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Study the Effect of Phosphorus Fertilizer Rates and Plant Densities on the Productivity and Profitability of Peanut in Sandy Soil

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Abstract

Two field experiments were carried out at Ismailia Agricultural Experiments and Research Station, A.R.C., El- Ismailia Governorate, Egypt, during growing seasons 2015 and 2016, respectively. In both seasons, the experiment was conducted using the split plot design in randomized complete block design with three replicates to study the effect of P fertilizer and plant density on pods and oil yields, as well as, net return. Three phosphorus (P) fertilizer rates (30, 45 and 60 kg P_2O_5 per fed) and three peanut plant densities (70, 105 and 140 thousand plants per fed) were tested. A split plot design replicated thrice was used. The results showed that increasing rate of P fertilizer from 30 up to 60 kg P_2O_5 per feddan increased significantly all the studied peanut traits except seed oil content. Decreasing peanut plant density from 140 to 70 thousand plants per feddan increased significantly numbers and weights of pods and seeds per plant, shelling and seed oil content mean, while the reverse was true for plant height in the two successive seasons. Peanut plant density of 105 thousand plants per feddan achieved the highest pods and oil yields per feddan compared with the other plant densities. Interaction between 60 kg P_2O_5 per feddan and 105 thousand plants per feddan increased significantly the most studied traits of peanut. Application of 60 kg P_2O_5/fed combined with 105 thousand plants per feddan achieved high pods, oil yields and net return.

Keywords: *P fertilizer rates, Peanut plant density, Pods yield, Oil yield, Net return.*

Introduction

Vegetable oils are consumed in different forms, these are liquid, hydrogenated, artificial ghee or frozen at room temperature. It is worth noting that oil and protein play extremely important roles in the normal function of all living systems. However, production of edible vegetable oils still suffers some problems in Egypt; the local oil production covers 10% only of the total requirement (FAO, 2016). Moreover, it is expected to rise in import bill of oil crops in coming years due to increase in population and lack of production, in addition to increase support for food commodities through ration cards and volatility in cultivated areas of oil crops and net revenue from them. Accordingly, it is not feasible to augment the acreage of these crops in the Nile Valley and Delta due to high competition of the other strategic field crops such as wheat, maize and rice. Great efforts must be directed toward the improvement of oil crops resources to fill the oil gap between production and consumption especially outside the Nile Valley and Delta.

However, unsuitable soil conditions for the plant development generally arise from the lack of organic contents in these soils. A sandy soil requires proper management to offer optimum productivity of crops. Fortunately, peanut (*Arachis hypogaea* L.) is the most suitable crop for these soils conditions. Developing countries constitute 97% of the global area and 94% of the global production of this crop (Ahmad *et al*., 2002). Oil content in seeds of this crop ranges between 48 and 52% (Khalil, 2010). Also, peanut has high protein, fatty acid, carbohydrates, vitamins and minerals contents (Gulluoglu, 2011). However, peanut cultivated area reached about 96 thousand fed in new lands (Bulletin of Statistical Cost Production and Net Return, 2016).

It was necessary to find a modern agricultural technical practice to increase peanut productivity per unit area during the summer season. Increase productivity of peanut, fertilizer management with plant density per unit area should be considered under sandy soil conditions. Certainly, as the number of plants per unit area increased, competition for growth resources such as nutrients, water and light also increased. A legume such as peanut is nitrogen fixers, and thereby phosphorus (P) is considered as a limiting factor in plant nutrition due to the deficiency of available phosphate in the soil (Uma Maheswar and Sathiyavani, 2012). In this concern, Kabir *et al*. (2013) reported that P is the second major essential nutrient element for crop growth and good quality yield, the most obvious effect of P is on the plant root system. Consequently, the level of P and the time of application are considered as two of the most important factors affecting crop growth and yield of peanut (Mohammed and Ismail, 2016).

On the other hand, the response of peanut to plant density has been investigated in many areas of the world. One way of increasing productivity and improving sustainability is through the use of improved cultural practices like placement of appropriate crop density. When the plant population density falls below the optimum level all inputs of production fail to produce any appreciable effect on yield. Different peanut varieties need specific agronomic and cultural practices to express their best potential in determining the yield responses to plant density. Sometimes, increasing plant density of peanut per unit area may have indefinite effect on productivity of the crop. Decreasing plant density increased yield per unit area (Wrihgt and Bell, 1992). However, Papastylianou (1995) showed that peanut yield was unaffected by further increasing plant density per unit area. Conversely, several researchers have reported that peanut pod yield was higher in high plant density than grown in low plant density (Lanier *et al*., 2004; Sorensen *et al*., 2005; Ahmad *et al*., 2007; Rasekh *et al*., 2010 and Konlan *et al*., 2013). The present study was therefore conducted to increase pods and oil yields, as well as, net return.

