SEBHA UNIVERSITY JOURNAL OF PURE & APPLIED SCIENCES VOL.21 NO. 2 2022
DOI: 10.51984/JOPAS.V21I2.1698

مجلة جامعة سبها للعلوم البحتة والتطبيقية
Sebha University Journal of Pure & Applied Sciences

Journal homepage: www.sebhau.edu.ly/journal/index.php/jopas

Effect of phosphorus on root growth, root to shoot ratio, phosphorus uptake and use efficiency in some barley genotypes as influenced by phosphorus fertilization

Suad. A. Amgada[a], *Kamal. A. Abdalgader[a] , Eman. A. Amgada[b]

[a] Soil and Water Department, Faculty of Agriculture, Omar Al Mukhtar Universit, El- Beida-Libya
[b] Natural Resources and Environmental Science, Omar Al-Mukhtar University, El- Beida-Libya

Keywords:
Phosphorus
Root Dry Weight
Root Shoot Ratio
Uptake
Use Efficiency

ABSTRACT

Root are important organs that supply phosphorus to growing plants. Data related to root growth and P-uptake by some barley genotypes are limited. A pot experiment was conducted in Faculty of Agriculture Omar –AL-Mukhtar University to evaluate the Effected phosphorus on root growth of different barley varieties during the growing season (2021). The objective of this study was to evaluate root growth of some barley genotypes and P-uptake and use efficiency under phosphorus (P) levels. A randomized complete block design was used in a factorial arrangement and the treatments were replicated three times. The P levels used were 0(low), 50 (medium) and 100 (high) mg kg-1 of soil, and four barley genotypes were evaluated. Root dry weight g plant-1, contribution of root in the total plant weight (%), root/ shoot ratio and P- uptake and use efficiency were significantly influenced by P and barley treatments. Maximum values of these root growth parameters were achieved with the addition of 50 mg P kg -1 soil. The P × barley genotypes interactions for P-uptake and use efficiency were significant, indicating variation in uptake pattern of P by barley genotypes with the variation in P rates. Increase in root growth with the addition of P can improve P uptake from the soil and lessen loss of nutrient from the soil and plants systems.

تأثير الفوسفور على نمو الجذور ونسبة المجموع الجذرى الى المجموع الخضرى وامتصاص الفوسفور وكفاءة استخدامه فى بعض اصناف الشعير متأثرة بالتسميد بالفوسفور

سعاد عبد القادر امقدع[1] و * كمال عبد السلام عبد القادر [1] وإيمان عبد القادر أمقدع[2]

[1] قسم التربة والمياه، كلية الزراعة، جامعة عمر المختار، ليبيا
[2] قسم علوم البيئة، كلية الموارد الطبيعية وعلوم البيئة، جامعة عمر المختار ، ليبيا

الكلمات المفتاحية:
الفوسفور
امتصاص
كفاءة الاستخدام
نسبة الجذور الى المجموع الخضرى
الوزن الجاف

الملخص

الجذر من الاعضاء المهمة التى تزود النباتات النامية بالفوسفور. البيانات المتعلقة بنمو الجذور والامتصاص من قبل بعض اصناف الشعير كانت محددة. تجربة أصص اقيمت في كلية الزراعة-جامعة عمر المختار لتقدير تأثير الفوسفور على نمو الجذور على أربعة أصناف مختلفة من الشعير خلال الموسم (2021). كان الهدف من هذه الدراسة تقييم نمو الجذور فى بعض اصناف الشعير وامتصاص الفوسفور وكفاءة استخدمه تحت مستويات الفوسفور. أستخدم في التجربة تصميم القطاعات كاملة العشوائية وهي تجربة عامليه بثلاث مكررات. كانت مستويات الفوسفور المستخدمة هي 0 (منخفض) ،50(متوسط) و100 (مرتفع) مجم/كجم من التربة وتم تقييم اربعة اصناف من الشعير (جم/نبات) ومساهمة الجذر في الوزن الكلى للنبات (%) ونسبة المجموع الجذري الى المجموع الخضرى وامتصاص وكفاءة استخدام الفوسفور تأثرت معنويا بمعاملات الفوسفور والأصناف. تم تحقيق اعلى القيم لمقاييس الجذر هذه مع اضافة 50 مجم فوسفور /كجم تربة. التداخل بين الاصناف وامتصاص الفوسفور وكفاءة استخدامه كان معنويا مما يشير الى التباين فى نمط امتصاص الفوسفور بواسطة

