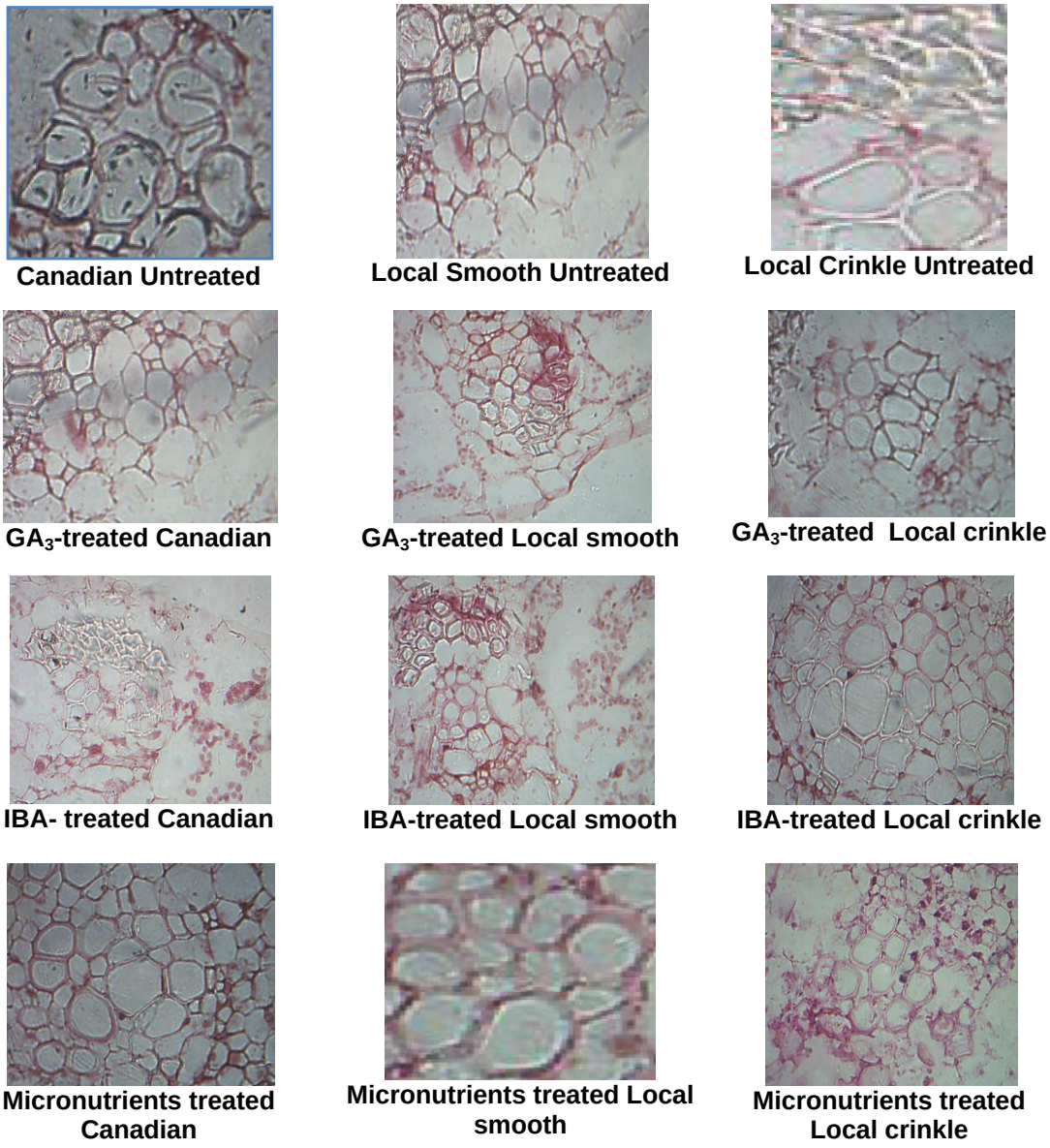

Fig. 3. Influence of spraying pea plant with GA_3, IBA and micronutrient on pea vessels behavior under varying irrigation levels.
Irrigating pea whenever 25% of pot available water capacity was depleted (25% PAWC)

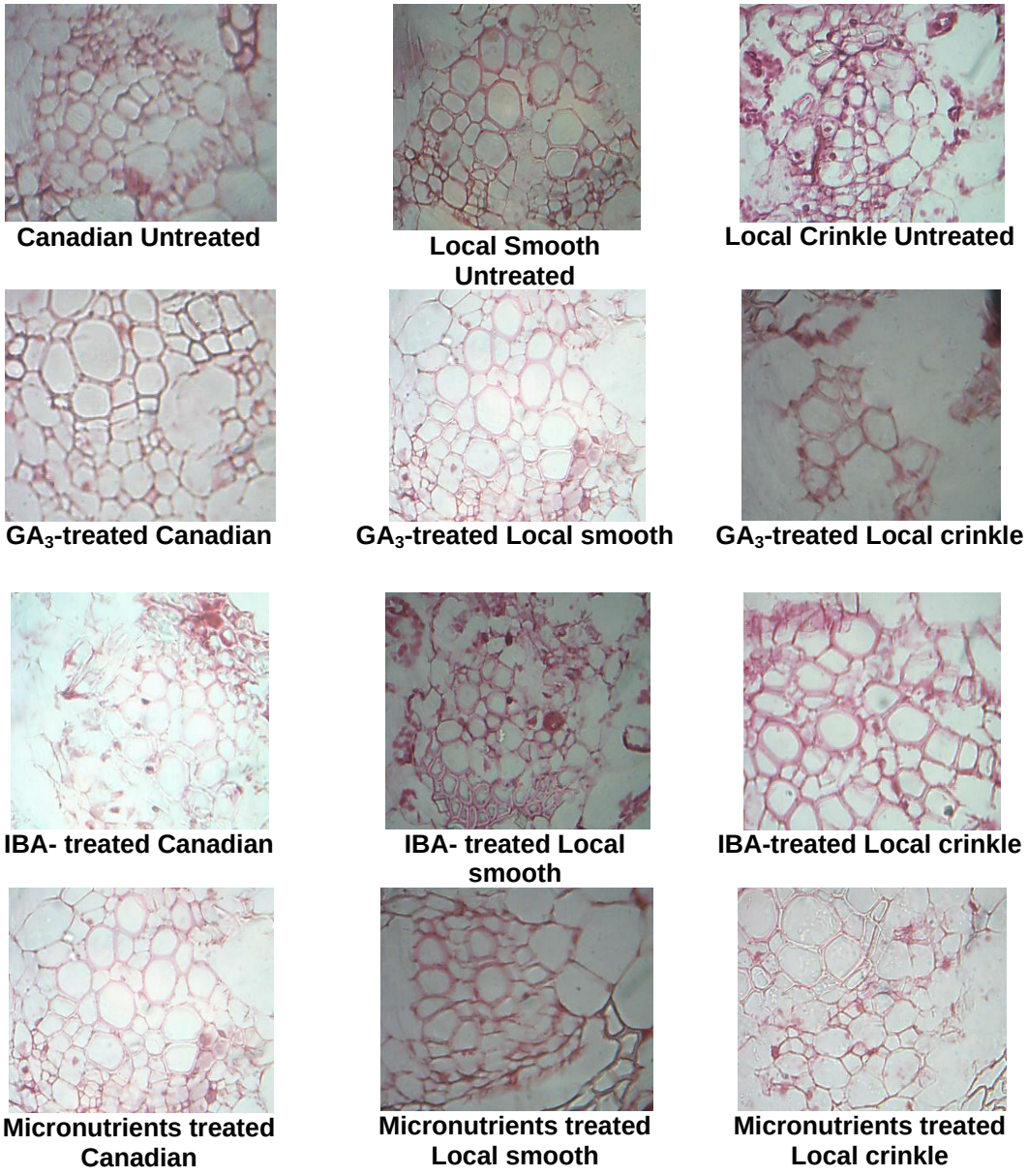

Fig. 4. Influence of spraying pea plant with GA_3, IBA and micronutrient on pea vessels behavior under varying irrigation levels.
Irrigating pea whenever 50% of pot available water capacity was depleted (50% PAWC)