Material and Methods

Two field experiments were carried out at Ismailia Agricultural Experiments and Research Station, A.R.C., Ismailia Governorate (Lat. 30° 35' 30'' N, Long. 32° 14' 50'' E, 10 m a.s.l.), Egypt during growing seasons 2015 and 2016 summer seasons. Mechanical and chemical analyses of the soil (0 – 60 cm) were done by Water, Soil and Environment Research Institute labs, ARC (Table 1). The experimental soil (0-60 cm) had 11.66 percent clay, 2.28 percent silt and 86.06 percent sand (loamy sand texture). Mechanical and chemical analyses of the soil were determined using the methods described by Jackson (1958) and Chapman and Pratt (1961).

Table 1. Chemical properties of Ismailia site in 2015 and 2016 seasons before peanut sowing.

Chemical soil properties	Growing season	
	2015	2016
pH	8.05	8.45
Available N ppm	10.9	11.7
Available P ppm	17.6	18.2
Available K ppm	62.0	74.0

The treatments were combinations of three phosphorus (P) fertilizer rates (30, 45 and 60 kg P_2O_5/fed) and three peanut plant densities (70, 105 and 140 thousand plants per fed). Peanut cultivar Ismailia 1 ' semi – erect' was used and it sown on May 22nd and 29th at 2015 and 2016 seasons, respectively. Sprinkler irrigation was the irrigation system in this area. Phosphorus fertilizer, as calcium superphosphate (15.5% P_2O_5) with the rate of 30, 45 and 60 kg P_2O_5/fed and potassium sulfate (48.0 % K_2O) with the rate of 50 kg per fed were added during the seed bed preparation. Calcium sulfate at rate of 500 kg per fed was applied for peanut after 35-40 days from peanut sowing. Nitrogen fertilizer was added at a rate of 35 kg N / fed as ammonium sulfate (20.6%N) in two equal portions, the first half at sowing and the second after 30 days later.

In the two seasons, peanut seeds were inoculated by *Bradyrhizobium* before planting it. Normal practices for growing the crop were used as recommended in the area. Plant density of peanut was 70, 105 and 140 thousand plants/fed, respectively, as follows:

- 70000 plants /fed: Growing two rows of peanut in beds 120 cm width and thinning to two plants per hill at 20 cm.
- 105000 plants /fed: Growing four rows of peanut in beds 120 cm width and thinning to two plants per hill at 20 cm for outer rows and one plant per hill at 20 cm for inner rows.
- 140000 plants /fed: Growing four rows of peanut in beds 120 cm width and thinning to two plants per hill at 20 cm.

Randomized complete block design (RCBD) using split plot arrangement with three replications. Phosphorus fertilizer rates were randomly assigned to the main plots and peanut plant density was allocated in subplots. The area of plot was 28.8 m^2, it consisted of 8 beds, and each bed was 3.0 m in length and 1.2 m in width.

At harvest, the following traits were measured on ten guarded plants from each sub plot: Plant height (cm), numbers of pods and seed per plant, pod and seed weights per plant (g).

Pod yield ard/fed (one ardab = 75 kg of pods) was recorded on the basis of experimental plot area by harvesting all plants of each sub plot. Fifty grams seed samples were grinded into fine powder and stored in brown glass bottles for oil seed content according to the method described by A.O.A.C. (1990). Oil yield/fed (kg) = Seed oil content (%) x Seed yield/fed (kg)

Financial return was calculated as follows:

- Total return = pods yield (ardab/fed) x peanut price (L.E./ardab).
- Net return = total return – total costs according to P fertilizer rate and peanut plant density.

Prices of main products are that of 2015: L.E. 681 for ardab of peanut; total costs: L.E. 4638 per fed, recommended P fertilizer rate: L.E. 160 per fed (Bulletin of Statistical Cost Production and Net Return, 2016).

Analysis of variance of the obtained results for each season was performed. The measured variables were analyzed by ANOVA using MSTATC statistical package (Freed, 1991). Mean comparisons were performed using the least significant differences (L.S.D) test with a significance level of 5% (Gomez and Gomez, 1984).

Results and Discussion

Effect of P fertilizer rates

In general, P fertilizer rates were significantly affected of plant height, number, weight of pods and seeds per plant, pods yield per fed, shelling % as well as oil yield/fed in the two growing seasons, whereas seed oil content was not affected significantly (Tables 2, 3 and 4). Increasing P fertilizer rates from 30 to 60 kg P_2O_5/fed increased significantly $(P \leq 0.05)$ plant height, number and weight of pods per plant, number and weight of seeds per plant, pods yield per fed, shelling % as well as oil yield/fed in the both seasons. Increasing P fertilizer rates from 30 to 45 kg P_2O_5/fed increased plant height and shelling % by 5.79 and 2.51% in the first season and 7.93 and 3.49 % in the second one, respectively.

Table 2. Effect of P fertilizer rate, peanut plant density and their interaction on plant height, number and weight of pods/plant, 2015 and 2016 summer seasons.

