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Effect of Application of phosphorus and Silicon on Wheat Productivity Under sandy Soil Conditions

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Abstract

A field experiment was carried out at Balouza North Sinai Research Station, Desert Research Center, to study the effect of application of P and Si on wheat productivity growing in the winter season of 2018-2019. The design of the experiment was a factorial randomized complete block design with two factors in three replicates. The first factor was the P fertilizer and the second one was the Si foliar spray. P treatments were P_1 = 60kgPha^{-1}, P_2= 30kgP ha-^{1} applied as soil application +30 kgP ha-^{1} applied as foliar application and P_3= 45kgP ha^{-1} applied as soil application +15 kgP ha^{-1} applied as foliar application. Silicon was applied in the form of potassium silicate at three rates as follows, S_1 (0 mgL^{-1}); S_2 (500mgL^{-1}); and S_3 (1000mgL^{-1}). At maturity , wheat plants were harvested on 9/5/2019. Grain and straw yields significantly increased by the application of P and Si . Also, the obtained results showed that N, P, and K contents in grains and straw increased with increasing the application P and Si.

Key words: phosphorus, Silicon, Wheat, sandy Soil.

Introduction

Wheat is one of the most important strategic crops. Phosphorus (P) is a macronutrient that plants require in relatively considerable quantities. Its primary role in plants is to store and transport the energy generated by photosynthesis for use in the growth and reproduction processes. A availability of P in soil is affected by several factors such as pH, **(White, 2006)**. Since P is not very mobile in soil, diffusion is the main way in which it reaches to the root surface **(Lamber*set al.*, 2008)**. Although its diffusion in soil is lower than that of other nutrients, it increase by increasing the concentration of phosphate in the soil solution **(Lamber*set al.*, 2006)** and also by spraying plants with it. **(Femandezand Eichert, 2009).**Uptake, and transport of foliar P determine the overall efficacy of its application **(Noack*et al.*, 2011).** Phosphorus spray reduces production costs **(Faulkner, 1999)**. The main reason for P spraying is to maintain at an early stage of growth **(Faulkner, 1999).**To enhance phosphorus application, **Fernandez** and **Eichert (2009)** suggested foliar application, **Talboyset al. (2020)** stated that fertilizers have a dramatic conventional methods of P application result in limited recovery of the applied P. **Irfan*et al.* (2019)** stated that enriching the aerial parts of plant with P via foliar application functions as P provider to grains. **Rafiullah *et al.* (2021)** applied P as foliar spray in conjunction with soil application and obtained an increase in plant height and biomass. **Concerning silicon, Epstein (1999)** reported that silicon is the second most abundant element in the Earth's crust, Silicon compounds reduce or neutralize the toxic effect of iron, aluminum, and manganese **(Cocker*et al.*, 1997; Epstein, 1999 and Rains *et al.*, 2006)** and is absorbed by roots and deposited within the plants. **Epstein, *et al.*, (1994)** found positive effects of gypsum and sodium silicate on wheat grown under waterlogged conditions. Although the effect of silicon is positive on many crops its efficiency as fertilizer has not been determined (**Sundahri *et al.*, 2001).**

Materials and Methods

A field experiment was conducted in winter seasons of 2018 - 2019, at Balouza Research Station of the Desert Research Center (DRC) in North Sinai, to study the effect of application of phosphorus and silicon on wheat productivity under sandy soil conditions. Table 1 show physical and chemical properties of the soil under study. Nitrogen was added to all plots (600 kg N ha^{-1}as ammonium sulfate) in three unequal doses i.e 20% at seedbed preparation prior to sowing, 40% after 25 days from sowing, and 40% after 45 days from sowing. K fertilizer was added to all plots in three equal doses in the form of potassium sulfate at a rate of 480 kg ha^{-1} after 25, 45, and 65 days after sowing.

The design of the experiment was a factorial randomized complete block design with two factors in three replicates. The first factor (A) was the P and the second one was Si. P was applied as soil and foliar applications, while silicon (potassium silicate) was applied as a foliar application. P treatments were three as follow: P_1=applied at a rate of 60kg P ha-^{1} as soil application; P2= 30 kgP ha-^{1} as soil application +30 kgP ha-^{1} as foliar spraying and P3= 45 kgP ha^{-1} as soil application +15 kgP ha-^{1} as foliar spraying. The second factor was Si applied as foliar spray in the form of potassium silicate at three rates; 0, 500, and1000 mg Si L^{-1}. Samples of grains and straw were

Table 1. Soil physical and chemical properties.