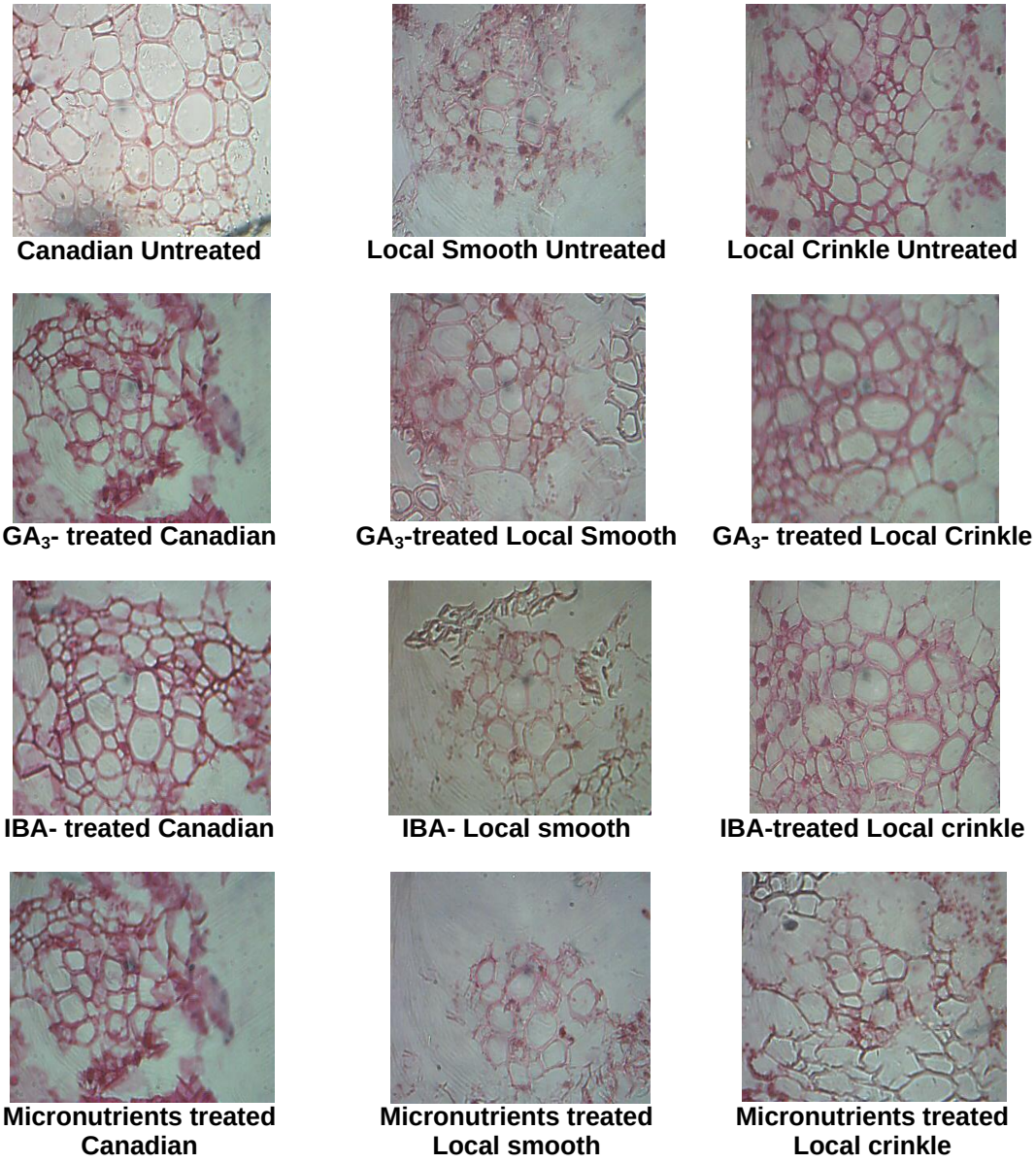

Fig. 5. Iinfluence of spraying with GA_3, IBA and micronutrient on pea vessels behavior under varying irrigation levels.
Irrigating pea whenever 75% of pot available water capacity was depleted (75% PAWC)

Irrigating pea plants whenever 75% soil AWC was depleted appeared to be the worst irrigation level. It substantially reduced most detected traits. However, it highly exceeded that of 25% level in terms of, proline content (37.8%) ABA (151.6%) and chlorophyll content percentage out of leaf pigment (17.3%) This irrigation level also exceeded that of 50% level

in term of proline content of seed (8.5%), ABA seed content (17.9%). It is well established that ABA is the dehydration hormones (Abdel and El-Hamadany, 2010) they found that application of ABA on droughted faba bean confer extra adaptation capability to plant drought resistance. Yamaguchi-Shinozaki (1996) reported that it is now hypothesized that at least four independent signal pathways function in the activation of stress inducible genes under dehydration conditions, two are ABA dependent (pathways I and 11) and two are ABA independent (pathways III and IV).