Corresponding author:
E-mail addresses: kamal.abdalsalam@omu.edu.ly, (S. A. Amgada) Suad.amqada@omu.edu.ly, (E. A. Amgada) ayiman.amqadaa@omu.edu.ly
Article History : Received 04 January 2022 - Received in revised form 14 June 2022 - Accepted 20 June 2022

الاصناف مع اختلاف معدلات اضافة الفوسفور ويمكن ان تؤدي زيادة نمو الجذور مع اضافة الفوسفور الى تحسين امتصاصه من التربة وتقليل من فقده من التربة وأنظمة النبات.

1.Introduction

Phosphorus (P) is an important essential macronutrient for plant growth [10 ,12]. It is required as a structural component of DNA, RNA and is a regulator in signal transduction cascades [13]. It is immobile in most soil conditions compared to other cronutrients [3] .A large number of studies have shown that P supply is critical for early plant growth ,maximum root development and optimum plant yield [5,15] . Plant attributes that lead to enhanced P acquisition efficiency are related to the extent to which roots are able to intercept more soil available P. these attributes include root architecture, root morphology, mycorrhiza,

Associations, high affinity transporters, rhizosphere alteration and changes in the root to shoot ratio [7]. In such sense, root to shoot ratio (RSR) is a useful tool to evaluate the biomass allocation among different plant organs [14]. RSR is the ratio of the belowground biomass to the aboveground bi ass, which is the parameter that most directly reflects biomass allocation by plants. many plants would change their RSR in response to shading or low nutrient availability [2]. so RSR is an important indicator of competitive interactions among different plant species [16]. The objective of this study was to evaluate root growth, root/shoot ratio ,phosphorus uptake and phosphorus use efficiency under different phosphorus levels .

2. MATERIALS AND METHODS

Table 1 . Some physical and chemical properties of the experimental Soil.

Properties	value
Soil texture	Sandy
pH	7.2
EC dSm^{-1}	0.48
Organic Matter %	0.2

A pot experiment was conducted to evaluate root growth , phosphorus uptake and phosphorus use efficiency by four barley genotypes *(Hordeum valgare* L*)* . characteristics of the soil used in the experiment (table 1) Four barley varieties were used , Rahan , Tramilo , M97 and B12-3 .The phosphorus levels used were : 0 mgkg-1 (low) ,50 $mgkg^{-1}$ (medium) and 100 $mgkg^{-1}$ (high) , applied as di- ammonium phosphate . Basal fertilizer rates used were 25 mg N/ kg (urea) and 50mg K/kg of soil to each pot (30cm×25cm) containing 5kg of soil . All fertilizers were mixed well with soil before planting . Moisture content was kept near field capacity during the experimental period with extended to 30 days after sowing .At the end of the experiment shoots and roots were removed and washed several times with fresh water. Dry weight of both shoots and roots were recorded after oven drying at 70°C. Shoots and roots were milled and digested according to method of [3]. Phosphorous was determined by an atomic absorption spectrophotometer

Root/Shoot ratio and P –use efficiency were calculated by using the following equation :

Root /Shoot ratio = Root dry weight ⁄ Shoot dry weight

Contribution of root in the total plant (wt)(%) =(Root dry weight(mg)/(Root + Shoot) dry weight)× 100

P – use efficiency ($mgmg^{-1}$)= Root dry weight mg /P uptake in mg

A randomized complete block design was used in a factorial arrangement and the treatments replicated three times were statically analyzed according to the method reported by [9] .

3. RESULTS AND DISCUSSION

Table 2: dry weight (g plant $^{-1}$) of four barley genotypes as influenced by phosphorus fertilization.

