J. Plant Production, Mansoura Univ., Vol. 9 (1): 101 - 108, 2018

An Attempt to Mitigation of Irrigation Water Deficit Stress in Pea (*Pisum sativum*, L) Plants by Phosphorus Fertilizer

Metwaly, E. E.
Vegetable and Floriculture Dept., Faculty of Agric., Mansoura University. Mansoura, Egypt

ABSTRACT

This investigation was carried in order to elucidate the response of pea (cv. Master pea) to various levels of Phosphorus fertilizer, i.e 45, 60, 75 and 90 kg as P_2O_5 /fed. under three levels of irrigation water deficit (100% of common irrigation as control, moderate stress 75 % of common irrigation and severe stress 50 % of the common irrigation). Therefore, two field experiments were conducted in the Experimental Station, Faculty of Agriculture, Mansoura University during 2015 and 2016 in winter seasons. The results indicated that vegetative growth characters (plant height, plant fresh weight, branches number, leaves fresh weight, leaves number and leaves area) per plant, leaves chemical composition (N, P, K and chlorophyll pigments), pods yield and its quality (pods weight per plant, pods number per plant, seeds fresh weight per plant, 100 seeds fresh weight, seeds dry weight yield and pods yield per fed., Vit. C and TSS) and plant water relations (leaf relative water content and leaf membrane stability index) were decreased by increasing of irrigation water deficit. On the contrast, leaves and seeds dry matter % were increased by increasing of irrigation water deficit. On the other hand, water use efficiency is not affected with irrigation water deficit. With respect to the effect of phosphorus fertilizer rates, the data show that, the mentioned attributes were increased up to 60 kg as P_2O_5 /fed then declined at and 75 kg as P_2O_5 /fed. On the other hand, 45 kg as P_2O_5 /fed gave the lowest values for most effective mentioned parameters. As for the interaction between irrigation water deficit and Phosphorus fertilizer rates showed that common irrigation and 60 kg as P_2O_5 /fed combination recorded the maximum values for more effective mentioned characters. In addition, results showed that common irrigation or moderate stress treatments with Phosphorus fertilizer rates had insignificant differences for most effective previous parameters.

Keywords: peas, water deficit, Phosphorus, pods yield, and water use efficiency.

INTRODUCTION

Pea (*Pisum sativum* L.) is one of the most important and popular legume vegetable crops. It has a high content of protein, vitamins, carbohydrates, minerals. Also, it's important for human nutrition and soil fertility (Ashraf *et al*., 2011).

Peas yield and its quality are affected with stress conditions which contribute to low productivity such as insects and other pests, disease, flooding, environmental conditions, soil problems especially low fertility, salinity and pH, chemical toxicity, ultraviolet radiation and water deficit (Jin *et al*., 2014)

Among these stresses, water deficit is on the top, which limits the plant growth and productivity of peas. It has effects on photosynthesis, plant growth, agricultural crop production and quality. Pea seed yield reduction was positively related to decreasing of amount irrigation water reduction and reach up to40 - 50% of seed yield (Dogan *et al*., 2015). Several studies have shown that water deficit has been reported as key factor to limit plant growth, development, and morphological characteristics (plant height, leaves fresh weight and pods yield) of pea plant (Ashraf *et al*., 2011). In addition, 100% of irrigation requirement gave the highest values of leaf area, pods weight per plant, seeds dry matter % of faba bean (Hegab *et al*., 2014 and Migdadi *et al*., 2016). Moreover, several investigates have shown that seeds yield (ton/fed.) was decline with reduction of irrigation water for different crops such as cow pea (Faisal and Suliman, 2010 and Hayatu *et al*., 2014). As well as, the highest branches, pods weight per plant and chlorophyll Content of common bean were recorded with 80 % of the potential evapotranspiration (ET) and the yield reduction has been achieved by decreasing irrigation water (Marzouk *et al*., 2016). Also water deficit results in profound effects on nodulation and nitrogen fixation of common bean (Ndimbo, 2015). On contrast, water use efficiency of rajmash (*Phaseolus vulgaris* L.) was increased with increasing irrigation water deficit (Nayak *et al*., 2015).

Phosphorus is one of the most important nutrient elements. Its has a fundamental role in many of the plants physiological processes such as the benefit from sugar and starch, required in the synthesis of nucleic acids, phospholipids, ATP, photosynthesis and the transfer of energy. Furthermore, stimulates root and flower formation and accelerates maturity of crops. A lot of studies also mentioned earlier that the applying phosphorus (P) stimulates growth responses under water stress. Therefore, plants under water stress have a greater internal requirement for P to become more tolerate to water scarcity (Jin *et al*., 2014). Phosphorus may be a critical restriction of legumes under shortage nutrient environments because there is a great need for P in the N_2 fixation process (Faisal, *et al*., 2000)

Several studies have shown that, applied phosphorus at 40kg of P_2O_5 ha^{-1} mitigation the negative impacts of water deficit and produced the biggest significant values of pods number per plant and seeds weight ha^{-1} on cowpea plants (Uarrota, 2010). Also, using 90 kg P ha^{-1} was more useful for improving growth, yield and its components of mungbean plants under irrigated water deficit (Amanullah *et al*., 2016). The highest nodule number, net return / ha and benefit cost ratio were recorded with the application of 75 kg P_2O_5/ha. of broad bean (Sarkar *et al*., 2017).On the contrary, its deficiency leads to significant reduction in pods and seeds yield productivity of mung bean (Ali *et al*., 2010) and adversely affected the growth characters (leaf area, leaves and pods number per plant, seeds number per pod, weight of 1000 seed and seed yield/ hectare in peas (Ashraf *et al*., 2011). The P scarcity situation become worst under shortage of irrigation water that lead to reducing in affect fertilizer efficiency and great production of legumes crop (Hussein *et al*., 2012). Therefore, fertilizer management becomes one of the important factors for crop productivity enhancement (Sakar *et al*., 2017).