3.36 Hormones and Proline Accumulation in Response to Spraying

The obtained results (Table 5) manifested that foliar application of 100 mgl^{-1} IBA on pea plants was the most potent treatment, since it substantially exceeded that of 100mgl^{-1} GA_3 in terms of protein (792.3%), proline (20.4%), ABA content of seed (1075.7%), GA_3 content of seed (337.3%), seed content of IAA (605.6%) and chlorophyll content out leaf pigments (36.9%). It also exceeded that of micronutrient in term of protein (7.7%) and seed content of GA_3 (1.9%). This treatment also exceeded untreated in term of ABA content of seed (6%) and GA_3 content of seed (5.5%). The next treatment in potency seems to be that of untreated pea plants. This treatment showed superiority over 100mgl^{-1} GA_3 in term of protein (788.4%), proline (20.8%), seed content of ABA (1009.4%), IAA seed content (573.3%) and chlorophyll content percentage out of leaf pigment (37.2%). Moreover, distilled water sprayed pea manifested superiority on 2.5$g.l^{-1}$ micronutrient treatment in seed protein content (7.2%). 2.5mgl^{-1} micronutrient treated pea was categorized to be the third treatment in the significance sequence. This treatment was superior on 100mgl^{-1} GA_3 in terms of seed protein content (728.8%), proline (26.5%), and seed content of ABA (1074.6%), seed GA_3 content (328.9%), seed IAA content (597.3%) and chlorophyll percentage out of leaf pigments (53.1%). Furthermore this treatment exceeded that of 100mgl^{-1} IBA treated pea in terms of proline content of seed (5.1%) and chlorophyll percentage out of leaf pigments (11.8%). This treatment also overwhelmed that of distilled water in terms of proline content of seed (6.9%), seed ABA content (5.9%) seed GA_3 content (3.5%) and chlorophyll content out of leaf pigments (11.6%). Therefore, the fourth order was confined to the feeblest 100mgl^{-1} GA_3 treatment which showed the lowest values in most desired traits. Recent studies confirmed gradual degradations of promotion of plant hormones commenced with late embryogenesis, these degradations accompanied by increasingly growth inhibitors accumulation in order to fulfilled seeds drying where the conversion of structural water into free water to met the atmospheric demand. These conversions are necessarily rolled by ABA through polymerizations of protein, carbohydrates and other materials. Therefore, most late embryogenesis abundant (LEA) proteins are part of a more widespread group of proteins called (hydrophilins). The physicochemical characteristics that define this set of proteins are Glycine content greater than 6% and a hydrophilicity index greater than 1. By database searching, it was shown that this criterion selects most LEA proteins, as well as additional proteins from different taxa (Garay- Arroyo et al., 2000).

3.37 Hormones and Proline Accumulation in Response Cultivars

The experiment results (Table 5) exhibited that the supreme cultivar response was confined to Local smooth pea. This cultivar apparently exceeded Canadian cultivar in terms of protein (9.6%), proline (14%), seed ABA content (8.4%), seed GA_3 content (24.7%), IAA content of seed (5.3%) and chlorophyll content percentage out of leaf pigment (10.1%). Furthermore this cultivar showed superiority over local crinkled in terms of protein (6.2%), proline (8.9%), and seed content of ABA (12.2%), GA_3 content of seed (11.7%) and seed IAA content

(15.1%). Crinkle local pea cultivar come next to Local smooth in the significance order. This cultivar showed superiority over Canadian in terms of seed proline content (4.7%) and GA_3 content of seed (11.6%). The inferior cultivar was Canadian as it revealed the lowest values in most detected parameters. However, it exceeded Crinkle cultivars in terms of seed ABA content (3.5%) and seed IAA content (9.2%). Variation in cultivar responses to varying irrigation levels were documented in faba bean (Al-Hamadany, 2005; Abdel 2006 a, b), in cowpea (Abdel and Al-Salem, 2010), in Cucumber (Hasawy and Abdel, 2010). However, all of them attributed the cultivar discrepancies to genetic variation, seed production techniques and field maintenance. Cultivar differences were reported in free proline concentration underwent remarkable increase in water stress conditions by between 5- and 50-fold, depending on cultivar (Fricke and Pahlich, 1990).

3.38 Hormones and Proline Accumulation in Response to Irrigation and Spraying Interaction

Pea plant irrigated whenever (50%) of soil AWC was depleted and sprayed with distil water (Table 5) appeared to be the supreme treatment. This dual interaction revealed the highest value in term of protein (31.99). Similar chlorophyll increases was documented by Bamarny (2011). Previous results confirmed that plants under drought conditions showed gradual reductions in their response to any applied chemicals which were intended from its application to counteract drought adversity. Moreover, in severe drought plant are completely deprived from responses, owing to the accumulations on reactive oxygen species (Abdel, 2006b). Drought stress is the major factor that induces free radical generation which causes lipid peroxidation and membrane deterioration in plant cells. These radicals lead to an imbalance between antioxidant defenses and the amount of active oxygen species (AOS) resulting in oxidative stress. The peroxidation of lipids in the cell membrane is one of the most damaging cellular responses to water stress (Thankamani *et al*., 2003).The amount of lipid peroxidation has long been considered as one of the factors, which indicate the severity of stress experienced by a plant (Chowdhury and Chowdhury, 1985).

3.39 Cultivar Hormones and Proline Accumulation in Response to Irrigation

Local smooth pea plant irrigated whenever 25% of soil AWC was depleted with (Table 5), appeared to be the most potent treatment. This interaction revealed the highest value in terms of protein (30.48%), GA_3 content of seed (424.31 $mg.Kg^{-1}$ dry seeds) and seed IAA content (4801.2 $mg.Kg^{-1}$ dry seeds). Moreover, this treatment showed no significant difference with treatments that gave the highest proline content (0.0046). Combination of adapted cultivar such as Local crinkle with adequate watering revealed the perfect chance for gene expressions in which there were no stresses. However, under stress this cultivar showed lower responses. Chartzoulakis et al. (2002) applied irrigation when soil water potential reached at -0.03 and -0.5 MPa for the wet and dry treatments, respectively. To investigate leaf anatomy alteration in water stressed leaves, which could have accounted for the decreased stomata conductance. They found that photosynthesis is inhibited by reducing the diffusion of CO_2 to the chloroplast, both by stomata closure. Changes in mesophyll structure, which decreases the conductance to CO_2 diffusion within the leaf. The extent to which photosynthetic capability is maintained during periods of water stress and the ability of rapid recovery of photosynthesis after re-watering may play an important role in plant adaptation to drought environments. In order to preserve photosynthesis under drought

conditions, plants have evolved physiological processes to maintain to some extent tissue turgor and stomata opening (Nunes et al., 1989).

3.40 Cultivar Hormones and Proline Accumulation in Responses to Spraying

Local smooth pea cultivar sprayed by 100mgl^{-1} IBA on (Table 5) gave the highest value in term of protein (31.21%), and ABA (705.18). Moreover, this treatment showed no significant difference with treatments that gave the highest chlorophyll content percentage out of leaf pigment (40.85%). El- Shraiy and Hegazi (2009) found that application of IBA at 50 and 100mgl^{-1} significantly increased the total chlorophylls in leaves, total soluble proteins, praline, phenol, total soluble carbohydrates and sugars in seeds, and significant increase in length of pod plant, number of pod per plant, number of seed, per pod, 1000 seeds weight and pods fresh and dry weights of pea plants (*Pisum sativum L.*). Ludwig-Muller (2000) found that IBA at 50mgl^{-1} gave the highest photosynthetic pigments content due to the stimulatory effect on the amount of metabolites synthesized through enhancement of cell division and chlorophyll accumulation which leads to higher rate of photosynthesis.