Treatments \ Traits		Plant height (cm)		No. of pods/plant		Weight of pods/plant (g)	
P fertilizer rate/fed	**Plant density/fed**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
30 kg P_2O_5	**70000 plants**	40.96	39.43	19.66	24.13	36.00	47.00
	105000 plants	55.10	54.10	19.00	19.10	32.33	37.33
	140000 plants	71.73	63.30	16.00	14.33	20.00	20.66
	Mean	**55.93**	**52.27**	**18.22**	**19.18**	**29.44**	**35.00**
45 kg P_2O_5	**70000 plants**	50.10	48.86	18.66	23.00	37.66	43.00
	105000 plants	54.06	52.10	19.00	21.33	30.33	34.00
	140000 plants	73.36	68.30	13.66	14.00	19.26	20.33
	Mean	**59.17**	**56.42**	**17.11**	**19.44**	**29.08**	**32.44**
60 kg P_2O_5	**70000 plants**	51.96	51.50	23.33	30.43	50.33	58.66
	105000 plants	56.70	56.13	23.00	30.86	41.00	34.00
	140000 plants	71.00	69.83	15.33	18.33	17.33	22.00
	Mean	**59.88**	**59.15**	**20.55**	**26.54**	**36.22**	**38.22**
Average of peanut plant density	**70000 plants**	**47.67**	**46.60**	**20.55**	**25.85**	**41.33**	**49.55**
	105000 plants	**55.28**	**54.11**	**20.33**	**23.76**	**34.55**	**35.11**
	140000 plants	**72.03**	**67.14**	**15.00**	**15.55**	**18.86**	**21.00**
L.S.D. 0.05 P fertilizer rates		**0.96**	**1.10**	**2.37**	**1.88**	**3.22**	**3.24**
L.S.D. 0.05 Peanut plant density		**1.10**	**1.35**	**2.05**	**1.58**	**2.18**	**2.03**
L.S.D. 0.05 Interaction		**1.66**	**2.04**	**-**	**2.56**	**3.82**	**3.97**

Table 3. Effect of P fertilizer rate, peanut plant density and their interaction on number and weight of seeds/plant and pods yield/fed, 2015 and 2016 summer seasons.

Treatments \ Traits		No. Seeds/plant		Seed yield/plant (g)		Pods yield/fed (ard)	
P fertilizer rate/fed	**Plant density/fed**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
30 kg P_2O_5	**70000 plants**	36.00	44.33	30.00	41.33	16.76	15.63
	105000 plants	36.00	36.00	29.00	30.00	22.43	22.43
	140000 plants	25.00	21.00	19.00	18.33	14.03	15.06
	Mean	**32.33**	**33.77**	**26.00**	**29.88**	**17.74**	**17.71**
45 kg P_2O_5	**70000 plants**	33.00	42.66	30.33	40.33	17.43	18.73
	105000 plants	35.33	35.00	28.33	28.33	21.10	22.33
	140000 plants	23.33	26.00	14.66	16.00	16.10	16.56
	Mean	**30.55**	**34.55**	**24.44**	**28.22**	**18.21**	**19.21**
60 kg P_2O_5	**70000 plants**	42.66	58.33	36.33	56.00	18.50	19.50
	105000 plants	42.00	59.00	40.66	57.33	24.06	25.36
	140000 plants	22.00	33.33	14.33	22.00	17.13	18.40
	Mean	**35.55**	**50.22**	**30.44**	**45.11**	**19.90**	**21.08**
Average of peanut plant density	**70000 plants**	**37.22**	**48.44**	**32.22**	**45.88**	**17.56**	**17.95**
	105000 plants	**37.77**	**43.33**	**32.66**	**38.55**	**22.53**	**23.37**
	140000 plants	**23.44**	**26.77**	**16.00**	**18.77**	**15.75**	**16.67**
L.S.D. 0.05 P fertilizer rates		**4.43**	**3.05**	**3.61**	**3.23**	**1.10**	**1.66**
L.S.D. 0.05 Peanut plant density		**2.28**	**2.23**	**1.76**	**1.94**	**0.78**	**0.91**
L.S.D. 0.05 Interaction		**4.64**	**3.81**	**3.74**	**3.63**	**1.35**	**1.79**

Table 4. Effect of P fertilizer rate, peanut plant density and their interaction on shelling, seed oil content and oil yield/fed (kg), 2015 and 2016 summer seasons.