Therefore, a field experiment was undertaken to assess the ability of Phosphorus fertilizer to mitigation of the worst impacts of irrigation water deficit on growth and yield of pea.

MATERIALS AND METHODS

Two field experiments were carried out in the Experimental Station, Faculty of Agriculture, Mansoura University in the two winter seasons of 2015 and 2016 to study the impact of three levels of irrigation water deficit (without stress as control 100% from common irrigation, moderate stress 75 % from common irrigation and severe stress 50 % from the common irrigation and Phosphorus fertilizer, i.e 45, 60, 75 and 90 kg as P_2O_5 /fed. on growth and yield of pea (cv. Master pea) grown under clay loamy soil conditions using surface improving irrigation system. The soil characters of the studied soil were determined (Table 1) from the top layer (0-30 cm depth).

Table 1. The soil characterized of the studied soil during the two seasons of 2015 and 2016.

Seasons	Silt %	Clay %	Sand %	Texture soil	F.C %	W.P %	AW %	PH	E.C (dSm-1)	O.M %	$CaCO_3$ %	N ppm	P ppm	K ppm
2015	41.2	36.9	21.9	Clay loamy	34.9	17.7	17.2	7.89	1.62	1.89	2.99	54.0	5.8	296
2016	41.7	36.7	21.6	Clay loamy	34.8	17.8	17.0	7.91	1.69	2.06	2.98	54.2	6.1	288

F.C : Field Capacity; W.P.: Welting point; AW: Available water; OM: Organic matter

Seeds of peas which uniformity in size and shape were sown in the soil (moderately moisture approximately 60%) on 18th and 15th of October in both seasons, respectively in hills on three side of ridges which were (3 m length and 0.7 m in width), five to seven seeds were sown in hills. Each sub plot consists of five rows and the plot area was 10. 5 m^2.

Irrigation water deficit treatments were carried out, i.e common water irrigation without stress as control (100% of common water irrigation based on quantity for each irrigation time), moderate stress and sever stress 75 % and 50 % of the common water irrigation of each one).

Irrigation water amounts of were applied as 262 and 266 m^3 water/fed. in the two seasons, respectively, to all experimental units in equal dose during germination as furrow irrigation across water counter. Treatments irrigation water deficit were done three times every 22 days as improved furrow irrigation by using pipe 63 mm in diameter, amounts of water irrigation were presented in (Table 2).

Table 2. Amounts of irrigation water applied (m^3 water/fed) during the two seasons of 2015 and 2016

Treatments	First season			Second seasons		
	100 %	75 %	50 %	100 %	75 %	50 %
Germination	262.0	262.0	262.0	266.0	266.0	266.0
First irrigation	161.0	120.8	80.5	162.0	121.5	81.0
Second irrigation	170.5	127.9	85.3	169.0	126.8	84.5
Third irrigation	179.0	134.3	89.5	181.0	135.8	90.5
Total	772.5	645.0	517.3	778.0	650.1	522.0

Treatments of phosphorus fertilizer levels, i.e 45, 60, 75 and 90 kg as P2O5 /fed. were added as single calcium super phosphate (15.5 % P2O5) i.e. 75% during preparation of the soil and 25 % at the first irrigation.

All treatments received 20 m3/fed of farmyard manure was added during soil preparation, 120 kg N and 50 kg K2O kg/ fed. as urea (46.5 %), and potassium sulfate (50 % K2O), respectively. Urea and potassium sulphate were added in two split equal doses at 22 and 44 days after sowing.

Experimental design:

Experiments were laid out in in a split - plots design based on complete randomized blocks design with three replications. Treatments of irrigation water deficit were designation in the main plots, while phosphorus fertilization rates were customize in the sub plots.

Measurements:

Five plants were chosen randomly at 75 days after sowing from each sub plot to measure the following parameters in both seasons.

1- Vegetative growth characters:

Plant height, plant fresh weight, branches number, leaves fresh weight, leaves number, leaves area and leaves dry matter percentage per plant.

2 – Leaves chemical composition:

N, P and K %, chlorophyll a, b, carotenoids content were determined according to AOAC (1990).

3- Pods yield and its chemical quality:

Pods weight per plant, pods number per plant, seeds fresh weight per plant, 100 seeds fresh weight, seeds dry matter percentage, Vit. C, TSS, seeds dry weight and pods yield per fed. were recorded at 85 days after sowing expect seeds dry weight (120 days after sowing).

4- Plant water relations:

Leaf relative water content (LRWC) and leaf membrane stability index were evaluated according to (Hayatu *et al*., 2014), Water use efficiency (WUE) was measured according to (Jin *et al*., 2014).

Statistical analysis:

All data were statistically analyzed by using the analysis of variance according to Snedecor and Cochran

(1980). Least significant difference (LSD) at the probability of 5 % was used as reported by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1- Vegetative growth characters:

Data presented in Table 3 showed that vegetative growth attributes (plant height, plant fresh weight, branches number per plant, leaves fresh weight per plant, leaves number /plant and leaves area /plant were significantly reduced by application of irrigation water deficit treatments. The maximum values of the mentioned attributes were recorded with common irrigation followed by moderate stress (75 % from common irrigation) treatment, the minimum values were obtained after using sever stress (50 % from common irrigation). On contrast, the highest leaves dry matter percentage values were achieved with sever stress treatment (50 % from common irrigation). On contrast, the lowest values were achieved with application of common irrigation in both seasons.

Such increases in case of control treatment can be due to that available a lot of water enhancement nutrient availability resulting in improving macro- and micro- elements absorption and transport. But, the decreasing in previous parameters may be due to the scarcity of cells growth, elongation and development in plant organs especially in stem and leaves. There for, the effect of water deficit stress can be revealing in smaller leaves or plant height, decline in leaf area, light absorption and reduction in of photosynthesis which reflected negatively on plant growth parameters. These results are in agreement with the findings of Hegab *et al*. (2014) on broad bean and Dogan *et al*. (2015) on peas.