Barley genotpys	Phosphorus Levels ($mgKg^{-1}$)		
	Low P (0 $mgKg^{-1}$)	Medium P (50 $mgKg^{-1}$)	High P (100 $mgKg^{-1}$)
Rahan	0.88	1.99	0.61
Tramilo	0.21	0.33	0.26
M97	0.11	0.41	0.22
B12-3	0.21	0.91	0.51
Averg	0.35	0.91	0.41
LSD at 5%	(P) 0.01	(G) 0.011	(P*G) 0.021

Phosphorus × barley genotypes interactions for root dry weight , root/shoot ratio and contribution of root in the total plant weight were significant (Tables 2) ,indicating that differential performance of barley cultivars tested at different P levels .Root dry weight varied from 0.11 to 0.88 g $plant^{-1}$ at low P level , with an average value of 0.35 g $plant^{-1}$. Similarly , at medium P level , root dry weight varied from 0.33 to 1.99 g $plant^{-1}$, an average of 0.91 g $plant^{-1}$. At high P level root dry weight varied from 0.22 to 0.61 g $plant^{-1}$, with an average value 0.41 g $plant^{-1}$ .Overall , significant increases were measured in root dry weight with the addition up to 50 mg P kg soil .This was in accordance with the finding of [15] who concluded that , increase in root weight of crop plant with the addition of phosphorus fertilizer .

Table 3 . Contribution of root in the total plant weight (%) of four barley genotypes as influenced by phosphorus fertilization.

Barley genotpys	Phosphorus Levels ($mgKg^{-1}$)		
	Low P (0 $mgKg^{-1}$)	Medium P (50 $mgKg^{-1}$)	High P (100 $mgKg^{-1}$)
Rahan	29.1	66.8	14.4
Tramilo	19.1	25.4	15.4
M97	8.33	27.2	12.0
B12-3	15.3	42.3	20.3
Averg	18.0	40.4	15.5
LSD at 5%	(P) 0.025	(G) 0.018	(P*G) 0.051

Data represented in table (3) showed that, contribution of root in the total plant weight was 18.0 % at low P level , 40.4 % at medium P level and 15 .5 % at high P level . The increase in contribution of root weight in total plant at medium P level reflects cover crops responses to P fertilization .

Table 4 . Root /shoot ratio of four barley genotypes as influenced by phosphorus fertilization.

Barley genotpys	Phosphorus Levels ($mgKg^{-1}$)		
	Low P (0 $mgKg^{-1}$)	Medium P (50 $mgKg^{-1}$)	High P (100 $mgKg^{-1}$)
Rahan	0.41	0.93	0.61
Tramilo	0.24	0.19	0.18
M97	0.91	0.22	0.21
B12-3	0.18	0.65	0.41
Averg	0.44	0.50	0.35
LSD at 5%	(P) 0.061	(G) 0.023	(P*G) 0.036

Root /shoot ratio was significantly affected by P level , barley genotypes (Table 4) .In addition , the interaction of P and genotypes was also significant for root /shoot ratio ,it can be concluded that ,root /shoot ratio of barley genotypes varied with the variation in P levels . Overall ,root / shoot ratio increased when P level was increased from 0 to 50 mg P kg^{-1} and then decreased . The decrease in root / shoot ratio at the greatest P level indicates increase in shoot dry weight more compared to root dry weight at this P level . This finding was

in harmony with the results obtained by [11] who concluded that, disproportionate growth of shoots over roots sharply decreases the root to shoot ratio when P concentration changes from deficient to low and slightly decreases it when P concentration changes from low to high. Similar results are obtained by [4] who indicated that, one of the main symptoms of P deficiency in plants is enhanced root: shoot ratio by either a reduction in shoot growth or an increase in root production or both.

Table 5 . Phosphorus uptake (mg plant $^{-1}$) in four barley genotypes as influenced by phosphorus fertilization.

Barley genotpys	Phosphorus Levels (mgKg^{-1})		
	Low P (0 mgKg^{-1})	medium P (50 mgKg^{-1})	high P (100 mgKg^{-1})
Rahan	0.14	0.65	1.42
Tramilo	0.17	0.41	0.15
M97	0.13	0.51	0.57
B12-3	0.22	0.46	1.66
Averg	0.17	0.51	0.95
LSD at 5%	(P) 0.016	(G) 0.025	(P*G) 0.036

Uptake of P increased with the increase in P levels in growth medium. Data represented in table (5) showed thatt, at low P level P uptake varied from 0.13 to 0.22 mg plant $^{-1}$, with an average value of 0.17 mg plant $^{-1}$. At medium and high P levels, P uptake values varied from 0.41 to 0.65 mg plant $^{-1}$ and from 0.15 to 1.66 mg plant $^{-1}$, respectively . However , there significant differences among barley genotypes in P uptake . This result was in agreement with the finding [8] who reported that , a variety of root properties such as length , dry weight , density and hairs might have caused variation in P uptake among the crop species[1].