Treatments \ Traits		Shelling (%)		Seed oil content (%)		Oil yield/fed (kg)	
P fertilizer rate/fed	Plant density/fed	2015	2016	2015	2016	2015	2016
30 kg P_2O_5	**70000 plants**	67.33	68.66	50.33	49.00	425.66	393.66
	105000 plants	66.33	66.66	49.00	48.33	546.66	542.66
	140000 plants	65.33	65.33	51.00	52.33	350.33	386.00
	Mean	**66.33**	**66.88**	**50.11**	**49.88**	**440.88**	**440.77**
45 kg P_2O_5	**70000 plants**	69.66	70.66	50.00	52.66	455.00	522.00
	105000 plants	67.66	69.33	47.00	46.66	502.33	541.66
	140000 plants	66.66	67.66	42.00	47.00	337.66	395.00
	Mean	**68.00**	**69.22**	**46.33**	**48.77**	**431.66**	**486.22**
60 kg P_2O_5	**70000 plants**	71.66	72.33	53.00	54.33	526.66	574.66
	105000 plants	70.33	70.33	51.00	52.66	647.33	704.33
	140000 plants	68.66	69.33	45.33	47.00	400.33	448.66
	Mean	**70.22**	**70.66**	**49.77**	**51.33**	**524.77**	**575.88**
Average of peanut plant density	**70000 plants**	**69.55**	**70.55**	**51.11**	**52.00**	**469.11**	**496.77**
	105000 plants	**68.11**	**68.77**	**49.00**	**49.22**	**565.44**	**596.22**
	140000 plants	**66.88**	**67.44**	**46.11**	**48.77**	**362.77**	**409.88**
L.S.D. 0.05 P fertilizer rates		**0.50**	**0.75**	**N.S.**	**N.S.**	**45.65**	**63.33**
L.S.D. 0.05 Peanut plant density		**0.76**	**0.80**	**4.80**	**3.32**	**22.22**	**46.23**
L.S.D. 0.05 Interaction		**N.S.**	**N.S.**	**6.21**	**5.49**	**47.23**	**78.82**

However, plant height and shelling % was increased by 7.06 and 5.86 % in the first season and 13.16 and 5.65 % in the second season, respectively, by increasing P fertilizer rates from 30 to 60 kg P_2O_5/fed. These results reveal that plant height and the efficiency of pod filling have been affected more negatively or positively by different rates of P fertilizer compared to other attributes under sandy soil conditions. It is known that the early vegetative growth stage is mainly concerned with mainstem elongation and leaf production, whereas the formation of lateral branches dominates later growth (Prasad *et al*., 2009). The correlation coefficient for seed weight per plant was highly significant and positive with plant height (Chijioke *et al*., 2010).

Furthermore, increasing P fertilizer rates from 30 to 60 kg P_2O_5/fed increased number of pods and seed per plant, weights of pods and seeds per plant, pods and oil yields per fed by 12.78, 9.95, 23.02, 17.07, 12.17 and 19.02% in the first season and 38.37, 48.71, 19.02 and 30.65% in the second one, respectively. These results could be due to the highest P fertilizer rate had a vital effect on nodule formation and fixation of atmospheric nitrogen (Brady and Well, 2002) by activation of metabolic processes of the plant tissues and building phospholipids and nucleic acid (Kabir *et al*., 2013). Accordingly, it is likely to say that application of 60 kg P_2O_5/fed developing a more extensive root system which had a good phonological development of peanut that enabling peanut plant to extract water and nutrients from more depth due to efficient utilization of P by the plants. Consequently, it was expected that application of the lowest of p fertilizer rate would be decreased dry matter accumulation in leaves and thereby low photosynthates translocated from leaves to seeds during seed filling period compared with the other P fertilizer rates.

These results show that application of 60 kg P_2O_5/fed enhanced the plant potential of peanut to produce more assimilates which reflected on high biomass under sandy soil conditions. These findings are confirmed with those obtained by Solaiman *et al.* (1991) who found that additional P application could increase the plant growth. Also, Subrahmaniyan *et al.* (2000) reported that proper fertilizer doses of P have vital effect on the yield of peanut.

Effect of peanut plant density

Plant height, number and weight of pods and seed per plant, pods yield per fed, shelling %, seed oil content and oil yield/fed were affected significantly by peanut plant density in the two successive seasons (Tables 2, 3 and 4). Increasing peanut plant density per unit area from 70 to 105 thousand plants increased significantly $(P \leq 0.05)$ plant height by 15.96 and 16.11 % in the first and second seasons, respectively. Also, increasing peanut plant density from 105 to 140 thousand plants per fed increased significantly plant height by 30.30 and 24.08% in the first and second seasons, respectively. These results may be due to peanut plant of the highest plant density suffered from mutual shading than that of the lowest plant density. Mutual shading is known to increase the proportion of invisible radiation, which has a specific elongating effect upon plants (Chang, 1974). Thus, it is expected that plant density of 105 thousand plants per fed led to acclimation of peanut plant to light intensity and translated into alteration of plant height growth rate for helping the plant to reach enough light under sandy soil conditions.

Increasing plant density from 70 to 105 thousand plants per fed had no significant influence $(P > 0.05)$ on number of pods and seeds per plant, as well as, seed yield per plant in the first season, but an increase from 105 to 140 thousand per fed decreased significantly $(P \leq 0.05)$ numbers of pods and seeds per plant, as well as, seed yield per plant by 26.21, 37.94 and 51.01% in the first season and 34.55, 38.21 and 51.30 % in the second one, respectively. These results might be attributed to plant density of 105 thousand plants per fed furnished better environmental growth resources which led to peanut benefited efficiently the available growth resources compared with the other plant densities. Increasing the plant density lead to increase in dry pod yield per ha until the optimum plant density (Gabisa *et al*., 2017).