Table 3. Impact of phosphorus fertilizer rates after 75 days from planting on vegetative growth characters of peas under irrigation water deficit during the two seasons of 2015 and 2016.

Treatments		Plant Height (cm).		plant fresh weight g / plant		Branches No / plant		Leaves FW g / plant		Leaves No / plant		Leaves area (cm^2) / plant		Leaves DM%	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Irrigation water deficit															
Common irrigation		71.6	73.6	35.9	36.7	0.98	1.01	9.04	9.29	8.93	9.18	340	350	13.12	13.48
Moderate		60.4	62.0	30.5	30.8	0.83	0.86	7.66	7.87	7.56	7.77	288	296	16.81	17.28
Sever		49.0	50.3	23.4	25.1	0.67	0.69	6.18	6.35	6.10	6.27	232	239	20.07	20.62
LSD 5%		11.4	11.7	5.5	6.0	0.15	0.16	1.44	1.48	1.42	1.46	54	56	3.34	3.43
Phosphorus fertilizer rates (kg as P_2O_5 /fed.)															
45		55.1	56.7	27.5	28.2	0.76	0.79	7.00	7.21	6.93	7.14	263	271	15.17	15.63
60		65.8	67.4	33.1	33.7	0.90	0.93	8.29	8.52	8.21	8.44	312	320	17.92	18.43
75		60.6	62.2	30.1	30.9	0.83	0.85	7.65	7.85	7.53	7.74	288	296	17.05	17.51
90		59.9	61.4	29.2	30.6	0.82	0.84	7.57	7.76	7.45	7.65	285	292	16.52	16.95
LSD 5%		9.0	9.2	4.6	4.4	0.12	0.13	1.14	1.17	1.12	1.16	43	44	2.48	2.56
Interaction															
Common irrigation	45	66.5	68.5	33.2	34.2	0.92	0.95	8.39	8.64	8.31	8.55	315	325	11.52	11.88
	60	75.9	77.8	38.8	38.9	1.04	1.08	9.56	9.83	9.47	9.73	360	369	14.42	14.81
	75	72.4	74.4	36.0	37.0	0.99	1.02	9.15	9.39	9.01	9.25	344	354	13.72	14.08
	90	71.8	73.7	35.7	36.7	0.99	1.01	9.07	9.31	8.94	9.17	342	351	12.82	13.16
Moderate	45	56.3	58.0	27.9	28.7	0.79	0.81	7.23	7.45	7.16	7.38	272	280	15.60	16.07
	60	65.6	67.2	32.7	33.6	0.90	0.93	8.26	8.49	8.18	8.41	310	319	18.00	18.51
	75	60.6	62.2	32.1	30.9	0.83	0.85	7.65	7.85	7.53	7.74	288	296	17.04	17.51
	90	59.2	60.7	29.5	30.2	0.81	0.83	7.48	7.68	7.37	7.56	282	289	16.60	17.04
Sever	45	42.6	43.8	21.2	21.9	0.59	0.60	5.37	5.53	5.32	5.48	201	208	18.40	18.95
	60	56.0	57.4	27.9	28.6	0.77	0.79	7.06	7.25	6.99	7.18	265	273	21.36	21.96
	75	48.7	50.0	22.2	24.9	0.67	0.69	6.15	6.31	6.06	6.22	231	238	20.40	20.93
	90	48.6	49.9	22.2	24.8	0.67	0.69	6.14	6.30	6.05	6.21	231	237	20.14	20.66
LSD 5%		15.6	16.0	8.0	7.7	0.21	0.22	1.98	2.03	1.95	2.01	74	76	4.30	4.43

Concerning the effect of phosphorus fertilizer rates (kg as P_2O_5 /fed.), results in Table 3 show that the characters mentioned previously were increased gradually until 60 kg P_2O_5 /fed. then decline. On contrary, the minimum values were noticed with by using 45 kg P_2O_5 /fed. treatment in both seasons. Improvement in vegetative growth parameters could be due to Phosphorus application might have adverse action to the water deficit stress effects. Phosphorus application might have increased the photosynthetic activities and transportation of photosynthates. Also, its plays an indispensable role within the energy storage and transfer in the form of adenosine triphosphate ATP, adenosine diphosphate ADP as well as deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). It also, stimulates root formation, cell wall division, synthesis of starch, fat and in fact most biochemical activities like amino acid synthesis and increasing the efficacy of other nutrients which might be resulted in higher vegetative growth. These results are in accordance with those reported by Ashraf *et al*. (2011) on peas and Sakar *et al* (2017) on broad bean.

As for the interaction between irrigation water deficit and phosphorus fertilizer rates effect on pea plant, results in Table 3 show that the combination common irrigation (control) treatment and 60 kg P_2O_5 was found to be the best as indicated by previous parameters, hence recorded the highest values. On contrary the minimum values were recorded by application of sever stress application (50 % from common irrigation) and 45 kg P_2O_5. These results are in agreement with those obtained by Ali *et al*. (2010) on mung bean; Tayel and Sabreen (2011) on broad bean and Hussein *et al*. (2012) on cowpea.

2- Leaves chemical composition parameters:

Results in Table 4 clear that decreasing irrigation water deficit led to significant increases in N, P, K, chlorophyll a, chlorophyll b, carotenoids content, in of pea leaves. The common irrigation gave the maximum values of the mentioned characters followed by moderate treatment (75 % from common irrigation). In addition, no significant differences were noticed between the common irrigation and moderate treatment for previous attributes. On contrast, the minimum values were obtained by sever treatment (50 % from common irrigation) in the two seasons.