3.41 Cultivar Hormones and Proline Accumulation in Responses to Irrigation and Spraying Interaction

Pea plant irrigated whenever 25% of soil AWC was depleted and sprayed with 100mgl^{-1}IBA on Local Smooth (Table 5) appeared to be the supreme treatment. This dual interaction revealed the highest value in term of protein percentage (34.13%). Supplementary irrigation was found to be beneficial to the pea yields when the temperature increased. Indeed, application of 60 mm of supplementary irrigation during the complete growth stages of crops that were subjected to an increase in mean daily temperature of 0.6–2.2 °C resulted in crop yields improving by 8.3%–12.8%. Consequently, in this region, supplementary irrigation may play an important role in maintaining pea yields that would otherwise be affected by climate warming. However, the results also show that application of 60 mm of supplementary irrigation does not decrease the number of stems with root-rot sickness and that the ratio of pea crops subjected to the same temperature conditions will increase (Xiao et al., 2009). Limited or no irrigation was required in March, whereas the rainfall in the April–June period was far below the evapotranspiration demand for pea in this region. The maximum daily ET values of pea varied from 4.1 to 4.8 mm per day in the 4 experimental years and they occurred in mid or late May during the pod formation stage of the crop. The low rainfall and high ET demand in the April–June period of all experimental years shows the importance of irrigation. It is estimated that a total of 175–316mm of irrigation would be required in this period to stabilize and improve seed yield (Uzum et al., 2005). In other investigation, Al-Hamadany and Abdel (2008) manifested that combination mixture of 20gm^{-2} + 10mgl^{-1} + 50mgl^{-1} GA_3 was the most effective treatment. It gave the highest values in term of plant height (47.35 cm), leaf numbers per plant (10.15), leaf fresh weight per plant (98.2 g) and marketable yield (8.1kgm^{-2}). Moreover, it substantially reduced the numbers of plants that failed to perform acceptable storage root. However, this treatment profoundly reduced swollen root numbers per m^2 and root fresh weight per m^2. Treatment of fertilizing radish plots by 20 gm^{-2} came next in the sequence of significance, as it displayed the highest value of leaf biomass productions (5.22 kgm^{-2}), dry matter accumulation in leaves per plant (17.88 g), root fresh weigh per m^2 (4.41 kgm^{-2}) and numbers of storage roots per m^2 (37.25). Untreated check was worst treatment. It manifested the lowest marketable yield (5.21kgm^{-2}), leaves fresh weight per m^2 (1.59kgm^{-2}). These results suggested that this mixture was more likely to be in favour of growth not for root swellings.

Table 5. Influence of irrigation levels, GA_3, IBA and micronutrients on chemical characteristics of Canadian, local smooth and local crinkle pea cultivars

Detected traits		Protein	proline	ABA	GA3	IAA	Chlorophyll %
Irrigation levels	25%	25.30a	0.0037c	286.97c	346.63a	4109.72a	30.89b
	50%	21.91b	0.0047b	612.59b	158.97b	3031.41b	36.33a
	75%	21.05b	0.0051a	722.15a	64.59c	1516.45c	36.23a
	Cont.	29.94a	0.0058b	673.83b	230.15c	3596.73a	35.90b
Sprayed Treatment	GA_3	3.37c	0.0049c	60.73c	55.53d	534.18c	26.16c
	IBA	30.07a	0.0059b	713.98a	242.81a	3769.11a	35.82b
	Micro	27.93b	0.0062a	713.31a	238.19b	3725.23a	40.05a
Canadian (Ca)		21.85b	0.0043c	529.72b	170.58c	2926.99b	32.83b
Local smooth (Ls)		23.94a	0.0049a	574.37a	212.69a	3083.27a	36.15a
Local crinkle (Lc)		22.55b	0.0045b	511.77c	190.41b	2679.64c	34.47ab
25% AWC depletion	Cont	28.58bd	0.0042e	253.32d	394.35b	4880.09b	32.293c
	GA3	10.11e	0.0015f	182.5e	166.6f	1602.55g	19.92d
	IBA	31.21ab	0.0044d	345.43c	413.89a	5003.69a	29.79c
	Micro	31.31ab	0.005c	366.64c	411.68a	4962.55ab	41.533a
50% AWC depletion	Cont	31.99a	0.0063b	803.14b	208.52d	4019.15d	36.42b
	GA3	0.00e	0.00g	0.00f	0.00h	0.00h	29.71c
	IBA	29.36ac	0.0063b	811.96b	225.48c	4134.23c	38.32ab
	Micro	26.44cd	0.0064b	835.29b	201.88e	3972.27d	40.85a
75% AWC depletion	Cont	29.26ac	0.0072a	965.03a	87.58g	1890.96f	38.97ab
	GA3	0.00f	0.00g	0.00f	0.00h	0.00h	28.85c
	IBA	29.65ab	0.0071a	984.56a	89.05g	2169.4e	39.36ab
	Micro	25.88d	0.0072a	963.63a	84.25g	2071.37e	37.75ab
25% AWC depletion	Ca	21.88b	0.0033c	230.39c	296.87c	3871b	27.83 e
	Ls	30.48a	0.0046ab	389.45b	424.31a	4801.2a	25.54 e
	Lc	23.55b	0.0035bc	241.07bc	318.72b	3656.9b	39.29 ab
50% AWC	Ca	21.88b	0.0046ab	614.92a	154.73e	3222.1c	33.55 d
	Ls	21.51b	0.0046a	609.89a	145.05e	2972.8c	35.22 cd

depletion		Lc	22.46b	0.0049a	612.95a	177.13d	2899.3c	40.21 a
		Ca	21.8b	0.0052a	743.86a	60.15f	1687.8d	36.03bd
75% AWC		Ls	19.84b	0.0054a	723.77a	68.72f	1475.8d	34.02 d
depletion		Lc	21.95b	0.0055a	717.28a	66.79f	1435.3d	38.64ac
		Ca	28.29a	0.0056e	669.17b	226.21de	3857.19b	32.29cd
Untreated		Ls	30.14a	0.0059cd	689.83ab	220.31e	3472.19e	19.92e
control		Lc	31.4a	0.006c	662.49b	223.93b	3460.82e	29.79d
		Ca	0.00d	0.00g	0.00d	0.00g	0.00g	41.53a
100 mgl^{-1}		LS	10.11c	0.0015g	182.5d	166.6f	1602.55g	36.42bc
GA_3		Lc	0.00d	0.00h	0.00e	0.00g	0.00h	29.7d
IBA mgl^{-1}		Ca	30.14a	0.0058de	724.72a	235.06c	3985.05a	38.32ab
		Ls	31.21a	0.006c	705.18a	233.59c	3678.18c	40.85ab
		Lc	28.88a	0.006c	712.05a	259.77a	3644.09c	38.97ab
2.5 $g.l^{-1}$		Ca	28.98a	0.006c	725a	221.05e	3665.71b	28.85d
Micronutrient		Ls	24.32b	0.0062b	719.97a	230.27cd	3580.15d	39.36ab
		Lc	30.33a	0.0064a	720.53a	246.49b	3550.32d	37.75ab
		Ca	25.37fh	0.0032j	210.88f	382.55f	5076.13ab	32.16cg
	Cont	Ls	29.46fh	0.0043i	308.86e	390.29ef	4743.7c	33.6bf
		Lc	31.21ae	0.0043i	240.21e	410.2d	4820.42c	31.12dh
		Ca	0.00i	0.00k	0.00g	0.00O	0.00L	14.42j
	GA_3	Ls	30.62af	0.0045i	547.49c	499.8a	4807.64c	23.66hi
		Lc	0.00i	0.00k	0.00g	0.00O	0.00L	21.68i
		Ca	31.21ae	0.0044i	351.57de	403.57d	5242.37a	27.84fi
25%	IBA	Ls	34.13a	0.0044i	342.36de	399.14de	4820.42c	28.98fi
AWC		Lc	29.17af	0.0045i	342.36de	438.97b	4948.29bc	32.56cg
		Ca	32.96ad	0.0048h	359.1de	401.35d	5165.65a	40.72ab
	Micro	Ls	28.58bf	0.0051g	359.1de	407.99d	4833.21c	40.86ab
		Lc	0.00i	0.0052g	381.71d	425.69c	4858.78c	43.02a
		Ca	29.75af	0.0062f	807.89b	217.73ij	4308.97d	34.24bf
	Cont	Ls	33.84ab	0.0063ef	792.82b	180.12k	3963.74fh	34.08bf