Soil Characteristics	Values
Particle size distribution	
Sand %	**91.5**
Silt %	**3.3**
Clay %	**5.2**
Textural class	**Sand**
pH	**8.12**
EC dS m $^{-1}$	**1.72**
O.M %	**0.22**
$CaCO_3$ %	**1.93**
Soluble cations and anions ($mmol_c$ L^{-1})	
Ca^{2+}	**3.92**
Mg^{2+}	**2.78**
Na^{+}	**4.29**
K^{+}	**1.64**
CO_3^{2-}	**0.00**
HCO_3^{-}	**1.37**
Cl^{-}	**4.80**
SO_4^{2-}	**6.46**
Available N (mg kg^{-1})	**7.6**
Available P (mg kg^{-1})	**6.6**
Available K (mg kg^{-1})	**144**

Results and Discussion

Effect of phosphorus application on wheat yield:-

Effect on grain yield:-

Results presented in Table 2 show the effect of P-fertilizer application, Si spraying, and their combination on wheat grain yield.

Concerning the effect of P, there were significant differences between the P treatments. The highest value was obtained with the application of phosphorus by the rate P_3 (45kgPha^{-1}as soil application +15kgPha^{-1} as foliar spraying. Meanwhile, phosphorus application by the rate P_1(60kg Pha^{-1}as soil application) gave the lowest value.

As for the effect of foliar spraying with Si, there were significant differences between the Si treatments. The highest value was obtained by Si_3treatment (1000 mg Si L^{-1}) whereas the lowest one was obtained by the treatment .Si_1 (0 mg Si L^{-1}).Concerning the interaction between the P-fertilizer application rates and the Si application rates, results in Table 2 show that there were significant variations among treatments. The obtained results show that increasing the P-fertilizer application rate increased wheat grain yield especially under the high rate of Si application. The highest value was obtained by P_3 treatment whereas the lowest one was obtained by P_1. These results are in harmony with those obtained by **Mosali et al, (2006) who** reported that foliar application of P increased wheat grain yield and P uptake.

Effect on straw yield:-

Data presented in Table 3 show the effect of P-fertilizer, Si spraying, and their interaction on straw yield. There were significant differences among the P treatments. The highest value was obtained by the application of P at the rate P_3 whereas the lowest one was obtained by application of P at the rate P_1. As for the effect of foliar spraying with Si, there were no significant differences between the Si treatments on straw yield. Increasing P rate increased wheat straw yield especially under the high rate of Si application. The highest value was obtained by P_3 application combined with the application of Si_3.

Table 2. Effect of phosphorus and silicon application on the grain yield (kg h^{-1}) of wheat plants grown on the sandy soil under study

Factor (A) P	Factor (B) Si			Mean
	Si_1	Si_2	Si_3	
	Grain yield (kg h^{-1})			
P_1	**4731**	**5044**	**5623**	**5133**
P_2	**5084**	**5621**	**5992**	**5566**
P_3	**4733**	**4981**	**5211**	**4975**
Mean	**4849**	**5216**	**5609**	
LSD at 0.05	**P**	**Si**	**P*Si**	
	119	**119**	**207**	

Notes: P_1= 60 kg p ha^{-1} applied as soil application, P_2= 30kg p ha^{-1} applied as soil application + 30 kg p ha^{-1} foliar. P_3= 45kg P ha^{-1} applied as soil application + 15 kg p ha^{-1} foliar , **Si_1**= (0 mg Si L^{-1}) ,**Si_2**= (500 mg Si L^{-1}) , **Si_3** = (1000 mg Si L^{-1}) foliar.