These results may be attributed to that irrigation water deficit lead to retarding of nutrients uptake and transports, failed of absorb more valuable nutrient elements by the roots, reducing in the content leaf of mineral due to a decreasing in roots formation. These data explain positive correlation among water deficit stress treatments and chlorophyll pigments and carotenoids content. This ameliorate in mentioned pigments may be due to increasing of macronutrients uptake, especially N and Mg elements by increasing water irrigation, whereas N and Mg elements are basic for chlorophyll pigments synthesis. The obtained data are in accordance with those reported by El-Noemani *et al*. (2010) and Ndimbo *et al*. (2015) on common bean.

Table 4. Impact of phosphorus fertilizer rates after 75 days from planting on N, P, K percentage and pigments in leaves of peas under irrigation water deficit during the two seasons of 2015 and 2016.

Treatments		N %		P %		K %		Chl. a mg/100 FW		Chl. b mg/100 FW		Carotenoids mg/100g FW	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Irrigation water deficit													
Common irrigation		3.03	3.12	0.382	0.393	4.37	4.49	66.76	68.60	31.75	33.13	15.52	16.42
Moderate		2.55	2.62	0.322	0.331	3.68	3.78	56.52	58.07	26.71	27.95	13.07	14.35
Sever		2.02	2.08	0.255	0.262	2.91	2.99	45.63	46.89	21.71	22.81	10.34	12.17
LSD 5%		0.50	0.52	0.063	0.065	0.73	0.78	10.64	10.94	5.06	5.19	2.57	2.21
Phosphorus fertilizer rates (kg as P_2O_5 /fed.)													
45		2.30	2.37	0.289	0.298	3.31	3.41	51.61	53.16	24.25	25.48	11.79	13.42
60		2.72	2.79	0.342	0.352	3.91	4.03	61.17	62.87	29.12	30.44	13.89	15.34
75		2.58	2.65	0.325	0.334	3.72	3.82	56.49	58.01	27.00	28.23	13.23	14.31
90		2.55	2.62	0.321	0.330	3.66	3.76	55.94	57.38	26.52	27.70	13.00	14.18
LSD 5%		0.37	0.39	0.047	0.049	0.54	0.52	8.44	8.67	4.00	4.12	1.92	1.63
Interaction													
Common irrigation	45	2.76	2.84	0.346	0.357	3.97	4.08	61.88	63.74	29.08	30.45	14.12	15.51
	60	3.24	3.33	0.408	0.419	4.67	4.80	70.54	72.50	33.84	35.29	16.56	17.23
	75	3.09	3.17	0.389	0.400	4.45	4.57	67.56	69.36	32.28	33.66	15.84	16.53
	90	3.06	3.14	0.385	0.395	4.39	4.51	67.08	68.80	31.8	33.11	15.58	16.41
Moderate	45	2.39	2.46	0.299	0.309	3.43	3.53	53.34	54.96	25.08	26.32	12.24	13.74
	60	2.73	2.81	0.344	0.353	3.93	4.04	60.92	62.6	28.54	29.84	13.96	15.29
	75	2.58	2.65	0.325	0.334	3.72	3.82	56.5	58.00	27.00	28.23	13.22	14.31
	90	2.52	2.59	0.318	0.326	3.62	3.72	55.32	56.74	26.22	27.40	12.86	14.06
Sever	45	1.76	1.81	0.221	0.228	2.53	2.61	39.62	40.80	18.60	19.67	9.02	11.01
	60	2.18	2.25	0.275	0.283	3.14	3.24	52.06	53.52	24.98	26.18	11.16	13.50
	75	2.07	2.13	0.262	0.269	2.99	3.07	45.42	46.66	21.72	22.80	10.64	12.10
	90	2.07	2.12	0.261	0.268	2.98	3.05	45.42	46.60	21.54	22.58	10.56	12.08
LSD 5%		0.65	0.67	0.082	0.085	0.94	0.91	14.62	15.01	6.93	7.13	3.32	2.83

Results in Table 4 cleary indicated that mentioned characters were significantly affected with application of phosphorus fertilizer rates (kg as P_2O_5 /fed). The addition of phosphorus fertilizer at rate 60 kg as P_2O_5 /fed. gave the biggest values. On contrary, the smallest values were recorded with 45 kg as P_2O_5 /fed.in first and second seasons. This may be due to reactive oxygen species (ROS) has destructive impact for chlorophyll pigments under water deficit. Phosphorus decreases the worst influences of (ROS) on chlorophyll by enhancement antioxidant systems, increasing of cell division and elongation. Also, its plays an indispensable role within the energy storage and transfer in the form of adenosine triphosphate ATP, adenosine diphosphate ADP as well as deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). In addition, stimulates root formation, cell wall division, synthesis of starch, fat and in fact most biochemical activities like amino acid synthesis and increasing the efficacy of other nutrients which might be resulted in higher increasing in mineral content and photosynthesis. These results are in harmony to those reported by Kandil *et al*. (2013) on common bean; Nkaa *et al*. (2014) on cowpea and Mahipat and Dhanai (2017) on pea.

Regarding the interaction between irrigation water deficit and phosphorus fertilizer rates, data indicated in Table 4 show that all mentioned attributes measurements significantly responded to the interaction treatments, the maximum values were achieved with by using common irrigation and 60 kg P_2O_5 /fed., On the other hand, the minimum values were recorded with sever application (50 % from common irrigation) and 45 kg P_2O_5 /fed in the two seasons. In addition, no significant differences were noticed between common irrigation or moderate treatments with phosphorus fertilizer. Ashraf *et al*. (2011) on pea and Marzouk *et al*. (2016) on snap bean came to similar conclusion.

