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Response of pea (*pisum sativum* l.) Grown on a sand soil to phosphoric acid and potassium humate under drip irrigation

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Abstract

To determine the effect of phosphoric-P and K-humate on pea development under drip irrigation, a field experiment on pea under drip irrigation was conducted during 2020 to assess different combinations of phosphoric acid-P (P_0, P_1 and P_2 of 0, 31 and 62 kg P ha^{-1}) and humate-K (K_0, K_1, K_2 and K_3 of 0, 50, 75 and 100 kg K ha^{-1}) given through drippers. The results demonstrated that the $P_{62}K_{100}$ treatment combination produced a high seed yield (3.66 Mg ha^{-1}). The most efficient treatment for seed P uptake was to fertilize green pea plants with 62 kg P and 100 kg K per hectare. $P_{62}K_{100}$ had the maximum K uptake by seeds at 52.72 Kg ha^{-1}. With rising K-humate and P-acid rates in low-fertility sandy soil and drip irrigation, yield of pods fresh weight increased. These results indicated that P and K interact in arid and infertile soil environments, and that employing unconventional sources enhances the growth and production of pea plants.

Keywords: Alternative-P and K, sandy soil, nutrient uptake, *Pisum sativum*.

Introduction

Pea (*Pisum sativum* L.) is one of the most important leguminous vegetable crops grown in Egypt and temperate regions of the world covering about 5.9 million hectare which produce about 11.7 million Mg (mega grams) (**Ahemad and Khan, 2011**). Pea seeds have high nutritional values due to their high contents of proteins **(El-Desuki *et al.*, 2010),** and carbohydrates as well as vitamins A and B **(Shedeed *et al.*, 2018)**. Pea seeds contain about 18 to 20% dry matter which have 10 to 12% carbohydrate and 5 to 8% protein **(Vural *et al.*, 2000).**

Enhancement of plant height, number of branches and leaves/plant, dry weight of branches and leaves/plant and yield and its components were attributed to increasing NPK fertilizer levels **(Mishra *et al.*, 2010)**. The importance of P fertilizer as one of the most important nutrients has been dealt with by **Tesfaye *et al.*, *(*2007); Tsvetkova and Georgiev, (2007) and Loguerre (2008**). The importance of K has been dealt with by **Shafeek *et al.* (2005)**; **Evans and Wildes (1971**) **and Das *et al.*, (1975**). Addition of high rate of rock-K feldspars resulted in highest yield, protein, N and K uptake by legumes (**Ezzat *et al.*, 2005**). **Shafeek *et al.* (2005)** found that all growth parameters, total yield, and chemical composition in seeds of pea crop were higher with supplying of chemical forms of P and K fertilizers than those induced by addition of P and K natural sources, i.e., rock-P and feldspars-K. Potassium is involved in numerous metabolic and biochemical processes in plant cells (**Rengel and Damon, 2008 and White, 2013**) including regulatory and transport mechanisms (**Adams and Shin, 2014**).

Humic acid is containing many elements which improve the plant growth, increase membrane permeability, photosynthesis and NPK uptake **(Khan *et al.*, 2012; Javaid and Shah, 2010; Hanafy *et al.* 2010 and Barakat, *et al.*, 2015).** It stimulates cytokinin **(Russo and Berlyn, 1990)** and auxin or gibberellin-like substance **(Pizzeghello *et al.*, 2001). Khan *et al.* (2012)** stated that application of humic acid increased plant height, shoot and root dry weight, number of green pods and green seeds $plant^{-1}$ as well as dry seeds weight $plant^{-1}$ of pea.

The present work was aimed at assessing the effect of applying phosphoric acid P and humate of K through drip irrigation on pea (*Pisum sativum*) grown on a sand soil and the role of alternative sources of phosphorus and potassium on enhancement of P and K and other nutrients to pea crop grown on sandy soil as well as avoiding the sparing solubility of such nutrients under alkalinity of soils.

