University of Benghazi
Faculty of Education Al marj
Global Libyan Journal

جامعة بنغازي
كلية التربية المرج
المجلة الليبية العالمية

العدد السادس والعشرون – 25 / أغسطس (2017)

PHOSPHOROUS USE EFFICIENCY BY BARLEY PLANTS

*** Suad A . Amgad, ** Kamal A . Abdlgader, *** Yousef H. Abdullah.**

Soil and Water Department, Faculty of Agriculture, Omar Al-Mukhtar University, El-Beida, Libya

الملخص:

يعتبر الفوسفور أحد العناصر الكبرى الضرورية للنبات و على الرغم من ذلك فإنه من أكثر العناصر الكبرى الأقل صلاحية و يسراً في التربة وفي كثير من الأحيان يكون الفوسفور عامل محدد لنمو النباتات ومن ثم فإن هناك حاجة لتطوير المحاصيل التي لديها القدرة على أن تحصل على أو تستخدم الفوسفور بكفاءة عالية حتى يمكن تقليل الحاجة إلى السماد الفوسفاتي ويمكن الاستفادة من التسميد الفوسفاتي بكفاءة عالية. تهدف الدراسة الحالية إلى تقييم أربعة أصناف من أصناف الشعير من حيث كفاءتها في استخدام الفوسفور وذلك تحت ثلاث مستويات من الفوسفور: مستوى منخفض (عدم إضافة فوسفور P_2O_5) مستوى متوسط (50 جزء من المليون P_2O_5) ومستوى مرتفع (75 جزء من المليون P_2O_5) وللوصول إلى هذا الهدف أجريت تجربة أصص لتصنيف أربعة أصناف من أصناف الشعير: (ريحان، تراميلو، M97 ، B12-3). حيث نميت في أصص لمدة 30 يوماً من الزراعة في وجود الفوسفور تحت المستويات الثلاثة المذكورة سابقاً. وقد دلت نتائج الدراسة أن الوزن الجاف لكلاً من الأجزاء الخضرية والجذور ومحتوى الاجزاء الخضرية والجذور من الفوسفور وكذلك كفاءة استخدام الفوسفور تأثر معنوياً بكل من معاملات الفوسفور والاختلافات بين أصناف الشعير المستخدمة في الدراسة، وبناء على إنتاج المادة الجافة وكفاءة استخدام الفوسفور قُسمت الأصناف المستخدمة إلى أصناف كفؤة ومستجيبة للفوسفور وهي (M97 و B12-3) وأصناف كفؤة وغير مستجيبة (ريحان) وأصناف غير كفؤة وغير مستجيبة (تراميلو).

الكلمات الدالة: كفاءة استخدام الفوسفور – أصناف الشعير – إنتاج المادة الجافة - كفؤة و غير مستجيبة -أصناف غير كفؤة و غير مستجيبة.

ABSTRACT

Phosphorous is an essential macronutrient for plants, however it is one of the most unavailable and inaccessible macronutrients in the soil and frequently limits growth. Consequently, there is a need to develop crops that either acquires P or uses it more efficiently, so that less P fertilizer is required and P fertilization can be managed efficiently. The objective of this work was to screen four barley cultivars for their P-use efficiency at low (0 ppm P_2O_5), moderate (50 ppm P_2O_5) and high (75 ppm P_2O_5) phosphorous levels. To achieve this purpose, a pot experiment was conducted, where four barley varieties (Raihan, Tramilo, M97 and B12-3) were grown in pots for 30 days under the three P levels mentioned above. Shoots and roots dry weight, P-content in roots and shoots and P-use efficiency were significantly influenced by P treatments and by cultivars differences. Based on dry matter production and P-use efficiency, cultivars were classified as efficient and responsive (ER) (M97 and B12-3), efficient and non-responsive (E-NR) (Raihan) and non-efficient and non-responsive (NE-NR) (Tramilo).

Key words: - P-use efficiency, Barley varieties, Dry matter production - efficient and non-responsive- non-efficient and non-responsive.