The highest shelling of 69.55% in the first season and 70.55% in the second season were recorded with the recommended plant density of 70 thousand plants per fed meanwhile the lowest shelling percentage (66.88%) in the first season and (67.44%) in the second season were recorded at the highest plant density of 140 thousand plants per fed (Table 4). This might be due to difference in efficient partitioning of assimilates into the seed rather than the pod in the recommended plant density and more luxurious growth in the highest plant density favored more pod formation than seed yield.

Conversely, increasing peanut plant density per unit area from 105 to 140 thousand plants decreased seed oil content by 2.89 and 0.45 % in the first and second seasons, respectively. In this concern, Onat *et al.* (2017) demonstrated that the oil content was decreased when the plant space was reduced. It is important to mention that seed oil content had the same response to increase in peanut plant density from 70 to 105 thousand plants per fed which indicating some degree of resource complimentarily under sandy soil conditions. It is important to accommodate the most appropriate number of plants per unit area to obtain better yield. Although pods and seed yields per plant were decreased by increasing plant density of peanut over 50% of the recommended plant density, but number of plants per unit area compensated this reduction in the economic yield by 28.30 % in the first season and 30.19 % in the second season. In other words, as the peanut plant density increased, yield per plant decreased. Greater yield per plant of the recommended plant density did not compensate for the contribution of yield made by more plants of the highest density.

Interaction between P fertilizer rates and peanut plant density

Plant height, number and weight of pods and seeds per plant, pods yield per fed, seed oil content and oil yield/fed were affected significantly by P fertilizer rates x peanut plant density in the two successive seasons except number of pods per plant in the first season and shelling% in the two seasons (Tables 2, 3 and 4). Application of 60 kg P_2O_5 with plant density of 70 thousand plants per fed had the highest mean values of number and weight of pods, shelling% and seed oil content, meanwhile application of 60 kg P_2O_5 with plant density of 105 thousand plants per fed achieved the highest seed yield per plant, pod and oil yields per fed compared to the other treatments. However, application of 60 kg P_2O_5 with plant density of 140 thousand plants per fed produced the tallest plants compared to the other treatments. Moreover, the highest plant density of peanut per unit area interacted negatively with application of 30 or 45 kg P_2O_5 and decreased oil yield per fed. In this concern, Babu *et al.* (1984) showed that interaction of fertilizers and plant density increased the pod yield of groundnut. These results could be due to application of 60 kg P_2O_5 interacted positively with the medium plant density of peanut and caused better environmental conditions for peanut growth and development as compared with the other treatments. It is known that limited plant-available P is associated with a more horizontal root angle in bean, placing roots in surface soil where P can accumulate because it is highly immobile (Bonser *et al.*, 1996). The productivity of groundnut depends on proper selection of variety, fertilizer management and other management practices (Lourduraj, 1999). These data show that each of these two factors act dependently *($P \leq 0.05$)* on plant height, numbers and weights of pods and seeds per plant, pods yield per fed, seed oil content and oil yield/fed.

Financial return

The financial return is shown in (Table 5) and Figure 1. Application of 60 kg P_2O_5/fed with plant density of 105000 plants/fed increased total return by 43.55 and 62.25 % in the first and second seasons, respectively, compared to those by application of 30 kg P_2O_5/fed with plant density of 70000 plants/fed. Also, application of 60 kg P_2O_5/fed with plant density of 105000 plants/fed increased net return by 67.05 and 103.19% in the first and second seasons, respectively, compared to those by application of 30 kg P_2O_5/fed with plant density of 70000 plants/fed. It is observed that application of 60 kg P_2O_5/fed with plant density of 105000 plants/fed recorded the highest net return in comparison with those of application of 30 kg P_2O_5/fed with plant density of 70000 plants/fed.

Table 5. Profitability as affected by P fertilizer rate, peanut plant density and their interaction in 2015 and 2016 summer seasons.

Treatments		Total return (L.E./fed)		Net return (L.E./fed)	
		2015	2016	2015	2016
30 kg P_2O_5	**70000**	11413	10644	6775	6006
	105000	15274	15274	10368	10368
	140000	9554	10255	4379	5080
	Mean	**12080**	**12057**	**7174**	**7151**
45 kg P_2O_5	**70000**	11869	12755	7151	8037
	105000	14369	15206	9383	10220
	140000	10964	11277	5709	6022
	Mean	**12400**	**13079**	**7414**	**8093**
60 kg P_2O_5	**70000**	12598	13279	7800	8481
	105000	16384	17270	11318	12204
	140000	11665	12530	6330	7195
	Mean	**13549**	**14359**	**8482**	**9293**
Average of peanut plant density	**70000**	**11960**	**12226**	**7242**	**7508**
	105000	**15342**	**15916**	**10356**	**10930**
	140000	**10727**	**11354**	**5472**	**6099**

Prices of main products are that of 2015: L.E. 681 for ardab of peanut; total costs: L.E. 4638 per fed, recommended P fertilizer rate: L.E. 160 per fed. Total costs were differed according to P fertilizer rate and peanut plant density.