Materials and Methods

A field experiment was carried out in the farm at Nuclear Research Center (NRC), Egyptian Atomic Energy Authority (EAEA), Abou-Zaabal, Egypt. Pea (*Pisum sativum* L.) cv. Master B, was the crop, irrigated through drop irrigation. The design was a randomized complete block, factorial (2 factors) in 3 replicates. **Factor 1** was mineral-P; P_0, P_1, and P_2 of 0, 31 and 62 kg P ha^{-1}, respectively. **Factor 2** was humate-K; K_0, K_1, K_2 and K_3 of 0, 50, 75 and 100 kg K ha^{-1}, respectively. Treatment combinations being 12 (3 P rates x 4 K rates). Plot area was 10 m^2. The soil was a poorly fertile sand (Table 1). P source was phosphoric acid; 316 g P L^{-1} while K source was K humate; 100 g K kg^{-1}. Each of P and K were given through the drip irrigation water. Soil analyses were carried out according to **Carter and Gregorich (2008)**.

Table 1. Main properties of soil of the experiment.

Soil Property		Value
Clay	(%)	0.2
Silt	(%)	4.0
Sand	(%)	95.8
Texture		Sand
pH		7.3
EC (paste extract) (dS m^{-1})		2.91
Organic matter (g kg^{-1})		0.03
$CaCO_3$ (g kg^{-1})		0.00
Available N	(mg kg^{-1})	0.4
Available P	(mg kg^{-1})	0.2
Available K	(mg kg^{-1})	13.4

Seeding was on 16 September 2020 and harvest was on 7 November 2020 with 83-day season. All plots received N and micronutrients as recommended (170 kg N ha^{-1}) in 2 equal splits 2 and 4 weeks after sowing. Foliar sprays were done at 1200 L ha^{-1} of 1300 mg L^{-1} for each of Fe, Mn, Zn and Cu as chelates in sprayed at 3 and 6 weeks after sowing. At harvest samples were subjected to chemical analysis using standard methods according to **Estefan *et al.* (2013).** P was measured using UV-spectrophotometer GENWAY Model 6405 and K was measured using by flame photometer JENWAY Model PFP7.

Statistical analysis

All experimental data were subjected to statistical analysis using MSTAT-C program software version 1.42.

Results and Discussion

4.1. Dry matter yields

4.1.1. Roots + Shoots dry matter yield: (Figure 1)

Application of P and K increased roots and shoots dry matter (Fig. 1). The highest of 6.74 Mg ha^{-1} was achieved by P_2K_3 (62 kg P plus 100 kg K ha^{-1}), while the lowest of 2.49 Mg ha^{-1} was by the un-fertilized (P_0K_0). Application of low and moderate rates of K resulted in values of root plus shoot dry weight nearly closed to each other. This was true under all P fertilization rates. These results agree with those obtained by **Saxena *et al.* (2003)** who reported that P added at 30 kg ha^{-1} and K at 40 kg ha^{-1} gave the highest yield of beans.

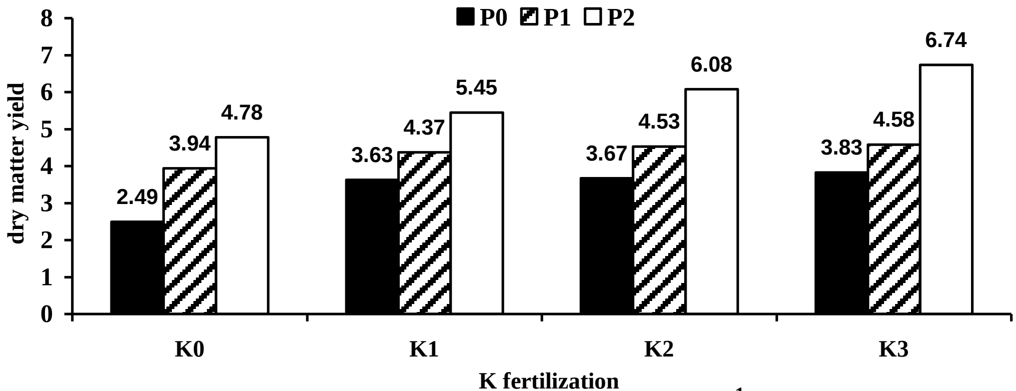

Fig. 1. Roots plus shoots dry matter yield (Mg ha^{-1}) of pea plants treated with different P and K fertilizers rates.

__Notes:__ P_0, P^1 and P_2 are 0, 31 and 62 kg P ha^{-1}, respectively; K_0, K_1, K_2 and K_3 are 0, 50, 75 and 100 kg K ha^{-1}, respectively.