		Lc	33.54ac	0.0064e	808.73b	227.7hi	3784.73h	40.94ab
		Ca	0.00i	0.00k	0.00g	0.00O	0.00L	24.92gi
50% AWC	GA_3	Ls	0.00i	0.00k	0.00g	0.00O	0.00L	34.22bf
		Lc	0.00i	0.00k	0.00g	0.00O	0.00L	29.98eh
		Ca	30.04af	0.0061f	822.12b	214.41j	4347.33d	32.34cg
	IBA	Ls	29.17af	0.0064e	803.7b	211.9j	4053.25ef	44.34a
		Lc	29.17af	0.0065e	810.07b	250.92g	4002.1fg	38.28ad
		Ca	28.58bf	0.0061f	829.66b	186.76k	4232.25de	39.80ac
	Micro	Ls	23.33gh	0.0064e	843.06b	188.97k	3874.24fh	42.78a
		Lc	27.71dg	0.0066de	833.01b	229.9h	3810.31gh	39.98ac
		Ca	3.33af	0.007bc	98.74a	78.35mn	2186.45ij	37.9ad
	Cont	Ls	28.29cf	0.0071ab	967.81a	90.52l	1709.14k	40.88ab
		Lc	30.04af	0.0074a	938.53a	93.87l	1777.29k	38.12ad
		Ca	0.00i	0.00k	0.00g	0.00O	0.00L	27.24fi
	GA_3	Ls	0.00i	0.00k	0.00g	0.00O	0.00L	33.86bf
		Lc	0.00i	0.00k	0.00g	0.00O	0.00L	25.46gi
		Ca	29.75af	0.0069cd	1000.47a	87.2lm	2365.46i	37.74ab
75% AWC	IBA	Ls	30.92ae	0.0071ab	969.49a	90.53l	2160.88ij	39.02ac
		Lc	28.88af	0.0072ab	983.72a	89.42lm	1981.87j	41.32ab
		Ca	27.71dg	0.007bc	986.23a	75.04n	2199.24ij	44.66a
	Micro	Ls	21.04h	0.0071ab	957.76a	93.84l	2033.02j	37.46ae
		Lc	29.17af	0.0074a	946.88a	83.88ln	1981.87j	31.14dh

*Note: *Means of unshared letters are signification at 0.05 level according to Duncan's Multiple Range test, ad=abcd*

4. CONCLUSIONS

Drought resistance variations were obvious among investigated cultivars where Local Crinkle was the most potent followed by Local Smooth. Superiority of Local cultivars in drought resistance over Canadian could be attributed to their adaptations. Flowering, pod swelling and seed filling are crucial stages where water should not be ceased to achieve high yield of high quality. Micronutrient was the paramount treatment in term of improving pea drought resistance as compared to IBA and GA_3. This finding may be attributed to the high sand content of pot soil and it may be not so if which otherwise. Gibberellic acid (GA_3) application on pea grown at very late growth stages particularly, under controlled conditions is not advisable. Since there are not enough time for its degradation endogenously and thus causes parthenocarpy setting. Growth regulators content of seeds were shifted to the faviour of inhibitors, as compared to promoters. Higher proline accumulation is not definitely confined to the most drought resistant cultivar. Water stressed plants manifest higher chlorophyll contents owing to their smaller cell size. Higher stomata apertures length and width may be devoted to drought resistance cultivar. Higher stomata populations resulted from lower cell turgour pressure acquired from water deficit. Finally, higher numbers of well performed xylem vessels are confined with most drought resistance cultivars and vice versa.

REFERENCES

Abd El-Wahed, M.S.A., Amin, A.A., Rashad, El.Sh.M. (2006). Physiological effect of some bioregulators on vegetative growth, yieldand chemical constituents of yellow Maize plants. World J. Agric Sci., 2(2), 149-155.

Abdel, C.G. (2007).water relation in faba bean (*Vicia faba* L. cv. Aquadulce): 2- Boosting growth and dry seed yield under rainfed by the use of Naphthalene-3-acetic acid (NAA) and inole-3-butyric acid (IBA). J. Tikrit University for Agricultural Sci., 7(2), 262-271.

Abdel, C.G. (1982). Drought resistance in (*Vicia faba* L.). A study of four cultivars. M.Sc. thesis. School of Biological science, Bath University, Bath England, UK.

Abdel, C.G. (1993). Effect of complementary watering on growth stages and yield of *Vicia faba* L. Mesopotamia J. of Agric., 25(3), 5-10.

Abdel, C.G. (1995). Effects of supplementary irrigation and indole-3-butyric acid on onion growth and yield. Mesopotamia J. Agric., 27(1), 26-29.

Abdel, C.G. (2005). Water relations in lettuce (*Lactuca sativa* L. var Longifolia). Mesopotamia J. of Agric., 33(4), 2-16.

Abdel, C.G. (2006a). Improving yield and yield quality of four faba bean cultivars grown under rain falls.1-Application of some inorganic nutrients. Mesopotamia J. of Agric., 34(4), 12-22.

Abdel, C.G. (2006b). Improving yield and yield quality of four faba bean cultivars grown under rain falls.2-Application of growth regulators. Mesopotamia J. of Agric., 34(4), 23-32.

Abdel, C.G. (2009). Evaluating the productivity of five cucumber (*Cucumis sativus* L.) cultivars and their response to varying rates of gibberellic acid (GA_3). J. Dohuk Univ.,12(1), 10-21.

Abdel, C.G. (2009a). Improving the production of well irrigated cauliflower (Brassica oleracea var. Botrytis cv. Snowball Y IMP) by foliar spray of some growth regulators. JZS., 12(1), 29-49 part A.

Abdel, C.G. (2009b). Stomata behavior of three irrigated and non-irrigated onion (*Alium cepa* L.), cultivars grown on polyethylene mulched soils. J. Dohuk Univ. Agric. Vet., 12(2), 1-11.

Abdel, C.G. (2011). Improving the production of radish (*Raphanus sativus* L.cv. local black) by Fe-EDDHA and carrots (*Daucus carrota* L. var. sativus cv. nates by indole-3-butyric acid (IBA). Afr. J. Agric. Res., 6(4), 978-985.

Abdel, C.G., Al-Hamadany, S.Y.H. (2007). Evaluation of some faba bean (*Vicia faba* L.) cultivars for drought resistance and water consumptive use. 3- Growth stages response to rainfall and supplementary irrigation. Mesopotamia J. Agric., 35(2), 9-17.