INTRODUCTION

Phosphorus (P) is an essential nutrient for plant growth and development. Due to the diverse functional and structural roles of P in plants. In many soils, P deficiency is a major limitation to crop production. Although the total amount of P in soils can be high, plant-available P is often low (William et al, 2013). As a result of high P fixation and/or nutrient mining in traditional land use system (Balemi and Negish, 2012), P is most widely occurring nutrient deficiency in cereal systems around the world. For this reason, crops are supplied with inorganic P fertilizers. However, excess P added to crops may cause environmental and economic problems (Withers et al, 2001). The development of sustainable agricultural systems will require new techniques that help to minimize application rates, with maintaining adequate crop yield. This might be achieved by developing crops that either acquire P or use P more efficiency, so that less P fertilizer is required.

Plant species as well as genotypes within the species differ widely in their ability to grow in soils of low available P (Fohse et al, 1991). The efficiency with which plants are able to extract and utilize phosphorus has been shown to vary markedly between cultivars of various cereals (Osborne and Rengel, 2002).

Phosphorous efficiency of plants may arise either from P uptake efficiency or from P use efficiency which is the ability of plants to acquire P from the soil or the ability of plants to utilize P in shoots for production of dry matter, respectively or both of this attributes (Blair, 1993). Many scientists have tried to select genotypes with a greater ability to absorb P under P-limiting conditions. The objective of this study was to screen four barley cultivars for their P-use efficiency in a P-deficient soil.

MATERIALS AND METHODS

A pot experiment was conducted to screen four barley varieties for P-use efficiency under P-deficient soil at Omar Al-Mukhtar Univ. ,Soil and Water Department in 2017. Soil samples were taken from the 0-30 cm depth from Al-Mazraa Al-Nomothajia, Al-Jabal Al-Akhdar. The soil used was a severely P-deficient soil ($NaHCO_3$ - extractable P in soil was 3 mg/Kg soil) determined after Olsen et al (1954). The soil characteristics were: pH 7.2, E.C. 0.48 ds/m, organic matter 0.2% and soil texture was sandy. Four barley varieties were used, Raihan, Tramilo, M97 and B12-3. Phosphorous was added at three levels, low (0 ppm), medium (50 ppm), and high (75 ppm) as di-ammonium phosphate together with a basal dose of 25N and 50K mg/Kg soil to each pot containing 5 Kg of soil. All fertilizers were mixed well with soil before planting. Moisture content was kept near field capacity during the experimental period which 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 Bao (2000). Phosphorous was determined by an atomic absorption spectrophotometer.

A complete randomized design was used in a factorial arrangement and the treatments replicated three times were statically analyzed according to the method reported by Gomez and Gomez (1984).

RESULTS AND DISCUSION

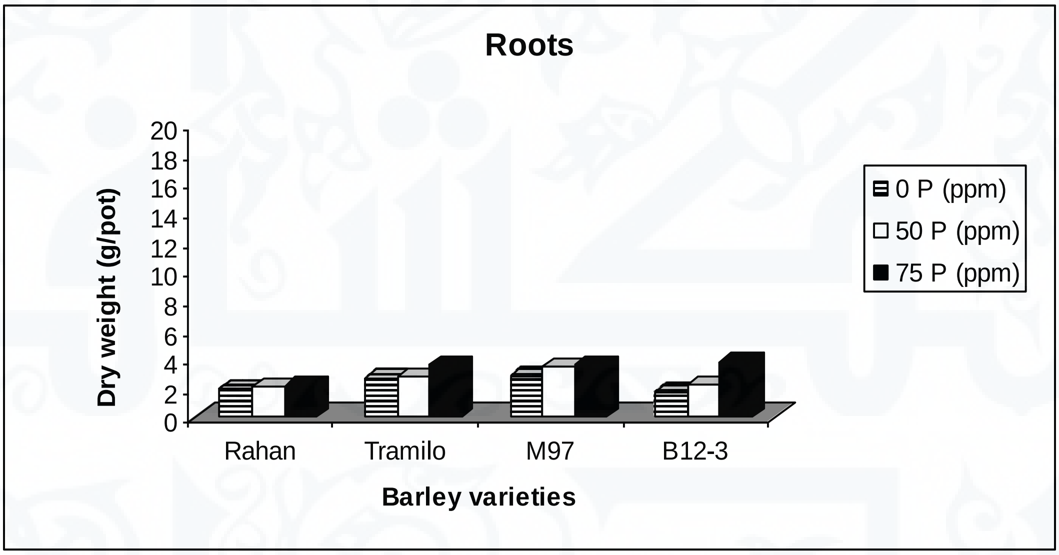
1. Effect of different levels of phosphorous on dry weight of various barley varieties:

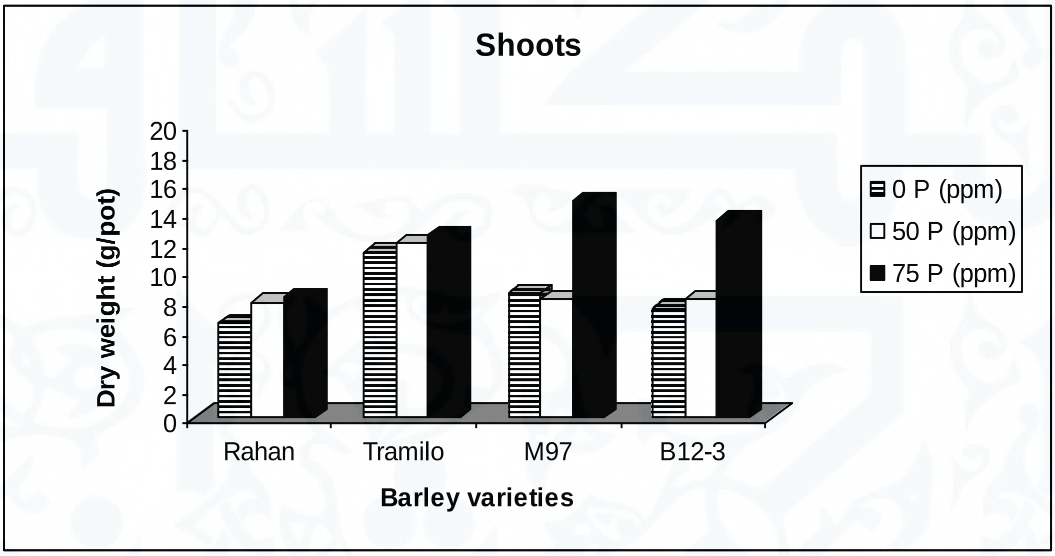
All plant growth parameters were significantly affected by P levels and barley varieties. The data presented in Figure (1) revealed that, irrespectively of barley varieties, increasing P levels up to 50 ppm P_2O_5 significantly increased dry matter accumulation in root, shoots and consequently whole plant.

The magnitude of the increase in roots, shoots, and whole plant dry weight resulted from P application at of 50 ppm P_2O_5 was 11.5, 6.7, and 8.5%, respectively, compared with 0 ppm P_2O_5 , while at 75 ppm P_2O_5 the corresponding increases were 30.3, 31.7 and 31%. In this respect, Blue et al. (1990) documented that growth and yield of crop responded positively to P fertilizer.

These results are in agreement with previous studies (Grant and Bailey 1993, Bhadoria et al 2002, Gill et al. 2005 and Korkmaz and Altintas . 2016). Significant differences could be observed in dry matter accumulation amongst barley varieties, regardless P levels, generally, Tramilo recorded the highest shoot and whole plant dry weight, M97 recorded the highest root dry weight. On the other hand, Raihan recorded the lowest dry weight of root, shoot, and whole plant, respectively.

Concerning the interaction effect of P levels and barley varieties, data presented in figure (1) revealed significant differences in root, shoot and whole plant dry weight between various varieties at each P-levels. The highest values were obtained for M97 variety at 75 ppm P_2O_5, followed by B12-3 variety, where it reached to about 1.8 times that of Raihan variety (recording the lowest shoot dry weight at 75 ppm P_2O_5). This was in accordance with the findings of Abou Zeid et al (2005) who found that the magnitude of response to P fertilization varied markedly among varieties.