Table 6. Phosphorus use efficiency (mg mg $^{-1}$) in root of four barley genotypes as influenced by phosphorus fertilization.

Barley genotpys	Phosphorus Levels (mgKg^{-1})		
	Low P (0 mgKg^{-1})	medium P (50 mgKg^{-1})	high P (100 mgKg^{-1})
Rahan	6285.7	3061.5	429.6
Tramilo	1235.3	804.9	1733.3
M97	846.6	803.9	385.9
B12-3	954.5	1978.3	307.2
Averg	2330.4	1662.2	714
LSD at 5%	(P) 18.40	(G) 17.14	(P*G) 19.2

Data represented in table (6) showed that the P – use efficiency decreased with the increase in P rate , suggesting increase in root dry weight with the increase in P rates . Similar results are obtained by [1 ,6 ,7] who found that , nutrient –use efficiency decreased with the increase in nutrient rates in crop plants .

REFERENCES

[1]- Amgada Suad, Abdlgader kamal,A and Abdullah Yousef,H.(2017). Phosphorous use Efficiency by Barley Plant , Global Libyan Joarnal.No(26).

[2]- Aphalo , P ; Ballare , C and Scopel , A (1999) . Plant – plant signaling the competition . J.Exp . Bot . 50 (340): 1629 – 1634.

[3]- Bao,S.D.(2000). Soil agricultural chemical analysis ,China, Agri, Press , Beiging.

[4]- Chien ,P ; Chien ,C ; Leog ,L and Chiou , J (2018) . Sensing and signaling of phosphate starvation : from local to long distance – Plant & Cell physiology . 59: 1714 – 1722

[5]- De Melo M ,E ; De Concalres , J and Rocha (2015) . responses of clonal eucalypt plantations to N, P and K fertilizer application in different edapho climatic conditions

[6]- Fageria ,N ,K (2009) . The use of nutrients in crop plants . Boca Roton ,F1: CRC Press

[7]- fageria ,N ,K . (1992) .Maximizing crop yields .New York :Marcel Dekker .

[8]- Gahoonia and Nielesn (2004) . Root traits as tools for creating phosphorus efficient crop varieties .Plant and Soil . 260:47- 57

[9]- Gomez, K and Gomez , A . (1984) ,Statistical procedures for agriculture research (2nded) John . wily and Sons. Inc New York . 365.P.

[10]- Hinsinger ,P (2001) . Bioavailability of soil inorganic P in the rhizosphere A affected by root-induced chemical changes : A review .Plant Soil .237: 173- 195

[11]- Hye .J (2016) .Effects of phosphorus on shoot and root growth , partitioning and phosphorus utilization efficiency in lantana .HOR .Sci . 8:1001 -1009 .

[12]- Lambers ,H; Plaxton ,W . 2018 . Back to the roots ,Annu .Plant Rev .Onlie .48: 3- 22.

[13]- Michigami ,T ; Kawai ,M ; Yamazaki ,M ; Ozono , K (2018). Phosphate as a signaling molecule and its sensing mechanism . Physiol .Rev .98: 2317 -2348 .

[14]- Niklas ,k (2005) . Medelling below and above ground biomass for non – woody and woody plants .Ann .Bot . 95 :315 – 321 .

[15]- Wu , P ; Ma , X ; Tigabu , M ; H uang ,Y ; Z hou , L ; Cai , L and Oden ,P.(2014).Comparative growth , dry matter accumulation and photosynthetic rate of seven Of eucalypt in response to phosphorus nutrition .J .Plant Sci . 81: 211 – 224

[16]- Zhang , H; Song , T ; Wang ,K ; Wang , G ; Liao , J ; Xu , G ; Zeng , F (2015) .Biogeographical patterns of forest biomass allocation vary by climate , soil and forest characteristics in china , Environ . Res .Lett .10(4): 044014.