4.1.2. Pods fresh weight: (Figure 2)

Pods fresh weight of seeds increased by P and K. The highest pods fresh weight (30.05 Mg ha^{-1}) was recorded with P_2K_3. The lowest (3.21 Mg ha^{-1}) was obtained with the non-fertilized P_0K_0. The results agree with those obtained by **Shafeek *et al.* (2005)** who found that P and K increased beans pod fresh weight.

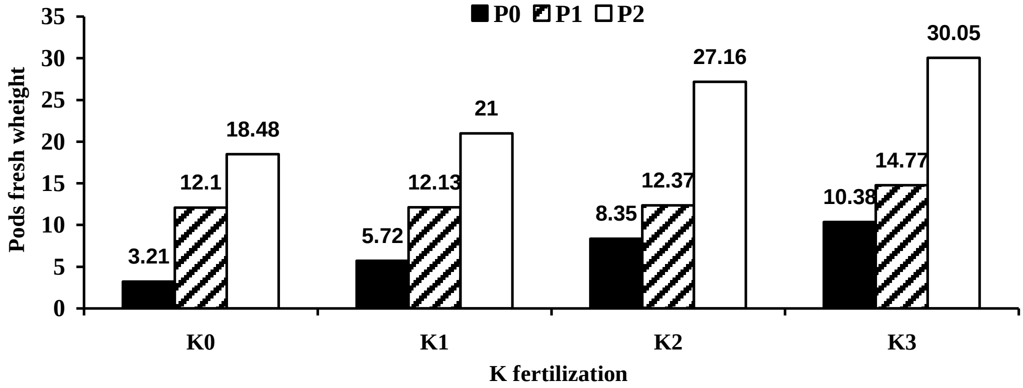

Fig. 2: Pods (with seeds) fresh weight (Mg ha^{-1}) of Pea plants treated with P and K fertilization. See Fig. 1 foot notes

4.1.3. Pods dry weight (with seeds): (Figure 3)

Phosphorus and potassium application increased seed pods dry weight. The P_2K_3 treatment recorded the highest dry weight (6.12 Mg ha^{-1}), while the nonfertilized P_0K_0 gave the lowest (0.46 Mg ha^{-1}). **Abdullah (2014)** found that 42 kg P +16.8 kg K ha^{-1} gave the highest dry seed pod yield of beans.

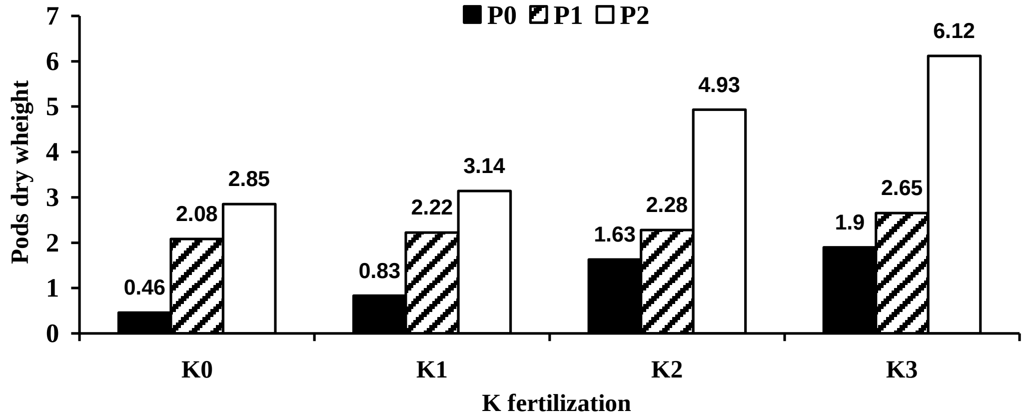

Fig. 3: Pods (with seeds) dry weight (Mg ha^{-1}) of Pea plants treated with P and K fertilization. See Fig. 1 foot notes

4.1.4. Pod cover dry yield: (Figure 4)

Application of P_2K_3 gave the highest pods cover dry yield (2.46 Mg ha^{-1}) while the lowest (0.29 Mg ha^{-1}) was given by the non-fertilized P_0K_0. The findings agree with those of **Kona *et al.* (2020)** who found that combined K+P resulted in increased pod weight of mung bean.