Table 3. Effect of phosphorus and silicon application on the straw yield (kg h^{-1}) of wheat plants grown on the sandy soil under study

Factor (A) P	Factor (B) Si			Mean
	Si_1	Si_2	Si_3	
P_1	7806	7590	7699	7698
P_2	8002	8102	8261	8121
P_3	9064	9056	9174	9098
Mean	8290	8249	8378	
LSD at 0.05	P	Si	P*Si	
	654	654	1132	

See footnotes of Table 2

Effect of phosphorus and silicon application on nutrients concentration in wheat grains and straw:-

a- **Effect on nutrients content in wheat grains**:

b- Results in Tables 4, 5 and 6 show the effect of P-fertilization, Si spraying, and their interaction on N, P, and K contents in the grains of wheat. Concerning the effect of P, the obtained results show that there were significant differences between the P treatments. P_3 treatment gave the highest value as compared with the P_1 treatment. As for the effect of foliar spray with Si, there were non-significant variations between the Si treatments. The highest N, P, and K content in grains of wheat were obtained by applying P_3 combined with Si_3 (1000 mgL^{-1}).

Table 4. Effect of application of phosphorus and silicon on N content (g kg^{-1}) in grains of wheat plants grown on the sandy soil under study.

Factor A P	Factor B Silicon concentration			Mean
	Si_1	Si_2	Si_3	
P1	116.4	132.1	139.7	129.4
P2	114.6	127.9	149.0	130.5
P3	134.8	153.2	172.5	153.5
Mean	121.9	137.7	153.7	137.8
LSD at 0.05	P	Si	P*Si	
	3.6	3.6	6.2	

Table 5. Effect of application of phosphorus and silicon on P content (g kg^{-1}) in grains of wheat.

Factor (A) P	Factor (B) Si			Mean
	Si_1	Si_2	Si_3	
P_1	22.21	26.46	32.68	27.12
P_2	22.80	28.61	39.65	30.35
P_3	28.90	35.75	43.15	35.93
Mean	24.64	30.27	38.49	31.13
LSD at 0.05	P	Si	P*Si	
	1.67	1.67	2.90	

See footnotes of Table 2

Table 6. Effect of application of phosphorus and silicon on K content (g kg^{-1}) in grains of wheat plants grown on the sandy soil under study.

Factor (A) P	Factor (B) Silicon concentration			Mean
	Si_1	Si_2	Si_3	
P1	52.68	55.49	61.00	56.39
P2	46.58	54.62	63.89	55.03
P3	57.78	70.27	77.14	68.40
Mean	52.35	60.13	67.34	59.94
LSD at 0.05	P	Si	P*Si	
	1.76	1.76	3.04	

See footnotes of Table 2

c- **Effect on N, P and K content in straw**:
Results in Tables 7, 8, and 9 show the effect of P-fertilization, Si spraying, and their interaction on N P K contents in the straw of wheat. P_3 gave the highest values of N, P contents and there were significant differences as compared with the P_1 treatment. However, there were no significant differences in K content as compared with the P_1treatment.

About the impact of foliar spray with Si on N, P and K contents, the obtained results show that there were no significant differences between the Si treatments on N, K contents, The highest content of N, P, and K in the straw of wheat occurred by applying P-fertilizer at P_3 combined with Si_3. These results are in harmony with **Lambers et al., (2008).** P- diffusion can be increased by increasing the concentration of phosphate in the soil solution **(Lambers et al., 2006)** and also by spraying plants with P.

Table 7. Effect of application of phosphorus and silicon on N content (g kg^{-1}) in the straw of wheat plants grown on the sandy soil under study.

Factor (A) P	**Factor (B) Si**			**Mean**
	Si_1	**Si_2**	**Si_3**	
P1	93.56	110.33	127.72	110.53
P2	90.75	104.38	133.54	109.55
P3	136.95	142.40	182.76	154.04
Mean	107.08	119.03	148.01	124.71
LSD at 0.05	P	Si	P*Si	
	3.02	3.02	5.24	

See footnotes of Table 2

Table 8. Effect of application of phosphorus and silicon on P content (g kg^{-1}) in the straw of wheat plants grown on the sandy soil under study .

Factor (A) P	**Factor (B) Si**			**Mean**
	Si_1	**Si_2**	**Si_3**	
P1	40.80	47.25	53.92	47.32
P2	36.30	41.15	51.42	42.96
P3	50.86	55.66	63.61	56.71
Mean	42.65	48.02	56.32	49.00
LSD at 0.05	P	Si	P*Si	
	3.90	3.90	6.75	

See footnotes of Table 2

Table 9. Effect of application of phosphorus and silicon on K content (g kg^{-1}) in the straw of wheat plants grown on the sandy soil under study

Factor (A) P	**Factor B Si**			**Mean**
	Si_1	**Si_2**	**Si_3**	
P1	260.85	333.91	376.12	323.63
P2	258.58	297.72	362.88	306.39
P3	322.89	361.01	416.71	366.87
Mean	280.77	330.88	385.24	332.30
LSD at 0.05	P	Si	P*Si	
	12.12	12.12	21.00	

See footnotes of Table 2

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Conclusion

It could be concluded that application of P-fertilizer at a rate of 45kg P ha^{-1} as soil application +15kg P ha^{-1} as foliar combined with foliar spraying with 1000 mg Si L^{-1} could be recommended for increase wheat yields, and contents of N P K in North Sinai Governorate.