Abdel, C.G., Al-Hamadany, S.Y.H. (2010). Response of five water stressed Fababean (*Vicia faba* L.) cultivars to exogenous absiscic acid application. Dohuk Univ. J. Agric. Vet., 13(1), 12.

Abdel, C.G., Al-Salem, S.S.D. (2010). Influence of three irrigation levels on growth, stomata behavior and yield of cowpea (*Vigna unguiculata* L. Walp, cv. Ramshorn) produced by three varying seed companies. Tikrit J. Agric. Sci., 10(2), 14.

Abdel, C.G., Rahi, H.S. (1992). The ability of copper sulphate in increasing drought resistance of onion. Mesopotamia J. 24, 1:41-46.

Adnan, A. S., Abdel, C. G. (1994). Effects of supplemental watering and gibberellic acid (GA_3) on Black Cumin (*Nigella sativa* L.) growth and yield. The Iraqi J. of Agricl. Sci. 25, 2:107-111.

Alexieva, V., Sergiev I., Mapelli, S., Karanov, E. (2001). The effect of drought and ultraviolet radiation on growth and stress markers in pea and wheat. Plant Cell Environ., 24, 1337–1344.

Alexieva, V., Sergiev, I., Mapelli, S., Karanov, E. (2001) The effect of drought and ultraviolet radiation on growth and stress markers in pea and wheat. Plant Cell Environ., 24, 1337–1344.

Al-Hamadany, S.Y.H. (2005). The effects of supplemental irrigation and absiscic acid (ABA) spraying on growth and yield of some fababean (*Vicia faba* L.) cultivars. PhD Thesis, Mosul University, Mosul, Iraq.

Al-Hamadany, S.Y.H., Abdel, C.G (2008). Improving radish yield by the application of nitrogen fertilizers. Tikrit Univ. J. Agric. Sci., 8(2), 360-370.

Al-Juboori, A. (2005). Effects of mulching and irrigation on yield of three onion cultivars. M.Sc. Thesis, Horticulture Dept, Agriculture and Forestry College, Mosul University, Iraq.

Al-Rawi, I.M.T. (2011). Anatomical and physiological alteration caused by water stress in some legume crops. PhD Thesis, Dept of Field crops Agriculture College, Salahalddin University, Kurdistan Region, Iraq.

Al-Taai, A.A.H., Al-Khafaji, M.A. Selman, M.A. (1994). The effect of nitrogen, iron and zinc application on the productivity of some citrus species .B˙-Clemanatina mandarin (*Citrusreliculate*)*. Iraq* .Agric. Sci., 25(5), 122- 133.

Amar, S. (2003). Fruit Physiology and Production-Kalyani Publishers-New Delhi – India.

Amin, A.A., Rashad, M.EL-Sh., EL-Abagy, H.M.H. (2007). Physiological Effect of Indole - 3 – Butyric Acid and Salicylic Acid on Growth, Yield and Chemical Constituents of Onion Plants. J. Appl. Sci. Res., 3(11), 1554-1563.

Asada, K. (1999). The water-water cycle in chloroplasts: Scavenging of active oxygens and dissipation of excess photons. Ann. Rev. Plant Physiol. Plant Mol. Biol., 50, 601-639.

Bamarny, K.A.A. (2011). Dry and cultivation of three water melon (*Citrullus lanatus* Thuub Matsum) cultivars in Duhok provine. M.Sc Thesis, agriculture horticulture department.

Bates, L.S., Waldren, R.P., Teare, J.D. (1973). Rapid determination of free proline for water stress studies. Plant Soil, 39, 205-208.

Berlyn, G.P., Miksche, P.J. (1976). Botanical Micro Technique and Cytochemistry. Ames Iowa Press.

Bhandari, A.R., Randhawa, N.S. (1985). Distribution of available micronulrients in soil of apple orchards in Mimachal Paradesh. J. Indian Soc. Soil Sci., 33, 171-174.

Bolanos, L., Brewin, N.J., Bonilla, I. (1996). Effects of boron on rhizobium-legume cellsurface interaction on nodule development. Plant Physiol. 110, 1249-1256.

Bolanos, L., Cebrian, A., Redondo-Nieto, M., Rivilla, R., Bonilla, I. (2001). Lectin-like glycoprotein PsNLEC-1 is not correctly glycosylated and targeted in boron-deficient pea nodules. Mol. Plant-Microbe Interact., 14, 663-670.

Bolanos, L., Redondo-Nieto, M., Rivilla, R., Brewin, N.J., Bonilla, I. (2004). Cell surface interactions of Rhizobium bacteroids and other bacterial strains with symbiosomal and peribacteroid membrane components from pea nodules. Mol. Plant-Microbe Interact. 17, 216-223.

Bonde, E.K. (2008). Effects of gibberellic acid on growth and parthenocarpy in the dwarf telephone pea. Physiologia Plantarum, 19(2), 356-364.

Borel, C., Frey, A., Marion-Poll, F., Tardieu, Simonneau, T. (2001). Does engineering ABA synthesis in N.plumbaginifolia modify stomatal response to drought? Plant, Cell and Environment, 24, 477-489.

Butterfield, B.G., Meylan, B.A. (1982). Cell wall hydrolysis in the tracheary elements of the secondary xylem. In P Baas, ed, New Perspectives in Wood Anatomy. Junk Publishers, The Hague, The Netherlands.

Chartzoulakis, K., Patakas A., Kofidis, G., Bosabalidis, A. Nastou, A. (2002). Water tress affects leaf anatomy, gas exchange, water relations and growth of two avocado cultivars. Scientia Horticulturae, 95, 39–50.

Chhun, T., Takcta, S., Tsurumi, S., Masahiko, I. (2004). Different behaviour of indole-3-acetic acid development in rice (*Oryza sativa* L.). Plant Growth Regul., 43, 135-143.

Choat, B.M., Ball, J., Luly, J., Holtum J. (2003). Pit Membrane Porosity and Water Stress-Induced Cavitation in Four Co-Existing Dry Rainforest Tree Species. Plant Physiology, 131, 41–48.

Chowdhury, R.S., Chowdhury, M.A. (1985). Hydrogen peroxide metabolism as an index of water stress tolerance in jute. Physiol. Plant, 65, 503-507

Cornic, G., Massacci, A. (1996). Leaf photosynthesis under drought stress. In 'Photosynthesis and the environment' (ed. N.R. Baker), Kluwer Academic Publishers, 347-366.

Cosgrove, D.J. (2005). Growth of the plant cell wall. Nat Rev Mol Cell Biol 6:850-861.

Crowly, D. E., Smith, W. (1994). Zinc nutrition of Avocado. California Avocado Society, 78, 155-165.

El-Shraiy, A.M., Hegazi, A.M. (2009). Effect of Acetylsalicylic Acid, Indole-3-Bytric Acid and Gibberellic Acid on Plant Growth and Yield of Pea (*Pisum sativum* L.). Australian Journal of Basic and Applied Sciences, 3(4): 3514-3523.