These results reveal that application of 60 kg P_2O_5/fed with plant density of 105000 plants/fed is more profitable to farmers than application of recommended P fertilizer rate with recommended peanut plant density under sandy soil conditions. These findings are parallel with those obtained by Basak *et al*. (1995) who found that the closest spacing gave the highest gross return and return above variable cost. Also, Ajeigbe *et al*. (2016) showed that cultivation of peanut at high density with phosphorus application will make groundnut production a more profitable venture in Sudan Savanna zone of Nigeria. Moreover, Haldera *et al*. (2017) indicated that using 30–50 kg P_2O_5 per ha for peanut during the summer season is profitable.

Conclusion

It can be concluded that productivity and profitability of peanut could be increased by increasing its plant density to 50.0% over recommended density of 70 thousand plants/fed; this increase requires doubling P fertilizer rate of the recommended rate during soil preparation.

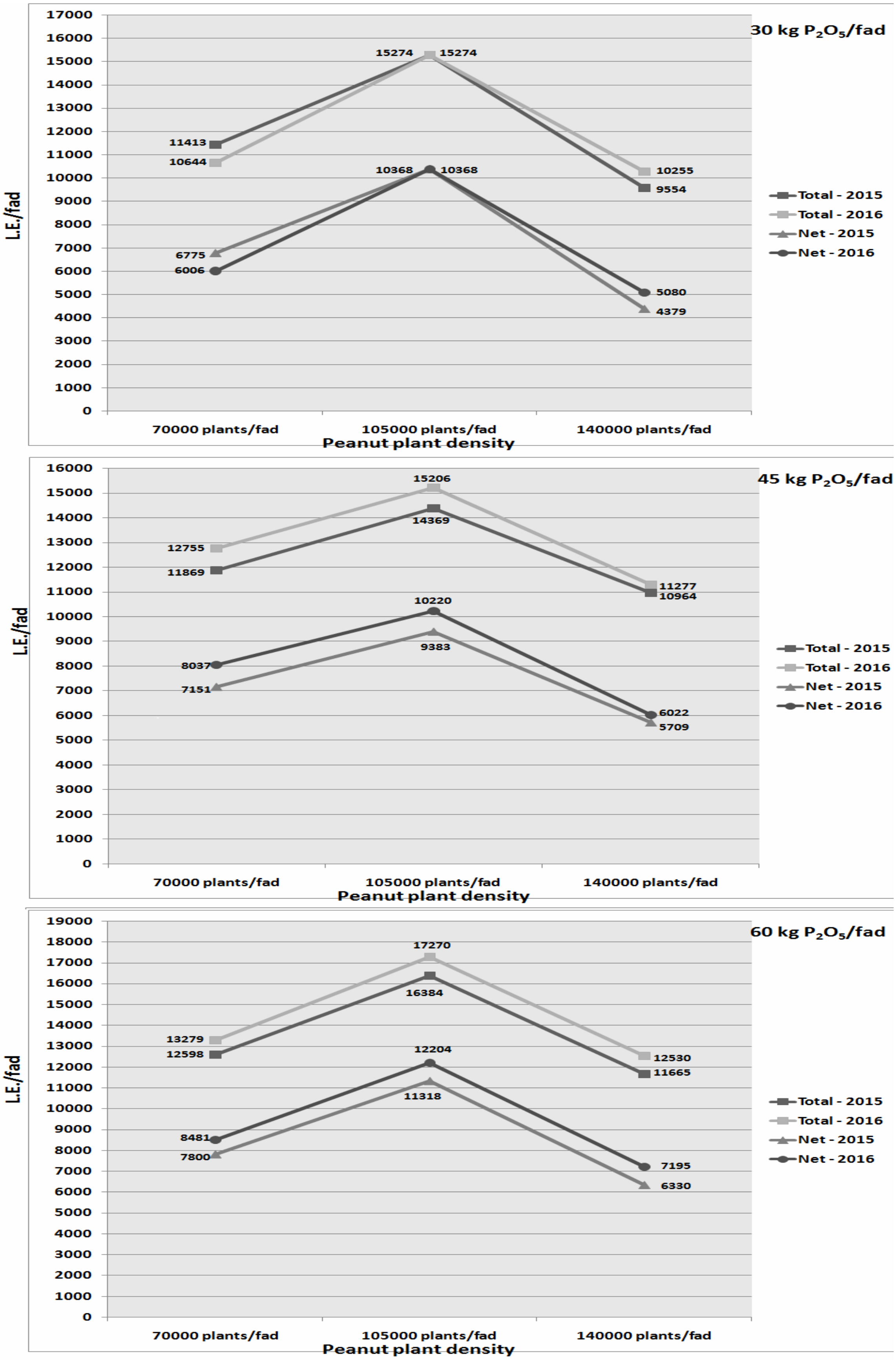

Figure 1: Financial return as affected by P fertilizer rate, peanut plant density and their interaction, 2015 and 2016 summer seasons.