3- Pods yield and its chemical quality:

Obtained data of Tables 5 indicate that irrigation water deficit were affected significantly, on pods weight per plant, pods number per plant, seeds fresh weight per plant, 100 seeds fresh weight, seeds dry weight and pods yield per fed.. The common irrigation gave rise to the highest values of the previous attributes followed by moderate stress treatment (75 % from common irrigation), Also, insignificant effect differences were observed between the common irrigation and moderate treatment for mentioned parameters. On contrast, the lowest values were recorded with sever stress treatment (50 % from common irrigation) in the two seasons. .

These results may be water deficit lead to increasing ROS which resulted in death of cells due to interaction with vital membranes, proteins and DNA, RNA. In addition, increasing of abscisic acid and ethylene production. On contrast, decreasing in cell turgidity, opening stomata, photosynthesis, CO_2 assimilation, nutritious elements uptake, N_2 fixation, gibberellins and cytokinins all will caused shortage of chlorophyll pigments content in plants which could be of great effect on vegetative growth and yield. The similar findings were reported with Faisal *et al*. (2010) and Hayatu *et al*. (2014) on cowpea and Ouji *et al*., (2017) on faba bean.

Table 5. Impact of phosphorus fertilizer rates after 85 days from planting on seeds, pods yield and its quality of pea under irrigation water deficit during the two seasons of 2015 and 2016.

Treatments		Pods weight (g) per plant		Pods number per plant		Seeds fresh weight per plant		100 seeds fresh weight		* Seeds dry weight kg/fed.		Pods yield (ton) per fed	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Irrigation water deficit													
Common irrigation		22.70	24.09	5.36	5.51	10.40	10.69	51.29	52.70	1385	1424	8.17	8.39
Moderate		19.11	20.40	4.54	4.67	8.75	9.00	43.17	44.37	1166	1199	6.87	7.06
Sever		15.13	16.32	3.72	3.82	6.83	7.02	33.68	34.62	910	935	5.44	5.59
LSD 5%		3.80	3.90	0.86	0.88	1.72	1.79	8.56	8.80	231	238	1.36	1.40
Phosphorus fertilizer rates (kg as P_2O_5 /fed.)													
45		17.17	18.45	4.16	4.28	7.86	8.09	38.72	39.88	1046	1078	6.18	6.36
60		20.34	21.66	4.92	5.06	9.33	9.59	46.00	47.29	1243	1277	7.32	7.52
75		19.34	20.62	4.59	4.73	8.87	9.11	43.74	44.92	1181	1213	6.95	7.14
90		19.07	20.35	4.48	4.60	8.58	8.82	42.38	43.49	1145	1175	6.87	7.05
LSD 5%		2.83	2.90	0.67	0.70	1.29	1.33	6.39	6.56	172	177	1.01	1.05
Interaction													
Common irrigation	45	20.56	21.93	5.00	5.12	9.42	9.68	46.36	47.74	1253	1290	7.39	7.62
	60	24.24	25.67	5.68	5.84	11.12	11.43	54.82	56.35	1481	1522	8.72	8.96
	75	23.14	24.51	5.42	5.58	10.60	10.89	52.32	53.72	1413	1451	8.32	8.54
	90	22.88	24.25	5.36	5.52	10.48	10.75	51.66	52.99	1396	1432	8.23	8.45
Moderate	45	17.80	19.09	4.30	4.42	8.14	8.38	40.14	41.34	1085	1117	6.40	6.60
	60	20.44	21.76	4.90	5.04	9.36	9.63	46.22	47.49	1248	1283	7.35	7.55
	75	19.34	20.62	4.52	4.68	8.90	9.11	43.74	44.93	1181	1214	6.96	7.14
	90	18.86	20.13	4.44	4.56	8.62	8.87	42.60	43.71	1151	1181	6.79	6.97
Sever	45	13.16	14.32	3.20	3.30	6.02	6.20	29.68	30.56	802	826	4.73	4.87
	60	16.36	17.57	4.20	4.32	7.52	7.71	36.98	38.01	999	1027	5.88	6.04
	75	15.54	16.73	3.84	3.94	7.12	7.32	35.16	36.12	950	976	5.59	5.74
	90	15.48	16.67	3.64	3.74	6.66	6.85	32.90	33.76	889	913	5.58	5.72
LSD 5%		4.90	5.03	1.17	1.21	2.24	2.30	11.07	11.36	299	307	1.7	1.81

*** Seeds dry weight (kg/fed.) after 120 days from sowing**

Data shown in Tables 5 indicated that the influence of the moderate dose 60 kg P_2O_5 /fed. of phosphorus fertilizer was registered the maximum values of the previous attributes followed by 75 kg P_2O_5 /fed. On contrast, the minimum values of these parameters were achieved with 45 kg P_2O_5 /fed. in the two seasons. This improvement in the yield and its component of pea may be Phosphorus application results in increasing of vegetative growth, N.P.K and chlorophyll leaves content (Table 3 and 4). Also, phosphorus might have increased the photosynthetic activities and translocation of photosynthates to sink, stimulate growth and initiate nodule formation. Also, its importance as energy storage and transferee necessary for metabolic processes. In addition, faster cell division and meristematic activity due to availability phosphorus which is the constitute of amino acid, protein, chlorophyll, and protoplast which enhance the photosynthetic and rhizobia activity in the plants, stimulate initiate nodule formationand N_2 fixation process which might be resulted in higher vegetative growth parameters then reflected to increasing of seed and pods yield. It also aids in flower initiation, seed and fruit development. These results are in the same trend with those recorded by Chaudhari *et al*. (2008) on French bean; Uarrota *et al*. (2010) on cowpea and Atif *et al*. (2014) on pea.

Also, the results in Table 5 show that the interaction between the two studied factors had significant effects on previous parameters in both seasons. The highest values were achieved with combination of common irrigation and 60 kg P_2O_5 /fed. On contrast, the lowest values were observed with sever treatment (50 % from common irrigation) and phosphorus fertilizer at 45 kg P_2O_5 /fed. in both seasons. Also, insignificant differences effects were registerated between common irrigation or moderate treatments with phosphorus fertilizer rates. Similar findings were found by Ashraf *et al*. (2011) on pea; Hussein *et al*. (2012) on cowpea; Amanullah *et al*. (2016) on mungbean; Sakar *et al*. (2017) on broad bean.