Emongor, V.E. (2002). Effect of benzyladenine and gibberellins on growth, yield and yield components of common bean (*Phaseolus vulgaris*). Uniswa Res.J. Agric. Sci. Technol., 6: 65-72.

Emongor, V.E. (2007). Gibbrilic acid (GA_3) Influence on vegetative growth, nodulation and yield of CowPea (*Vigna unguiculata* L.) Walp.Jornal of agronomy 6(4) :509-517.

Epstein, E., Zilkah, S., Faingersh, G., Rotebaum, A. (1993).Transport and metabolism of indole-3-butyric acid in sterile easy-to-root and difficult-to-root cuttings of sweet cherry(*Prunus avium* L.). Acta Hort 329: 292–295.

Evans, J.R., von Caemmerrer, V., Setchell, B.A., Hudson, G.S. (1994). The relationship between CO2 transferconductance and leaf anatomy in transgenic tobacco with a reduced content of Rubisco. Aust. J. Plant Physiol. 21:4754–4795.

FAO (Food and Agriculture Organization of the United Nations) (2008). FAOSTAT. Available at [http://faostat.fao.org]. Accessed March 23, 2010.

Fricke, W., Pahlich, E. (1990). The effect of water stress on the vacuole–extravacuole compartmentation of proline in potato cell suspension cultures. Physiol. Plant 78, 374–378.

Gaber, A.M., El–Shahaby, A O., Ramadan, A.A. (2000). Effect of some hormonal treatments on chemicalcomposition and favism causative agents in the yielded seeds of *Vicia faba*. Egypt. J. Sci., 24:17–45.

Garay-Arroyo, A.J., Colmenero-Flores, M., Garciarrubio, A., Covarrubias, A.A. (2000). Highly hydrophilic proteins in prokaryotes and eukaryotes are common during conditions of water deficit. J Biol Chem 275: 5668–5674.

Garg, A.K., Kim, J.K., Owens, T.G. Ranwala, A.P., Choi, Y.D., Kochian, L.V., Wu, R. (2002). Trehalose accumulation in rice plants confers high tolerance levels to different abiotic stresses. Proc. Natl. Acad. Sci. USA 99, 15898-15903.

Goldspink, B.H., Sutton, J. (2001) . Trace element and magnesium treatments for apple trees. (Western Australia) . Farm note 97/2000.

Goodwin, T.W., Mercer, E.I. (1985). Introduction to Plant Biochemistry. 2nd ed. Pergamum Press.

Gregory, P.J. (1988). Root growth of chick pea, faba bean, lentil and pea and effect of water and salt stresses. In R. J. Summerfield ed. World Crops: Cool-Season Food Legumes. Dordencht, The Netherland Kluwer Academic Publisher.

Gunes, A., Inal, A., Adak,M.S., Bagci, E.G., Cicek, N., Eraslan, F. (2008). Effect of drought stress implemented at pre- or post- anthesis stage some physiological as screening criteria in chickpea cultivars. Rus. J. Plant Physiol., 55: 59-67.

Hacke, U.G., Stiller, V., Sperry, J.S., Pittermann, J., McCulloh, K.A. (2001). Cavitation fatigue: embolism and refilling cycles can weaken the cavitations resistance of xylem . Plant physiol., 125:779-786.

Hassawy, W.A., Abdel, C.G. (2010). Influence of priming two cucumber cultivar seeds by soaking and drying cycles in some growth regulator solutions on growth and yield. J. of Tikrit Univ. for Agricl Sci. , 10 :18 .

Hearin, A.B. (1981). Cotton nutrition. Field Crop Abst.34: 11-34.

Hemphill, D. (2002). Commercial vegetable production guides: Peas, Western Oregon. OregonState University. http://www.orst.edu/Dept/NWREC/pea-w.html.

Hooley, R. (1994) Gibberellins : Perception, transduction and responses. Plant Mo1.26:1529-1555

Huang, J.R., Hirji, L., Adam, K.L., Rozwadowski, J.K., Hammerlind, W.A., Keller, A., Selvaraj, G. (2000). Genetic engineering of glycinebetaine production toward enhancing stress tolerance in plants: metabolic limitations. Plant Physiol. 122, 747-756.

Jones, J.B. Jr. (1998) Plant Nutrition Manual . CRC press . Florida , USA . 149.

Kavi Kishor, P.B., Hong, Z., Miao, G., Hu, C.A., Verma, D.P.S. (1995). Overexpression of D 1-pyrroline-5-carboxylate synthetase increases proline production and confers osmotolerance in transgenic plants. Plant Physiol. 108, 1387-1394.

Kient, J.M., Sachs, R.M., Beriner, G. (1985). The Physiology of Flowering. Vol. II, CRS Press Inc.

Kozlowski, T.T. (1980). Water Deficit and Plant Growth. Vol III, Harper and Row Pub. New York.

Leite, V.M., Rosolem, C.C., Rodrigues, J.D. (2003). Gibberlin and Cytokinin effects on soybean growth . Sci . Agric . 60 (3).

Lodwig E. and P. Poole (2003). Metabolism of Rhizobium bacteroids. Critical Reviews in Plant Sciences 22, 37–78.

Lovisolo, C., Schubert, A. (1998). Effects of water stress on vessel size and xylem hydraulic conductivity in *Vitis vinifera* L. Journal of Experimental Botany, Vol. 49, No. 321, pp. 693–700.

Lucena, J. J. (2000). Effects of bicarbonate, nitrate and other environmental factors on iron deficiency chlorosis. A review. J. Plant Nutr. 23(11-12): 1591-1606.

Ludwing-Muller, J. (2000). Indole-3-butyric acid in plant growth and development. Plant growth regul., 32:219-230.

Miller, P.R., Holmes, A.J., Engel, R.E. (2005). Optimizing fertilizer N in direct-seeded, diversified crop –ping sequences.MSU extension service fertilizer facts.

Mishra, L.N., Sigh, S.K., Sharma, H.C., Goswanu, A.M., Pratap, B. (2003). Effect of micronutrients and rootstocks on fruit yield and quality of kinnow under high density planting. Indian J. Hort., 60: 131–134.

Mukhtar, F.B., Singh, B.B. (2006). Influence of photoperiod and gibberelic acid (GA3) on the growth and flowering of cowpea (*Vigna unguiculata* (L) Walp). J. Food Agric. Environ., 4, 201-203.

Murphy, L.S., Walsh, L.M. (1972). Correction of Micronutrient Deficiencies with Fertilization in: Micronutrient in Agriculture. Ist Edn., Mortvedt et al., 1972. (eds.), Soil Sci. Soc. Am. Madison Wisconsin, USA, PP, 347-381.

Naguib, N., Ali, M. (2002). Variations in productivity of *Hibiscus sabdariffa* L. in response to some agricultural supplementations. Annals Agric. Sci., Cairo, 47, 875–892.

Neumann, P.M. (1995). The Role of Cell Wall Adjustment in Plant Resistance to Water Deficits. Crop Sci., 35, 1258-1266.

Nunes, M. A., Catarino, F., Pinto, E. (1989). Strategies for acclimation to seasonal drought in Ceratonia siliqua leaves. Physiol. Plant, 77, 150–156.