References

Bouma, D.1969. The response of subterranean clover (*Trifoliumsubterranean* L.) to foliar applications of phosphorus. Aust. J. Agric. Res. 20: 435-445.

Chapman, H.D. and P.F. Pratt. 1961. Methods of Analysis for Soil, Plant and Water. Univ. of Calif., USA.

Cocker, K.M.; Hodson, M.J.; Evans, D.E. and Sangster, A.G. (1997). The interaction between silicon and aluminium in *Triticumaestivum* L. Israel J. Plant Sci.45, 285–292.

Epstein, E. (1994). The anomaly of silicon in plant biology. Proc. Natl. Acad. Sci. 91, 11–17.

Epstein, E.(1999). Silcon.Annu. Rev. Plant Physiol. Plant Mol. Biol. 50, 641–664.

Faulkner, S.P.(1999). Foliar Feeding when your Plants Need it Fast. In the Growing Edge. New Moon Publishing, Inc., Corvallis, OR, p: 42-47.

Femandez, V. and Eichert, T.(2009).uptake ofhydrophilic solutes through plant leaves: current state of knowledge and perspectives offoliar fertilization. Crit. Rev. Plant Sci. 28: 36-68.

Hazen, J.L.(2000). Adjuvants: terminology, classification and chemistry. Weed Technol. 14: 773-784.

Hess, F.D. and Foy, C.L.(2000). Interaction of surfactants with plant cuticles. Weed Technol., 14: 807- 817.

JagadeeshMosali, KefyalewDesta, Roger K.Teal, Kyle W. Freeman, Kent L. Martin, Jason W. Lawles, and William R. Raun.2006.effect of foliar application of phosphorus on winter wheat grain yield, phosphorus uptake, and use efficiency. Journal of plant nutrition, 29: 2147-2163.

Koontz,H. and Biddulph, O.(1957). Factors affecting absorption and translocation offoliar applied phosphorus. Plant Physiol. 32: 463-470.

Lambers, H.; Chapin F.S. and Pons, T.L. (2008). Plant physiological ecology. New York: Springer.

Lambers, H.; Shane, M.W; Cramer, M.D; Pearse, S.J. andVeneklaas, E.J. (2006) Root structure and functioning for efficient acquisition of phosphorus.matching morphological and physiological traits. Annals of Botany9.693-713.

McBeath, T.M.;McLaughlin,M.J.andNoack,S.R.(2011): Wheat grain yield response to and translocation offoliar-applied phosphorus. Crop Pasture Sci. 62: 58-65.

Noack,S.R.;McBeath, T.M. and McLaughlin, M.J.(2011): Potential for foliar phosphorus fertilization of dryland cereal crops: A Review.Crop Pasture Sci. 62: 659-669.

Noack,S.R.;McBeath, T.M. and McLaughlin, M.J.(2011): Potential for foliar phosphorus fertilization of dry land cereal crops: a review. Crop Pasture Sci . 62: 659-669.

Page, A.L. R.H. Miller and D.R. Keeney. 1982. Methods of soil analysis. Part 2: Chemical and Microbiological Properties. Second edition.Agronomy J. 9: 2, Am. Soc. Agron. Inc., Soil Sci. Soc. Am. Inc. Pub. Madison, Wisconsin, USA.

Peirce, C.A.E.; Priest, C.;McMeath, T.M.andMcLaughlin, M.J.(2016): Uptake of phosphorus from surfactant solutions by wheat leaves: spreading kinetics, wetted area, and drying time. Soft Matter12: 209-218.

Rains, D.W.; Epstein, E.; Zasoski, R.J. andAslam, M. (2006): Active silicon uptake by wheat. Plant Soil280: 223–228.

Snedecor, G.W. and Cochran, W.G. (1990). Statistical Methods.The Iowa State Univ. 7th Ed. pp. 507.