4- Plant water relations:

Tabulated data in Table 6 show that the irrigation water deficit significantly effected on seeds dry matter percentage, Vit. C, TSS, leaf relative water content %, leaf membrane stability index and water use efficiency except water use efficiency. The presented data show that increasing of irrigation water deficit led significantly to increases seeds dry matter percentage in both seasons of study. The highest values were notice with sever treatment (50 % from common irrigation). On contrary, the lowest values were registered with common irrigation. On the other hand, Vit. C, TSS, leaf relative water content % and leaf membrane stability index were decreased by increasing of irrigation water deficit, the maximum values were observed with common irrigation while the minimum values were achieved with sever treatment (50 % from common irrigation), Also, insignificant effect differences registered between the common irrigation and moderate treatments. These results may be due to that irrigation water deficit led to increasing production of abscisic acid and ethylene. Reducing uptake of nutritious elements, production of cytokinins and gibberellins which led to low roots formation, the stomata should be closed to avoid water shortage. Moreover, full irrigation to plants resulted in keep higher water content in plant tissues. Irrigation water deficit lead to the membrane damage and release of ions from the cell to extra cellular space and lipid peroxidation. Obtained results are in the same line with those recorded by Dogan et al. (2015) on pea; Nayak et al. (2015) and Marzouk et al. (2016) on snap bean.

Table 6. Impact of foliar application with phosphorus fertilizer rates after 85 days from planting on seeds dry matter percentage, Vit. C, TSS and some plant water relations parameters of peas under irrigation water deficit during the two seasons of 2015 and 2016.

Treatments		Seeds dry matter percentage		Vit. C mg/100g F.W		TSS %		Leaf relative water content %		leaf membrane stability index		Water use efficiency (kg per m^3 water)	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Irrigation water deficit													
Common irrigation		19.77	20.32	36.42	37.42	18.24	18.74	85.70	88.08	52.42	53.87	10.58	10.79
Moderate		22.09	22.70	30.67	31.52	15.36	15.78	72.16	74.15	43.92	45.13	10.67	10.87
Sever		25.58	26.29	23.93	24.59	11.97	12.31	56.29	57.85	34.26	35.21	10.55	10.72
LSD 5%		1.62	1.67	6.09	6.26	3.05	3.13	14.34	14.73	8.73	8.97	N.S	N.S
Phosphorus fertilizer rates (kg as P_2O_5 /fed.)													
45		20.97	21.60	27.46	28.28	13.74	14.17	64.65	66.59	39.62	40.83	9.56	9.76
60		23.79	24.45	32.68	33.59	16.36	16.82	76.89	79.03	46.82	48.12	11.36	11.57
75		22.75	23.37	31.07	31.92	15.56	15.98	73.10	75.08	44.52	45.71	10.80	10.99
90		22.41	23.00	30.14	30.92	15.10	15.48	70.89	72.74	43.17	44.30	10.67	10.85
LSD 5%		1.50	1.55	4.53	4.65	2.27	2.33	10.68	10.96	6.50	6.68	1.47	1.50
Interaction													
Common irrigation	45	18.18	18.73	32.88	33.86	16.46	16.96	77.40	79.72	48.04	49.50	9.60	9.79
	60	21.14	21.73	38.96	40.02	19.52	20.05	91.62	94.18	55.80	57.34	11.30	11.52
	75	19.88	20.42	37.14	38.16	18.60	19.11	87.40	89.77	53.24	54.66	10.76	10.98
	90	19.87	20.39	36.72	37.66	18.40	18.87	86.38	88.64	52.6	53.98	10.68	10.86
Moderate	45	21.27	21.91	28.48	29.32	14.26	14.69	67.00	69.02	40.74	41.96	9.92	10.14
	60	22.98	23.61	32.82	33.74	16.44	16.89	77.26	79.38	47.04	48.33	11.40	11.62
	75	22.37	22.98	31.08	31.94	15.56	15.98	73.12	75.09	44.52	45.72	10.82	10.99
	90	21.75	22.31	30.30	31.10	15.18	15.56	71.26	73.11	43.40	44.52	10.54	10.72
Sever	45	23.45	24.15	21.04	21.68	10.52	10.86	49.56	51.03	30.10	31.03	9.18	9.34
	60	27.25	28.01	26.28	27.02	13.14	13.52	61.80	63.53	37.62	38.68	11.40	11.58
	75	26.00	26.71	25.00	25.66	12.52	12.85	58.78	60.37	35.80	36.76	10.82	11.00
	90	25.63	26.30	23.40	24.00	11.72	12.02	55.04	56.48	33.52	34.39	10.80	10.96
LSD 5%		2.61	2.69	7.85	8.07	3.93	4.04	18.50	18.99	11.26	11.57	N.S	N.S

Data given in Table 6 indicated that application of phosphorus fertilizer rates have significantly effect on mentioned previous parameters. The addition of phosphorus fertilizer at rate 60 kg as P_2O_5 /fed. recorded the highest values, but the lowest values were noticed with 45 kg as P_2O_5 /fed.in both seasons. This may be attributed to (ROS) has destructive impact for chlorophyll pigments under water deficit (Table 4). Phosphorus decreases the worst effects of (ROS) on chlorophyll by enhancement antioxidant systems. Increasing of cell division and elongation. Also, its plays an indispensable role within the energy storage and transfer in the form of adenosine triphosphate ATP, adenosine diphosphate ADP as well as deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). In addition, stimulates root formation, cell wall division, synthesis of starch, fat and in fact most biochemical activities like amino acid synthesis and increasing the efficacy of other nutrients which might be resulted in higher increasing in mineral content and photosynthesis which reflected on quality of seeds and plant water relations. These finding are similar to those obtained by Hussein *et al*. (2012) on cowpea; Jin *et al*. (2014) on pea; Sakar *et al*. (2017) on broad bean.

