# Agronomic Phosphorus use Efficiency and Partial factor productivity for wheat genotypes

Abdulbari Mohammed Billaid*
*High institute of Agricultural Technique, Tripoli, Libya, P. O. Box 151*
baribillaed@yahoo.co.uk

المستخلص

اقيمت تجربة حقلية عمليه لتقدير كفاءة استخدام الفوسفورالمحصولي (APE) وعامل الانتاجية الجزئى (PFP). اجريت التجربة في مزرعة خاصة في منطقة جنزور بضواحي مدينة طرابلس ليبيا في سنة 2018 . استخدم في التجربة صنفين محليين من القمح (L1, L2) وثلاثة مستويات من سماد سوبر فوسفات ثلاثي (0, 60, 120 ) كجم من خامس اكسيد الفوسفور للهكتار .اظهر كل من كفاءة الفوسفور المحصولي وعامل الانتاجية الجزئى علاقة ايجابية مع معدل تسميدي 60 كجم خامس اكسيد الفوسفور للهكتار للصنفين. حسابات كفاءة الفوسفور المحصولي اوضحت علاقة ايجابية مع زيادة قيم اختبار فوسفور التربة وفي نفس الوقت بقت نتائج كفاءة الفوسفور المحصولي متقاربة عند مستوى تسميدي 120 كجم خامس اكسيد الفوسفور للهكتار.

## Abstract

Factorial field experiment was done to estimate agronomic phosphorus use efficiency (APE) and partial factor productivity (PFP). The experiment was run in a private farm in Janzour area which is located west of Tripoli Libya in 2018. Two localized wheat genotypes (L1, and L2) and three rates of triple super phosphate fertilizer (0, 60, and 120) kg $P_2O_5$ ha$^{-1}$ were used. The results indicated that both genotypes have good response to phosphate fertilization. APE and PFP achieved positive relationship with only 60 kg $P_2O_5$ ha$^{-1}$ rate for both genotypes. Moreover, APE calculation showed positive relationship with increasing soil phosphorus test values, meanwhile, APE values was kept steady at 120 kg $P_2O_5$ ha$^{-1}$.

Key wards: *Agronomic phosphorus use efficiency, partial factor productivity, wheat genotypes*.

## Introduction

Phosphorus (P) is an essential element for every living cell, both animal and plant. Plants uptake dissolved P from the soil solution as phosphate ions, principally, $H_2PO_4^-$ and $HPO_4^{-2}$. These ions move towards roots by diffusion and mass flow of the soil solution [1]. Plants can partly compensate for a lack of P. Crop genotypes differ in P uptake when grown under the same condition, indicating that some genotypes achieved greater uptake than others when grown on low P soils. In these cases, many of the physiological and biochemical processes such as root exudations or rhizosphere modification [2] in some plant species have evolved for adaptation to surrounding condition

[3]. These species have the ability to produce higher yield under phosphorus – limiting conditions [4]. Furthermore, these genotypes or species differ in their amount of phosphorus taken up from the same soil or phosphorus utilization in shoot dry matter production. According to glossary of soil science terms which were introduced by soil science society of America in 1997, this kind of plants are named nutrient efficient plants [5].

*Author e-mail: baribillaed @yahoo.co.uk
Mobile :+ 218924002678

To cope with the lack of phosphorus and increase its efficiency, some plant species and genotypes may modify some of the mechanisms that would increase phosphorus availability in root zone, such as rhizosphere acidification, root exudation, and root morphology [6][2]. Previous studies were defined nutrient use efficiency as the ability to acquire nutrients from a growth medium and /or incorporate or utilize them in production of shoot and root biomass or utilizable plant material such as grain [7][8]. According to this work, various procedures and methods are applied to calculate nutrient use efficiencies such as Agronomic efficiency, Physiological efficiency, Utilization efficiency, partial factor productivity...etc. Agronomic phosphorus use efficiency is one of these definitions which is as the economic production obtained per unit of nutrient applied [8], while partial factor productivity is defined as the ratio of the grain yield to the applied rate of nutrient [9]. The objectives of this study were to test computing agronomic phosphorus and its impact on two local genotypes in terms efficacious use and partial factor productivity.