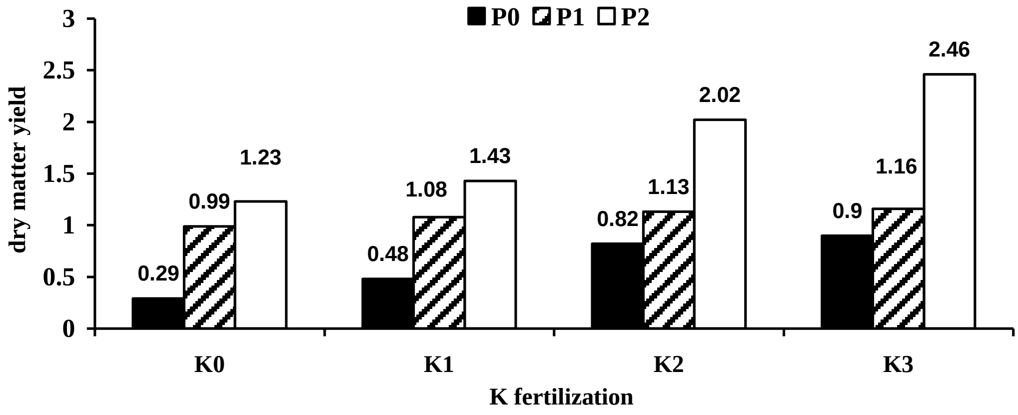

Fig. 4: Pods cover dry matter yield (Mg ha^{-1}) of Pea plants treated with P and K fertilization. See Fig. 1 foot notes

4.1.5. Seed yield: (Figure 5)

The highest seed yield of 3.66 Mg ha^{-1} was by P_2K_3 (62 kg P plus 100 kg K ha^{-1}) which increased the seed yield by about 21 folds over those recorded for the un-fertilized (Fig. 5). These results agree with those reported by **Karim *et al.* (2020)** who found that 25 kg P + 40 kg K ha^{-1} gave the highest seed yield of French beans. Phosphorus and potassium promote synthesis of amino acid, translocation of sugars, accumulation of carbohydrates, photosynthesis and respiration **(Arif *et al.*, 2005 and Yildirim *et al.*, 2009).** **P**otassium regulates the opening and closing of the stomata and improves the photosynthesis by regulating the absorption of CO_2 and plays a crucial role in photosynthesis which ultimately increases crop yield and improves grain quality (**Pettigrew 2008; Zorb *et al.* 2014; Lu *et al.* 2016**).

According to **Zhao *et al.* (2001)** plants deficient in K show stunted growth, yellowing of leaf edges, poor root system and reduced yields.

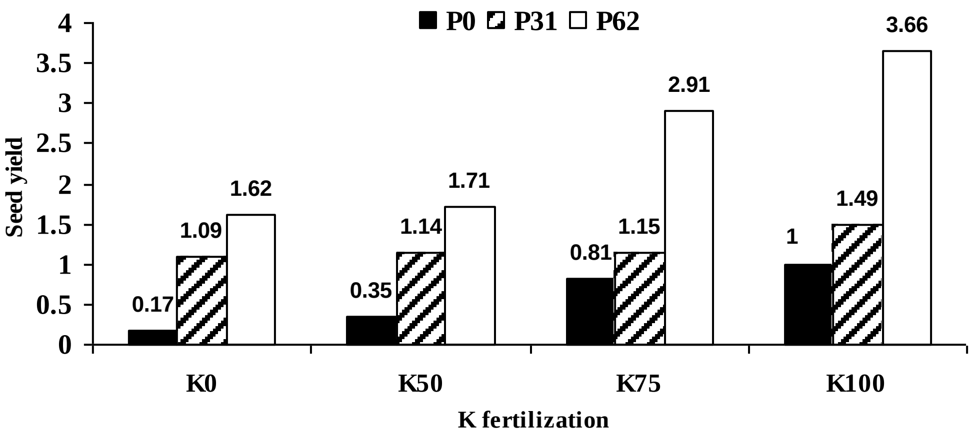

Fig. 5: Seed yield (Mg ha^{-1}) of pea plants treated with different P and K fertilizers rates. See Fig. 1 foot notes

4.2. Nutrient uptake

4.2.1. Phosphorus:

4.2.1.1. P uptake by Roots+Shoots: (Table 2)

P uptake by shoot plus roots responded positively to P and K rates (Table 2). Lowest of 5.99 kg P ha^{-1} was by the non-fertilized followed. The highest P uptake of 17.16 kg ha^{-1} by roots plus shoots was by P_2K_2 with a relative increase by 186% over the lowest. These results agree with those reported by **Mourice and Tryphone, (2012)** who observed that shoot and root biomass of bean (*phaseolus vulgaris* L.) and P uptake were increased with increasing rates of applied P.