Data presented in Table 6 show that the combination effects between irrigation water deficit and phosphorus fertilizer rates, results revealed that all mentioned attributes measurements significantly responded to the interaction treatments except water use efficiency. The highest values of seeds dry matter percentage were notice with sever treatment (50 % from common irrigation) combined with 60 kg P_2O_5 /fed. On contrary, the lowest values were recorded with common irrigation and 45 kg P_2O_5 /fed. On the other hand, Vit. C, TSS, leaf relative water content % and leaf membrane stability index were recorded the maximum values by using common irrigation with 60 kg P_2O_5 /fed. while the minimum values were recorded with combination consist of sever treatment (50 % from common irrigation) and 45 kg P_2O_5 /fed., Also, insignificant effect differences recorded between the common irrigation and moderate treatments. Hegab *et al*. (2014) on faba bean; Hayatu *et al*. (2014) on cow pea; Ndimbo *et al*. (2015) on common bean and Marzouk *et al*. (2016) on snap bean were found the same trend.

CONCLUSION

It was concluded from this investigate that phosphorus application under different irrigation water deficit levels has potential to alleviate the adverse impacts of water stress and to fully to benefit from the existing abiotic conditions and express maximum growth, yield and quality criteria as compared to water stressed conditions. Moderate dose of phosphorus (60 kg/fed.) under unstressed application gave the highest vegetative growth and crop yield. Also, application of phosphorus under different irrigation water deficit is basic to achieve maximum growth and yield of pea plants and to reduce the worst effects of water stress. In addition, insignificant effect differences observed between the common irrigation and moderate treatments. Therefore, the combination of moderate stress treatment (75% of common irrigation) and moderate dose of phosphorus 60 P_2O_5 /fed. is recommended for pea grown under loamy soil conditions using surface irrigation system for obtain the highest pods yield and quality.

REFERENCES

Ali, M. A.; G. Abbas; Q. Mohy-ud-Din; K. Ullah; G. Abbas and M. Aslam (2010) response of mungbean (*Vigna radiata*) to phosphatic fertilizer under arid climate. The J. of Animal and Plant Sciences, 20(2): 83-86.

Amanullah, M.; A. Muhammad; K. Nawab and A. Ali (2016) Effect of tillage and phosphorus interaction on yield of mungbean (*Vigna radiata* L., Wilczek) with and without moisture stress condition. Inter. Scientific Researches J., 72 (2): 114-139.

AOAC (1990) Official Methods of Analysis.15th Ed. Association of Official Analytical Chemists, Inc., Virginia, USA.

Ashraf, M. I.; M. A. Pervez; M. Amjad; R. Ahmad and M. Ayub (2011) Qualitative and quantitative response of pea (*Pisum sativum* L.) cultivars to judicious applications of irrigation with phosphorus and potassium. Pak. J. life Soc. Sci., 9(2): 159-164.

Atif, M. J.; S. A., Shaukat; S. Z. A. Shah; Y. A. Choudry and S. K. Shaukat (2014) Effect of different levels of phosphorus on growth and productivity of pea (*Pisum sativum* L.) cultivars grown as off-season under rawalakot Azad Jammu and Kashmir conditions. J. Recent. Adv. Agr., 2(6): 252-257.

Chaudhari, S.; C. Sahu; G. Bardhan and A.B. Khot (2008) Response of French bean (*Phaseolus vulgaris*) to irrigation schedules, phosphorus levels and phosphorus solubilizer in vertisols. J. Agric. Physics, 8: 1-4.

Dogan, E.; I. Rat; A. Kahraman and I. S. Ipek, (2015) Green pea response to deficit irrigation rates under semi-arid climatic conditions. Bulg. J. Agric. Sci., 21(5):1005–1011.

El-Noemani, A. A.; H.A. El-Zeiny; A. M. El-Gindy; E. A. El-Sahhar and M. A. El-Shawadfy (2010) Performance of some bean (*Phaseolus vulgaris* L.) varieties under different irrigation systems and regimes. Australian Journal of Basic and Applied Sciences, 4(12): 6185-6196.

Faisal, E. A. and A. H. Suliman (2010) Effect of water stress applied at different stages of growth on seed yield and water-use efficiency of cowpea. Agric. Biol. J. N. Am., 1(4): 534-540.

Faisal, E. A.; S. O. Yagoub and E. A. E. Elsheikh (2000) Effects of mycorrhizal inoculation and phosphorus application on the nodulation, mycorrhizal infection and yield components of faba bean grown under two different watering regimes. U. of K. J. Agric. Sci., 8(2): 107-116.

Gomez, K.A. and A.A., Gomez (1984) Statistical Procedures for Agricultural Research. John Wiley & Sons Inc., Singapore 680.

Hayatu, M.; S.Y. Muhammad and U. A. Habibu (2014) Effect of water stress on the leaf relative water content and yield of some cowpea (*Vigna unguiculata* (L) Walp.) Genotype. Inter. J. of Scientific & Tech. Res., 3(7):148-152.

Hegab, A.S.A.; M.T.B. Fayed; Maha M.A. Hamada and M. A. Abdrabbo (2014) Productivity and irrigation requirements of faba bean in North Delta of Egypt in relation to planting dates. Annals of Agricultural Science, 59 (2): 185–193.

Hussein, M.M.; S.M., Al-Ashry and C. Y., El-Dewiny (2012) Cowpea growth and yield components as affected by drought and pk soil fertilization. Inter. J. of Science and Research (IJSR) ISSN (Online): 2319-7064.