## Material and Methods

Field experiment was conducted to evaluate agronomic phosphorus use efficiency (APE) and partial factor productivity (PFP) for two localized wheat genotypes (*T. aestivum*). The experiment was conducted in a private farm at Tripoli countryside (Janzour located is about 10 km west Tripoli, Libya). Table (1) demonstrates some chemical and physical properties of the experimental soil [9]. The soil texture of the experimental site is sandy; sand 87.8%, silt 11% and clay 1.2%. Randomized complete block design was used. The experiment consisted of three replicates and three phosphate fertilizer rates which equivalent, (0, 60, and 120) kg $P_2O_5$ $ha^{-1}$ for both genotypes. Triple superphosphate fertilizer (46% $P_2O_5$) was used. Available soil phosphorus had been determined at the beginning of the experiment. A lot of soil samples (0 – 20 cm) were collected to determine available soil phosphorus levels. The Olsen soil test (0.5 *M* of $NaHCO_3$ at pH 8.5) was used for soil extracting [10]. Spectrophotometer at wavelength at 880 µm was used to determine available soil phosphorus. The area of experimental treatment was 16 $m^2$. Basic applications of nitrogen, potassium, and micronutrient were made. Weeds and insecticides were controlled. The experiment was watered to 80% of its water holding capacity at least three times per week throughout the growing period of the wheat. Two square meters in the central of each treatment were harvested at the end of the experiment. Data was analyzed by Minitab version 17 and plotted by Excel software. Agronomic phosphorus use efficiency (APE) had calculated by formula which suggested by Fageria *et. al* [8][12].The formula is: APE( kg $kg^{-1}$ ) = ( $G_f$ - $G_u$ / $N_a$)----

(1), where, $G_f$ is the grain yield of the fertilized plot ( kg) and $G_u$ is the grain yield of unfertilized plot (kg), and $N_a$ is the quantity of nutrient applied (kg). The partial factor productivity formula which was described by Terry et al., [1] and have used for the calculation. PFP = Y/ $F_P$----(2), where; Y is the yield of harvested crop and $F_P$ is phosphorus fertilizer applied.

**Table 1.** Some chemical characteristics of the experimental soil.

| **Soil property** | **pH* (1:1)** | **CEC meq 100g$^{-1}$** | **F. capacity %** | **B. density g cc$^{-1}$** | **O. M %** | **$^{**}P_a$ mg kg$^{-1}$** | **K mg kg$^{-1}$** |
|---|---|---|---|---|---|---|---|
| value | 8.1 | 1.4 | 8.2 | 1.5 | 0.2 | 1.6 | 150 |

*pH in water (suspension 1:1 w: v)
**$P_a$ = available phosphorus.

## Results and Discussion

*Phosphate effect*

All fertilization treatments of both genotypes responded to phosphate fertilizer additions. Increasing in both available soil phosphorus (native phosphorus) and phosphate fertilizer rates led to increase in quantities of wheat yield. The wheat yield of unfertilized treatments of L2 genotype was more than L1 genotypes. There was no significant yield between L1 and L2 genotypes in fertilization treatments, where tables 2 and 3 show the effect both of phosphate rates and available soil phosphorus. Yield boots was accompanied by increase for phosphate rates. Moreover, wheat yield was increased with increase in soil phosphate content (native phosphate) and the soil treatments which received phosphate fertilizer doses. Although all unfertilized treatments for both genotypes had responded to phosphate, the productivity of L2 genotype was higher than L1 genotype. At soil test value 2.3 µg P mg$^{-1}$, the yield were 410.4 kg grain ha$^{-1}$ and 829.9 kg grain ha$^{-1}$, whereas the genotypes productivity was raised to 1190.6 kg grain and 1559.2 kg grain at 9.8 µg P mg$^{-1}$ for L1 and L2 genotypes respectively. Both genotypes were alike at other phosphate fertilizer rates. Statically, high significant relationship was found R = 0.92 ($P \geq 0.001$) between genotypes, phosphate rates and values of soil phosphorus test, while no significant interaction was found within the experimental parameters.