Nasiri J., A. Haghnazari and J. Saba. (2009). Genetic diversity among varieties and wild species accessions of pea (*Pisum sativum* L.) based on SSR markers. African Journal of Biotechnol., 8(15), 3405-3417.

Pic, E., de la Serve, B. T., Tardieu, F.O., Turc, O. (2002). Leaf Senescence Induced by Mild Water Deficit Follows the Same Sequence of Macroscopic, Biochemical, and Molecular Events as Monocarpic Senescence in Pea. Plant Physiology, 128, 236–246.

Pilon-Smits, E.A.H., Ebskamp, M.J.M., Paul, M.J., Jeuken, M.J.W., Weisbeek, P.J., Smeekens, S.C.M. (1995). Improved performance of transgenic fructan-accumulating tobacco under drought stress. Plant Physiol. 107, 125-130.

Prasad, R., Power, J.F. (1997). Soil fertility management for sustainable agriculture CRC lewis pub. Pp.256-268.

Pritchard, J., Wyn, R.G. Jones, Tomos, A.D. (1991). Turgor, growth and rheological gradients of wheat roots following osmotic stress. Journal of Experimental Botany, 42, 1043–1049.

Ramos, M.L.G., Gordon, A.J., Minchin, F.R., Sprent, J.I., Parsons, R. (1999). Effect of Water Stress on Nodule Physiology and Biochemistry of a Drought Tolerant Cultivar of Common Bean (*Phaseolus vulgaris* L.). Annals of Botany, 83, 57-63.

Ringo, P. (2006). Plant Hormones: Part 8, A Basic Botany Series. Adapted from: the Nature of Life 2006 McGrow Hill.

Riov, J., Yang, S.F. (1989). Ethylene and auxin-ethylene interactionin adventitious root formation in mung bean (*Vignaradiata*) cuttings. J Plant Growth Regul., 8, 131–141.

Routley, D.G. (1966) Proline accumulation in wilted ladino clover leaves. Crop Sci., 6, 358-361.

Schon, M.K., Blevins, D.G. (1990). Foliar boron application increases the final number of branches and pods on branches of field grown soy beans. Plant Physiol., 42, 1329-1333.

Serraj, R. Sinclair, T.R. (2002). Osmolyte accumulation: can it really help increase crop yield under drought conditions? Plant, Cell Environ., 25, 333-341.

Sharp, R.E., Hsiao, T.C., Silk, W.K. (1990). Growth of the maize primary root at low water potentials, II: Role of growth and deposition of hexose and potassium in osmotic adjustment. Plant Physiol., 93, 1337-1346.

Shashidhar, V.R., Prasad, T.G., Sudharshan, L. (1996). Hormone signals from roots to shoots of sunflower (*Helianthus annuus* L.). Moderate soil drying increases delivery of abscisic acid and depresses delivery of cytokinins in xylem sap. Annals of Botany, 78, 151 – 155.

Slinkard, A.E., Bascur, G., Hernandez-Bravo, G. (1994). Biotic and abiotic stresses of cool season food legumes in the western hemisphere. 195-203

Tagliavini, M., Rombola, A.D. (2001). Iron deficiency and chlorosis in orchard andvineyard ecosystems. Eur. J. Agron., 15, 71-92.

Tarczynski, M.C., Jensen, R.G., Bohnert, J.H. (1993). Stress protection of transgenic tobacco by production of the osmolyte Mannitol. Sci., 259, 508-510.

Thankamani, C.K., Chempakam, B., Ashokan, P.K. (2003). Water stress induced changes in enzymatic activities and lipid peroxidation in black pepper (*Piper nigrum*). J. Medicinal Aromatic Plant Sci., 25, 646(2003).

Todd, G.W., Webster, D.L. (1965). Effects of repeated drought periods on photosynthesis and survival of cereal seedlings. Agron. J., 37, 399.

Tohidi-Moghadam, H.R., Shirani-Rad, H.A., Nour-Mohammadi, G., Habibi, D., Mashhadi-Akbar-Boojar, M. (2009). Effect of Super Absorbent Application on Antioxidant Enzyme Activities in Canola (*Brassica napus* L.) Cultivars under Water Stress Conditions. American Journal of Agricultural and Biological Sciences, 4(3), 215-223.

Turner, N.C. (1986). Crop Water Agronomy. 39 1-51.Deficit. Academic Progress Advances in Varanini, Z., R. Pinton, M. G. De Biasi and A. Maggioni (1993). Low molecular weight humic substances stimulate H^+-ATPase activity of plasma membrane vesicles isolated from oat (*Avena sativa* L.) roots. Plant Soil, 153, 61-69.

Unyayar S., Topcuoglu, S.F., Unyayar, A. (1996). Modified method for extraction and identification of Indole-3-acetic acid (IAA), Gibberellic acid (GA_3), Abscisic acid (ABA) and Zeatin produced by *Phanerochaete chrysospoium* ME446. Bulg. J. Plant Physiol., 22(3–4), 105–110.

Uzun, A.B., Sincik, M., Filya, I., Acikgoz, E. (2005) .Yield and quality of forage type pea lines of contrasting leaf types. Europ. J. Agronomy, 22, 85-94.

Valentovic, P., Luxova, M., Kolarovic, L. Gasparikova, O. (2006). Effect of osmotic stress on compatible solutes content, membrane stability and water relationsin two mwize cultivars. Plant Soil Environ., 52(4), 186-191.

Varanini, Z., Pinton, R., De Biasi, M.G., Maggioni, A. (1993). Low molecular weight humic substances stimulate H^+-ATPase activity of plasma membrane vesicles isolated from oat (*Avena sativa* L.) roots. Plant Soil, 153, 61-69.

Vocanson, A., Jeuffroy, M., Roger-Estard, J. (2006). Effect of sowing date and cultivar 0n root system development in (*Pisum sativum* L .). Plant Soil, 283, 339-352 .

Wery, J., Turc, O., Lecoeur, J. (1993). Mechanism of resistance to cold and drought. In Cool Season Legumes, with special reference to chick pea and pea in breeding for stress.

Wolfe, D.W., Henderson, D.W., Hsiao, T.C., Alvino, A. (1988). Interactive water and nitrogen effects on senescence of maize: I. Leaf area duration, nitrogen distribution, and yield. Agron. J., 80, 859–864.

Xiao, G.J., Zhang, Q., Xiong, Y.C., et al. (2009). Effects of temperature increase on water use and total yields of crops in a pea–spring wheat–potato rotation system in semiarid regions of China. Agric Water Manage. A, 91, 86–91.

Yamaguchi-Shinozaki K., Mundy, J., Chua, N.H. (1990). Four tightly linked rab genes are differentially expressed in rice. Plant Mol. Biol., 14, 29-39.

Zang, J., Daves, W.J. (1990). Changes in the concentration of ABA in xylem sap as a function of changing soil water status can account for changes in leaf conductance and drought. Plant Cell Environ. 13, 277-85.

Zhang, J., Davies, W.J. (1989). Does ABA in the xylem sap control leaf growth in soil-dried maize and sunflower plants? Journal of Experimental Botany, 41, 1125-3276.