Table 2. Effect of P and K on P uptake (kg ha^{-1}) by pea shoots+roots

	K_0	K_1	K_2	K_3	mean
P_0	5.99	6.79	5.59	8.95	**6.83**
P_1	12.74	11.36	14.63	10.70	**12.36**
P_2	11.49	17.16	9.05	11.39	**12.27**
Mean	**10.08**	**11.77**	**9.76**	**10.35**	**10.49**
P_0, P_1 and P_2 are 0, 31 and 62 kgha^{-1}; K_1K_1 K_2 and K_3 are 0,50, 75 and 100 kgha^{-1}					
LSD $_{0.05}$	**P: 0.02**	**K: 0.03**	**P K: 0.04**		

See Fig. 1 foot notes

4.2.1.2. P uptake by seeds (Table 3)

Results were rather similar to those of roots + shoots. Application of phosphorus and potassium increased of P uptake in seeds (Table 3). The highest of 19.11 kg ha^{-1} resulted from application of P_2K_2 which caused more than 49–fold over the un-fertilized plants (P_0K_0). These findings agree with those reported by **Zafar *et al.*, (2011)** who found that P uptake in seeds of common beans increased 37 to 197 % by application of P fertilizer combined with poultry manure.

Table 3. Effect of P and K on P uptake (kg ha^{-1}) in pea seeds.

	K_0	K_1	K_2	K_3	
P_0	0.38	1.53	2.50	4.20	**2.15**
P_1	3.62	4.81	4.08	6.64	**4.79**
P_2	6.50	8.18	12.56	19.11	**11.59**
Mean	**3.50**	**4.84**	**6.38**	**9.98**	**6.18**
See footnotes of Table 2 for treatment designations					
LSD $_{0.05}$	**P: 0.02**	**K: 0.03**	**P K:0.05**		

See Fig. 1 foot notes

4.2.2. Potasium:

4.2.2.1. K uptake by Roots + Shoots: *(Figure 6)*

Data in Fig. 6 show that P and K increased K uptake by roots and shoots. The highest of 117.68 kg ha^{-1} by roots and shoots occurred by application of P_1K_3. The lowest of 25.97 Kg ha^{-1} occurred with the non-fertilized P_0K_0. These results agree with those reported by **El-Sharkawy (2013)** who found that K combined with yeast extract increased peas vegetative growth and **Balpande *et al.* (2016)** who found that vegetative growth of pea plants increased with K application.

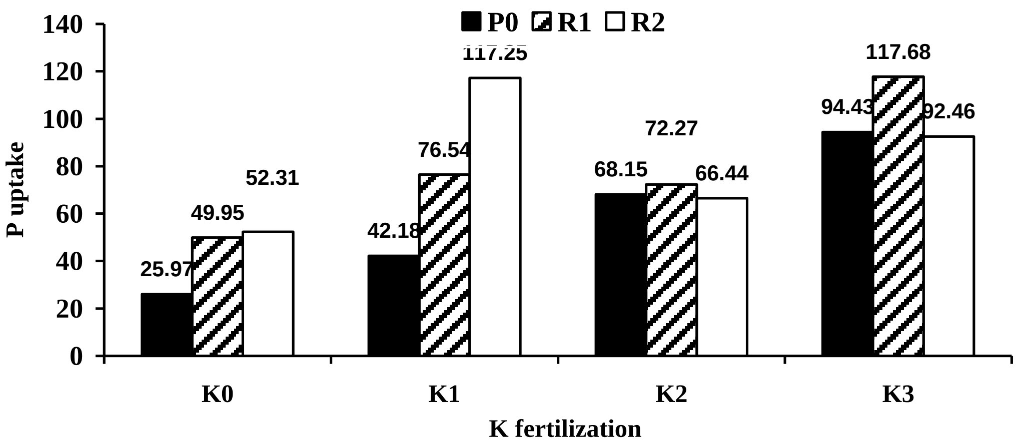

Fig. 6: Roots + Shoots K uptake (kg ha^{-1}) of Pea plants treated with P and K fertilization. See Fig. 1 foot notes