**Table 2.** Actual yield (kg ha$^{-1}$) of L1 genotype, Agronomic phosphorus efficiency (kg yield kg$^{-1}$ fertilizer applied) and partial factor productivity (kg kg$^{-1}$).

| | Treatments Yield | | | | | | |
|---|---|---|---|---|---|---|---|
| **Soil test (µg P mg$^{-1}$)** | **$Y_0$** | **$Y_{60}$** | **$Y_{120}$** | **$APE_{Y60}$** | **$PEP_{Y60}$** | **$APE_{Y120}$** | **$PEP_{Y120}$** |
| **2.3** | 410.4 | 1017.6 | 3158.4 | 10.1 | 17.0 | 22.9 | 26.3 |
| **3.5** | 505.9 | 1213.3 | 3112.8 | 11.8 | 20.2 | 21.72 | 25.9 |
| **3.6** | 529.4 | 1346 | 3304.1 | 13.6 | 22.4 | 23.12 | 27.5 |
| **5.9** | 761.5 | 2026.9 | 3419.7 | 21.1 | 33.8 | 22.15 | 28.5 |
| **7.7** | 1002 | 2246.8 | 3670.8 | 20.7 | 37.4 | 22.24 | 30.6 |
| **8.4** | 1004.5 | 2271.5 | 3697.5 | 21.1 | 37.9 | 22.44 | 30.8 |
| **9.8** | 1190.6 | 2812.1 | 3925.8 | 27.0 | 46.9 | 22.79 | 32.7 |

The variation between both genotypes was observed at unfertilized treatments 0 kg $P_2O_5$ (Fig. 2). Genotype L2 have more ability for phosphate exploitation under lack of phosphorus condition (Fig. 1), this feature was not allowanced to appear at high phosphate levels. It may be attributed to fertilizer use efficiency. It was suggested that higher fertilizer use efficiency might be associated with low fertilizer rate [12].

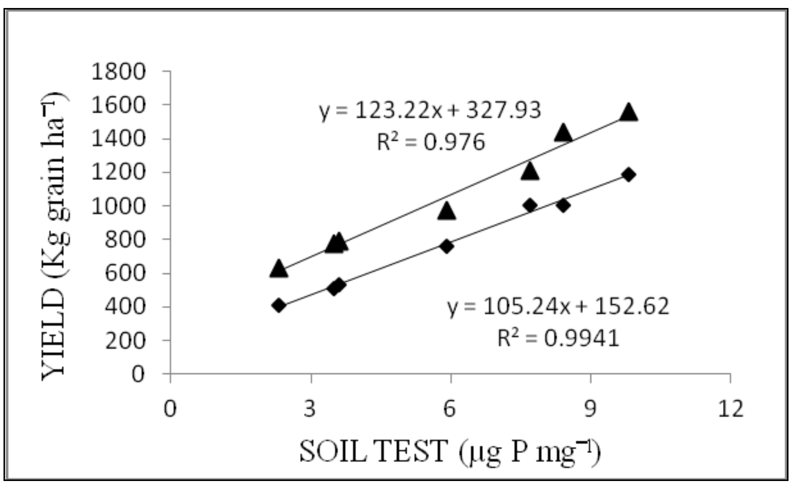


**Figure 1.** The relationship between soil test- P and yield for both localized genotypes L2 (Triangle) and L1 (Diamond) at unfertilized treatments