Jin, J.; D. Lauricella; R. Armstrong; P. Sale and C. Tang (2014) Phosphorus application and elevated CO_2 enhance drought tolerance in field pea grown in a phosphorus-deficient vertisol. doi:10.1093/aob/mcu209, available online at www.aob.oxfordjournals.org.

Kandil, H.; N, Gad and M. T. Abdelhamid (2013) Effects of different rates of phosphorus and molybdenum application on two varieties common bean of (*Phaseolus vulgaris* L.). J. Agric. Food. Tech., 3(3): 8-16.

Mahipat, S. Y. and C.S. Dhanai (2017) Impact of different doses of phosphorus application on various attributes and Seed yield of pea (*Pisum sativum* L.). J. of Entomology and Zoology Studies, 5(3): 766-769.

Marzouk, N. M.; R.E. Abdelraouf; S. R. Salman and M. H. Abd El Baky (2016) Effect of Water stress on yield and quality traits of different snap bean varieties grown in an arid environment. Middle East J. Agric. Res., 5(4): 629-635.

Migdadi, H. M.; E. H. El-Harty; A. Salamh and M. A. Khan (2016) Yield and proline content of faba bean genotypes under water stress treatments. The J. of Animal & Plant Sciences, 26(6): 1772-1779.

Nayak, B. R.; N. Panigrahy; A. K. Dash; K. Pramanik and S. K. Swain (2015) Influence of irrigation regimes and mulching on yield attributes, yield and water use efficiency of rajmash (*Phaseolus vulgaris* L.). Int. J. Bio-res. Env. Agril. Sci., 1(2): 32-36.

Ndimbo, M. A. (2015) Effects of moisture stress levels at different growth stages on nodulation and nitrogen fixation in common bean (*Phaseolus vulgaris* L.) genotype. Asian J. of Agriculture and Rural Development, 5(8): 187-201.

Nkaa, F.A.; O.W. Nwokeocha and O. Ihuoma (2014) Effect of phosphorus fertilizer on growth and yield of cowpea (*Vigna unguiculata*). IOSR J. of Pharmacy and Biological Sciences, 9(5): 74-82.

Ouji A.; M. Naouari; M. Mouelhi and M. Ben Younes (2017) Yield and yield components of faba bean (*Vicia faba* L.) as Influenced by supplemental irrigation under semi-arid Region of Tunisia. World Journal of Agricultural Research, 5(1): 52-57.

Sarkar, S.; A. Sarkar and A. Zaman (2017) Effect of irrigation and phosphorus levels on broad bean (*Vicia faba* L.) for improving growth, yield and water extraction pattern. Legume Research, 40 (2): 257-263.

Snedecor, W.G. and G.W. Cochran (1980) Statistical Methods. 7th Ed., the Iowa State Univ. Press, Ames, Iowa, USA.

Tayel, M.Y. and K. P. Sabreen (2011) Effect of irrigation regimes and phosphorus level on two vica faba varieties: 1- Growth characters. J. of Applied Sciences Research, 7(6): 1007-1015.

Uarrota, V. G. (2010) Response of cowpea (*Vigna unguiculata* L. Walp.) to water stress and phosphorus fertilization. J. of Agronomy, 1-5.

محاولة تخفيف اجهاد نقص مياه الرى فى البسلة بالتسميد الفسفورى

السعيد السيد متولى
قسم الخضر والزينة- كلية الزراعة جامعة المنصورة

نفذت هذة الدراسة لتوضيح استجابة البسلة صنف ماستر بى لمستويات مختلفة من الفسفور(45- 60- 75- 90 وحدة خامس اكسيد الفسفور للفدان) تحت ثلاث مستويات من العجز المائى بدون اجهاد ككنترول (100% من الرى الشائع) والإجهاد المتوسط والحاد 75 و 50 % من الكنترول. ولذلك اجريت تجربتان حقليتان متتاليتان بمحطة البحوث – كلية الزراعة جامعة المنصورة فى الموسم الشتوى من عامى 2015 و2016. اوضحت النتائج ان صفات النمو الخضرى (ارتفاع النبات –وزن النبات- عدد الافرع للنبات - الوزن الطازج للاوراق - عدد الاوراق – المساحة الورقية للنبات). التركيب الكيماوى للاوراق (نسبة النتروجين والفسفور والبوتاسيوم – كلورفيل أ – كلورفيل ب – الكاروتينيدات). محصول القرون وجودتها الكيمائية (وزن القرون – عدد القرون – وزن البذور الطازج للنبات – وزن 100 بذرة- محصول البذور الجاف للفدان- محصول القرون للفدان– فيتامين س - المواد الصلبة الذائبة الكلية). العلاقات المائية للنبات (محتوى المياة النسبى للاوراق- معامل ثبات الغشاء الورقى) نقصت بزيادة العجز المائى. وعلى العكس زادت كل من (النسبة المئوية للمادة الجافة للاوراق والبذور). وعلى جانب اخر لم تتاثر كفاءة استخدام المياة معنويا بزيادة العجز المائى. بالنسبة لتأثير التسميد الفسفورى اوضحت النتائج زيادة جميع الصفات السابقة حتى معدل 60 وحدة خامس اكسيد الفسفور للفدان ثم تنخفض عند 75 وحدة خامس اكسيد الفسفور للفدان. وعلى جانب أخر سجل معدل 45 وحدة خامس اكسيد الفسفور للفدان أقل القيم للصفات المذكورة. ولقد اوضح التفاعل بين نقص مياة الرى و التسميد الفسفورى ان المعاملة المكونة من الرى الشائع و 60 وحدة خامس اكسيد الفسفور للفدان اعطت أعلى القيم لمعظم المؤثرة للصفات السابقة. ايضا لوحظ عدم وجود فرق معنوى بين الرى الشائع والاجهاد المتوسط مع التسميد الفسفورى.