4.2.2.2. K uptake seed (Figure 7)

Application of P and K increased K uptake by pods and seeds. The highest uptake by pods and seeds (29.03 Kg ha^{-1}, 52.72 Kg ha^{-1}) was by P_2K_3 while the lowest (3.72 Kg ha^{-1}, 2.45 Kg ha^{-1}) was by the non-fertilized. These results are similar to those by **Ismail *et al.* (2017)** who spraying pea plants with K humate and obtained enhanced plant growth.

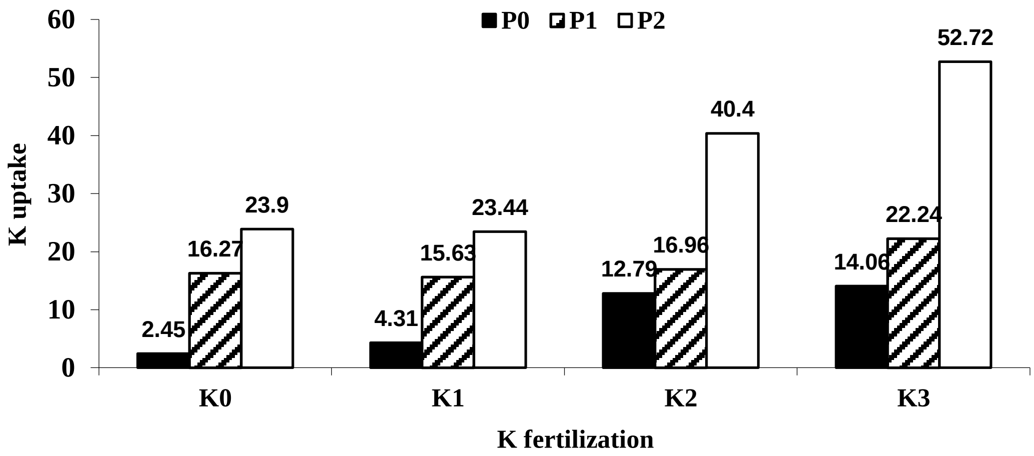

Fig. 7: Seeds K uptake (kg ha-1) of Pea plants treated with P and K fertilization. See Fig. 1 foot notes

Conclusion:

Appropriate use of P and K contributes to the achievement of sustainable pea crop production and quality. Maintaining an optimal nutritional status of P and K is essential for pea plants to resist biotic and abiotic stress.

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إستجابة نبات البازلاء المنزرع فى أرض رمل لحامض الفوسفوريك وهيومات البوتاسيوم تحت الرى بالتنقيط

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لتحديد تأثير حامض الفوسفوريك وهيومات البوتاسيوم على نبات البازلاء تحت الري بالتنقيط، أجريت تجربة حقلية على البازلاء تحت الري بالتنقيط خلال عام 2020 لتقييم توليفات مختلفة من حمض الفوسفوريك من صفر، 31 و 62 كجم فوسفور لكل هكتارو هيومات البوتاسيوم من صفر، 50، 75 و 100 كجم بوتاسيوم لكل هكتار تعطى من خلال النقاطات. أظهرت النتائج أن المعاملة $P_{62}K_{100}$ اعطت محصول عالى (3.66 مجم هكتار$^{-1}$) .كانت المعاملة الأكثر كفاءة لامتصاص الفوسفور بواسطة البذور هي تسميد نباتات البازلاء الخضراء بـ 62 كجم من الفوسفور و 100 كجم من البوتاسيوم للهكتار. بارتفاع معدل هيومات البوتاسيوم وحامض الفوسفوريك فى التربة الرملية منخفضة الخصوبة تحت الرى بانتفيط إزداد محصول الوزن الطازج للقرون. أشارت هذه النتائج إلى أن التداخل ما بين الفسفور والبوتاسيوم تحت ظروف التربة الجافة وغير الخصبة فى صورة مصادر غير تقليدية يعزز نمو وإنتاج نبات البازلاء.