References

A.O.A.C. (1990). Official methods of analysis. Association of Official Analytical Chemists-Int. 15th Ed. AOAC-Int., Arlington, VA.

Ahmad A., M. Rahim and U. Khan (2007). Evaluation of Different Varieties, Seed Rates and Row Spacing of Groundnut, Planted Under Agro-Ecological Conditions of Malakand Division. J. Agron., 6(2): 385 – 387.

Ahmad R., T. Mahmood, M.S. Farrukh and S. Ahmad (2002). Comparative performance of two sesame (*Sesamum indicum* L.) varieties under different row spacing. Asian J. Plant Sci., 1(5): 546-547.

Ajeigbe H.A., A.Y. Kamara, A. Kunihya, A.H. Inuwa and A. Adinoyi. (2016). Response of groundnut to plant density and phosphorous application in the Sudan Savanna Zone of Nigeria. Int. J. Biosci, 9(1): 291 – 302.

Babu N.R., S.R. Reddy, G.H.S. Reddi and D.S. Reddy (1984). Effect of fertilizers, irrigation and plant density on groundnut (*Arachis hypogaea* L). Fert. Res., 5(3): 273 – 279.

Basak N.C., M.K. Chowdhury and F.U. Mia (1995). Effect of spacing on the yield and economoics of groundnut. Legume Res., 18 (1): 45 – 49.

Bonser A., J. Lynch and S. Snapp (1996). Effect of phosphorus deficiency on growth angle of basal roots in Phaseolus vulgaris. New Phytologist, 132: 281 – 288.

Brady N.C. and R.R. Well (2002). The nature and properties of soils. 13th Ed. Pearson Education (Singapore) Pvt. Ltd. Indian branch.

Bulletin of Statistical Cost Production and Net Return (2016). Summer and Nili Field Crops and Vegetables and Fruit, Agriculture Statistics and Economic Sector, Ministry of Egyptian Agriculture and Land Reclamation, Part (2), August 2016.

Chang J.H. (1974). Radiation balance. Climatic and Agriculture. An ecological survey. Aldine Publishing Company, Chicago, Illinois, USA. Pp. 4–22.

Chapman H.D. and P.E. Pratt (1961). Methods of Analysis for Soils, Plants and Waters. Division of Agricultural Sciences, University of California, U.S.A.

Chijioke O.B., U.M. Ifeanyi and A.Ch. Blessing (2010) Comparative study on growth and development of some accessions of local Germplasm of Bambara groundnut (*Vigna subterrenea* L. Verdc.) of Nigeria in two cropping seasons. J. Crop Sci. and Biotechno., 13 (1): 21–27.

FAO. (2016). Statistical Year Book, World food and agriculture. Food and Agriculture Organization of the United Nations, Rome.

Freed R.D. (1991). MSTATC Microcomputer Statistical Program. Michigan State Univ., East Lansing, Michigan, USA.

Gabisa M., T. Tana and E. Urage (2017). Effect of planting density on yield components and yield of groundnut (*Arachis hypogaea* L.) varieties at Abeya, Borena Zone Southern Ethiopia. Int. J. Sci. Eng. and Appl. Sci., 3(3): 1 – 18.

Gomez, K.A. and A.A. Gomez (1984). Statistical Procedures for Agric. Res. 2nd Ed. John Willey and Sons, Toronto, ON, Canada.

Gulluoglu, L. (2011). Effects of regulator applications on pod yield and some agronomic characters of peanut in Mediterranean region. Turk. J. Field Crops, 16(2):210 – 214.

Haldera, D., R.K. Pandab, R.K. Srivastavac and S. Kheroard (2017). Evaluation of the CROPGRO-Peanut model in simulating appropriate sowing date and phosphorus fertilizer application rate for peanut in a subtropical region of eastern India. The Crop J., Available online 1 April 2017. https://doi.org/10.1016/j.cj.2017.02.005.

Jackson, M.L. (1958). Soil Chemical Analysis. Prentice Hall, Englwood Cliffis, New Jersy.

Kabir R., S. Yeasmin; A.K.M.M. Islam and Md.A Sarkar (2013). Effect of Phosphorus, Calcium and Boron on the Growth and Yield of Groundnut (*Arachis hypogea* L.). Int. J. Bio-Sci. and Bio-Tech., 5(3): 51 – 60.

Khalil M.A.I. (2010). Expected trends of self-sufficiency rates of main agricultural crops in Egypt. Case Study of Major Oilseed Crops, Department of Agricultural Economics, Mansoura Univ.

Konlan S., J. Sarkodie-addo, E. Asare-and and M.J. Kombiok (2013). Groundnut (*Arachis hypogaea* L.) varietal response to spacing in the guinea savanna agro-ecological zone of Ghana. Growth and yield. Afr. J. Agric. Res., 8 (22): 2769 – 2777.

Lanier J.E., D.L. Jordan, J.F. Spears, R. Wells, P.D. Johnson, J.S. Barnes, C.A. Hurt, R.L. Brandenburg and J.E. Bailey (2004). Peanut response to planting, row spacing, and irrigation. Agron. J., 96: 1066 – 1072.