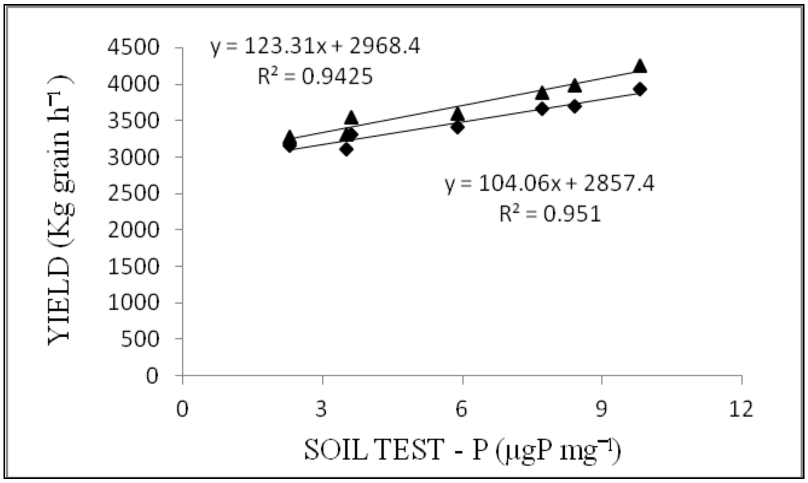


**Figure 2.** The relationship between soil test- P and yield for both localized genotypes L2 (Triangle) and L1 (Diamond) at 120 kg $P_2O_5$ $ha^{-1}$ treatments

*APE and PEP effect*

Both APE and PFP showed positive relationship with increase in both available phosphorus which is extracted by Olsen soil test and phosphate fertilizer rates as shown in tables 2 and 3. Maximum partial factor productivity (PFP) was 50.9 kg grain per one kg of $P_2O_5$ and 46.9 kg grain per one kg of $P_2O_5$ at 60 kg of $P_2O_5$ $ha^{-1}$ for L2 and L1 genotypes respectively. Maximum agronomic phosphorus efficiency (APE) of both genotypes was 27.0 kg grain and 24.0 for L1 and L2 genotypes, respectively at phosphate rate 60 kg of $P_2O_5$ $ha^{-1}$ and at soil test value was 9.8 µg P $mg^{-1}$. On the other hand, the PFP values for both genotypes and APE was ranged from 21.1 kg $kg^{-1}$ to 23 kg $kg^{-1}$ L2, whereas, APE for L1 was ranged from 21.7 kg $kg^{-1}$ to 23.1 kg $kg^{-1}$. The values of APE and PFP at 120 kg of $P_2O_5$ $ha^{-1}$ rates were very close, because due to both genotypes have the same ability of fertilizer use efficiency.

**Table 3**. Actual yield (kg $ha^{-1}$) of L2 genotype, Agronomic phosphorus efficiency (kg yield $kg^{-1}$ fertilizer applied) and partial factor productivity (kg $kg^{-1}$).

| | Treatments Yield | | | | | | |
|---|---|---|---|---|---|---|---|
| soil test (µg P $mg^{-1}$) | $Y_0$ | $Y_{60}$ | $Y_{120}$ | $APE_{Y60}$ | $PEP_{Y60}$ | $APE_{Y120}$ | $PEP_{Y120}$ |
| 2.3 | 628.9 | 1175 | 3281.1 | 9.1 | 19.6 | 22.1 | 27.3 |
| 3.5 | 776.1 | 1420.5 | 3305.3 | 10.7 | 23.7 | 21.1 | 27.5 |
| 3.6 | 791.9 | 1522.1 | 3549.4 | 12.2 | 25.4 | 23.0 | 29.6 |
| 5.9 | 972 | 2180.3 | 3599.4 | 20.1 | 36.3 | 21.9 | 30.0 |
| 7.7 | 1209.3 | 2550.5 | 3884.8 | 22.4 | 42.5 | 22.3 | 32.4 |
| 8.4 | 1434.8 | 2661.4 | 3985.9 | 20.4 | 44.4 | 21.3 | 33.2 |
| 9.8 | 1559.2 | 3055.4 | 4253.3 | 24.9 | 50.9 | 22.5 | 35.4 |

## Conclusion

The current study has revealed that some wheat genotypes differ in their phosphorus uptake when grown under the same conditions, and it is confirmed that these genotypes have the ability to produce higher yield under phosphorus – limiting conditions. The results of the study have coincided previous results which conducted by Amanullah and Lal K. Almas [9] and A. Billaid and Allafi [2]. Moreover, the study opens new horizons for crop breeders for use these results to discover and exploit the genotypes that have high nutrient use efficiency. APE and PFP estimation might be used by national crop breeders for new genotypes selection.

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