Sundahri, T.; Bell1, C.J.; Salel, P.W.G. and Peries, R. (2001). Response of canola and wheat to applied silicate and gypsum on raised beds. Proc. 10thAustralian Agronomy.Conference.2001.Available.onlinewww.regional.org.au/au/asa/2001/p/14/sundahri.htm.

Swanson,C.A. and Whitney,J.B. Jr. (1953): Studies on thetranslocationoffoliar-appliedP 32 and otherradioisotopes in bean plants. Am. J. Bot. 40: 816-823.

Tukey, H.B.;Bukovac,M.J. and Wittwer, S.H.(1961). Absorptions ofradionuclides by aboveground plant parts and movement within the plant. J. Agric. Food Chem. 9: 106-113.

White, R.E. (2006). Principles and practice of soil science.The soil as anatural resource. 4thed. Blackwell Publishing company. Chapter 10.pp.200-229.

تأثير إضافة الفوسفور والسليكون على إنتاجية القمح تحت ظروف التربة الرملية

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أجريت تجربة حقلية فى الموسم الشتوى 2018– 2019فى محطة بحوث بالوظة شمال سيناء ، مركز بحوث الصحراء ، لدراسة تأثير إضافة الفوسفور والسليكون على إنتاجية القمح تحت ظروف التربة الرملية. حيث أقيمت تجربة عاملية فى تصميم قطاعات كاملة العشوائية مع عاملين في ثلاث مكررات. كان العامل الأول هو السماد الفوسفاتى والعامل الثاني هو إضافة السليكون. تم إضافة السوبر فوسفات إلى التربة والرش على الأوراق ، بينما تم إضافة السليكون (سيليكات البوتاسيوم) رشاً على الأوراق. تم إضافة سماد السوبر فوسفات بثلاث معدلات على النحو التالي: P1 = 840 كجم سماد سوبر فوسفات (6,8٪ P) كإضافة أرضية (أي 60 كجم فو / هيكتار) ؛ P2 = 420 كجم /هكتار سماد سوبر فوسفات كإضافة أرضية (أى ما يعادل 50 % من المعدل الموصى بة) + 420 كجم /هكتار سماد سوبر فوسفات كرش ورقي (أي 30 كجم فو/هكتاركإضافة أرضية + 30 كجم فو/هيكتار رشاً على الأوراق)+ 420 كجم فوسفور/هكتار (ما يعادل 50 % من المعدل الموصى بة) كرش بمنقوع سماد السوبر فوسفات؛ P3 = 630 كجم/ هكتار سماد سوبر فوسفات كإضافة أرضية + 210 كجم/ هكتار سماد سوبر فوسفات كرش ورقي (أي 45 كجم فو هكتار$^{-1}$إضافة أرضية + 15 كجم فو هكتار $^{-1}$رش ورقي) أى (ما يعادل 75 % من المعدل الموصى بة) + 210 كجم فوسفور/هكتار (ما يعادل 25 % من المعدل الموصى بة) كرش بمنقوع سماد السوبر فوسفات.

تم إضافة السليكون فى صورة سيليكات البوتاسيوم بثلاث معدلات على النحو التالي: S1= صفر مجم لتر$^{-1}$ ؛ S2 = 500 مجم لتر $^{-1}$ ؛ و S3 = 1000 مجم لتر $^{-1}$.تم زر اعة حبوب القمح (*Triticumaestivum* cv. Giza 168) فى 23 نوفمبر 2018 وكذلك تم الرى بمياه ترعة السلام. بعد النضج تم حصاد نباتات القمح وأخذ قياسات النمو ثم تم تسجيل وزن محصول الحبوب والقش وكذلك محتواهم من الNPK وقد أضحت النتائج أن هناك زيادة معنوية فى أوزان الحبوب والقش نتيجة إضافة الفوسفور والسليكون وبصفة خاصة عند إضافة المعدل الثالث من سماد السوبر فوسفات (630 كجم فوسفور/هكتار للتربة +210كجم فوسفور/هكتاركرش) مع المعدل الثالث من السليكون (1000 ملجم/اللتر). أمابالنسبة لمحتويات النيتروجين والفوسفور والبوتاسيوم (٪) في الحبوب والقش فقد أوضحت النتائج أنها زادت معنوياً في الغالب.