Lourduraj C. (1999). Nutrient management in groundnut (*Arachis hypogaea* L.) cultivation.– A review. Agric. Res. Rev., 20: 14 – 20.

Mohammed H. and B.S. Ismail (2016). Effects of phosphorous fertilizer on growth and yield of groundnut. AIP Conf. Proc. 1784, 060018, pp. 1 – 6; DOI: 10.1063/1.4966856.

Onat B., H. Bakal, Leyla Gulluoglu and H. Arioglu (2017). The effects of row spacing and plant density on yield and yield components of peanut grown as a double crop in Mediterranean environment in Turkey. Turk J Field Crops, 22(1): 71–80. DOI: 10.17557/TJFC.303885.

Papastylianou I., (1995). Spacing of peanut plants (*Arachis hypogaea* L.) under irrigation. Eur. J. Agron., 4: 101 – 107.

Prasad P.V., V.G. Kakani and H.D. Upadhyaya (2009). Growth and Production of Groundnut. Soils, Plant Growth and Crop Production, [Ed. Willy H. Verheye], in Encyclopedia of Life Support Systems (EOLSS), Developed under the Auspices of the UNESCO, Eolss Publishers, Oxford ,UK, [http://www.eolss.net].

Rasekh H., J. Asghari, M.N. Safarzadeh Wishkai, S.L. Massoumi and R. Zakerinejad. (2010). Effect of planting pattern and plant density on physiological characteristics and yield of peanut (*Arachis hypo-*

geal L.) in Iran. Res. J. Biological Sci., 5(8): 542 – 547.

Solaiman A.R.M., A.F.M.S. Sattar, M.S. Islam and M.A. Khan (1991). Response of *Rhizobium* inoculated groundnut to nitrogen, phosphorus application under field conditions. Bangladesh J. Sci., 22: 51 – 58.

Sorensen R.B, D. Sternitzke and M. Lamb (2005). Row orientation and seeding rate on yield, grade, and disease incidence of peanut with subsurface drip irrigation. Peanut Sci., 28: 15 – 18.

Subrahmaniyan K., P. Kalaiselvan and N. Arulmozhi (2000). Studies on the effect of nutrient spray and graded level of NPK fertilizers on the growth and yield of groundnut. Int. J. Tropical Agric. 18: 287 – 290.

Uma Maheswar N. and G. Sathiyavani (2012). Solubilization of phosphate by *Bacillus Sps*., from groundnut rhizosphere (*Arachis hypogaea* L.). J. Chemical and Pharmaceutical Res., 4(8): 4007 – 4011.

Wright G.C. and M.J. Bell (1992). Plant population studies on peanut (*Arachis hypogaea* L.) in subtropical Australia. 3. Growth and water use during a termal drought stress. Aust J. Exp. Agric., 32: 197 – 203.

دراسة تأثير معدلات مختلفة من التسميد الفوسفوري والكثافات النباتية على إنتاجية وربحية الفول السوداني فى الأرض الرملية

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الملخص

أقيمت تجربة حقلية بمحطة البحوث والتجارب الزراعية بالإسماعيلية خلال موسمى النمو ٢٠١٥ و ٢٠١٦م لدراسة تأثير ثلاثة معدلات من التسميد الفوسفوري (٣٠، ٤٥ ، ٦٠ كجم فو٢أ٥/فدان) وثلاثة كثافات نباتية للفول السودانى (٧٠، ١٠٥ ، ١٤٠ ألف نبات/فدان) على محصول القرون والزيت وكذلك العائد النقدى. تم إستخدام تصميم القطع المنشقة مرة واحدة مع ثلاثة مكررات ويمكن تلخيص أهم النتائج فيما يلى:

- أدت زيادة معدل التسميد الفوسفوري من ٣٠ إلى ٦٠ كجم فو٢أ٥/فدان إلى زيادة معنوية لجميع صفات الفول السودانى تحت الدراسة ما عدا نسبة الزيت بالبذور لكلا موسمى النمو.
- أدت نقص الكثافة النباتية للفول السودانى من ١٤٠ إلى ٧٠ ألف نبات/فدان إلى زيادة معنوية فى عدد القرون والبذور للنبات ووزن القرون والبذور للنبات ونسبة التصافى ونسبة الزيت بالبذور، بينما العكس كان صحيحا بالنسبة لطول النبات لكلا موسمى النمو.
- حققت الكثافة النباتية للفول السودانى ١٠٥ ألف نبات/فدان أعلى القيم لمحصول القرون والزيت للفدان مقارنة بالكثافات النباتية الأخرى.
- زادت معظم الصفات تحت الدراسة معنويا بالتفاعل بين المعدل المرتفع من التسميد الفوسفوري والكثافة النباتية للفول السودانى ١٠٥ ألف نبات/فدان.
- حقق إستخدام ٦٠ كجم فو٢أ٥/فدان مع زراعة ١٠٥ ألف نبات/فدان أعلى حاصل من القرون والزيت والعائد النقدى.