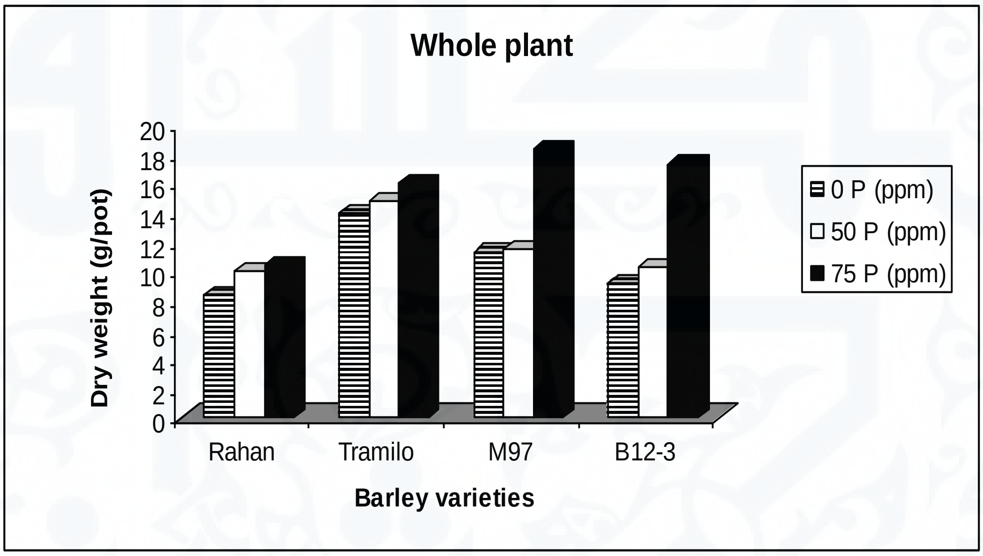


Fig.1. Effect of different phosphorous levels on roots, shoots and whole plant dry weight of various barley varieties (mg/pot)

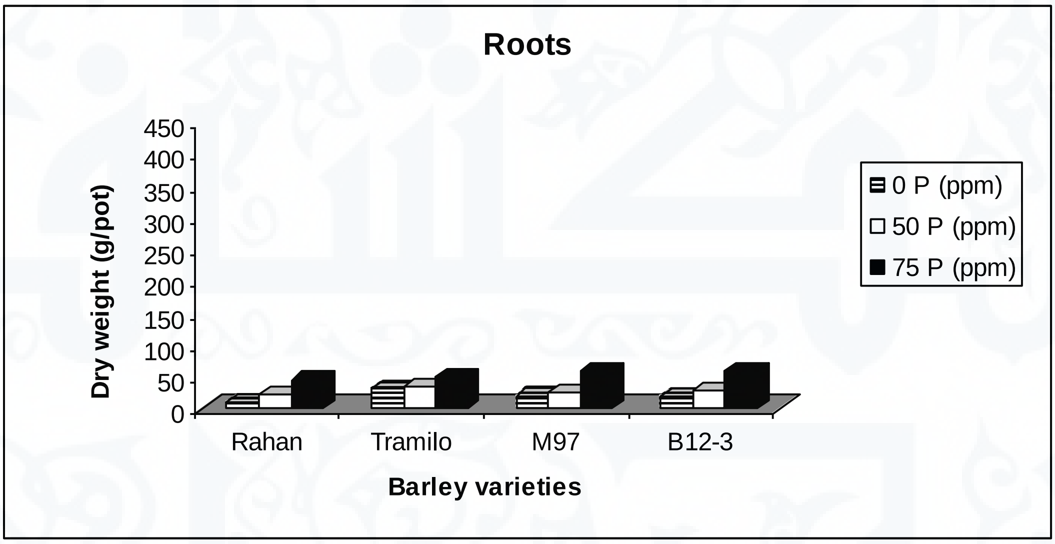
2.Effect of different phosphorous levels on phosphorous content of various barley varieties:

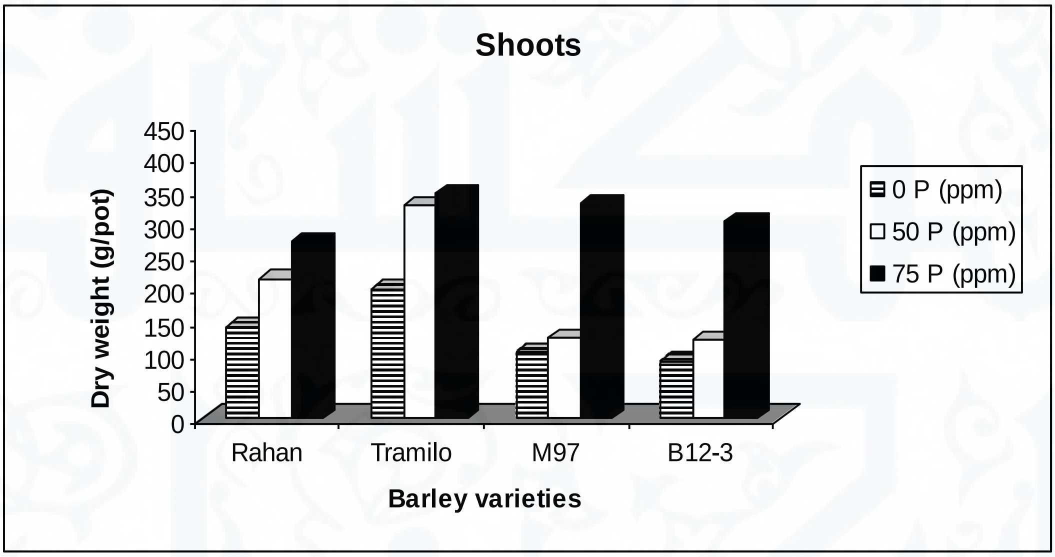
Date presented in figure (2) revealed that, regardless of barley varieties, mean P-content in roots were 20.4, 27.0 and 53.0/pot, the corresponding values for shoots were 132.3, 196.0, and 311.8 mg/pot and for the whole plant were 152.7, 222.9 and 378.0 mg/pot, at 0, 50 and 75 ppm P_2O_5, respectively.

However, P-content of various varieties (as an average across P-levels) ranged in roots between 25.6 and 38.7 mg/pot in roots, between 170.2 and 307.9 mg/pot in shoots and for the whole plant ranged from 219.2 and 346.6 mg/pot.

Concerning the interaction effect of phosphorous levels and barley varieties, it could be noticed that at zero P-level (0 ppm), the highest P-content in roots, shoots and whole plant were obtained for Tramilo while the lowest ones were obtained by Raihan in roots and B12-3 in shoot and whole plant.

This was in harmony with the results obtained by Chungin et al (2002) who demonstrated that P-efficient genotypes maintained relatively high P-concentration in root and shoot even under conditions of P-deficiency. From the previous discussion it could be noticed that all growth parameters and P-content increased significantly with increasing levels of soil phosphorous. This means that the soil used in the experiment was appropriate for screening purposes according to Fageria (1989).





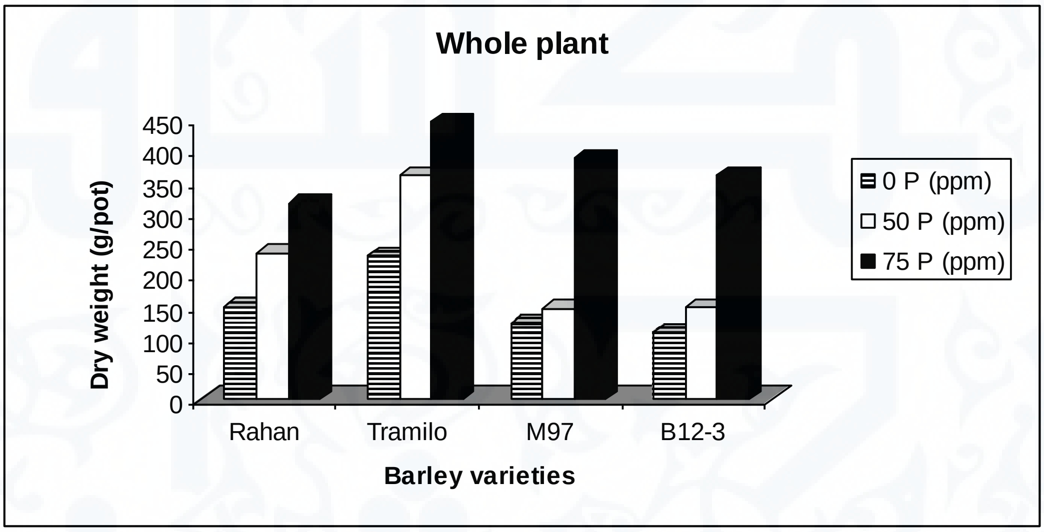


Fig.2. Effect of different phosphorous levels on phosphorous content in roots, shoot and whole plant of various barley varieties (mg/pot)

3.Effect of different phosphorous levels on P-use efficiency:

Data presented in Table (1) showed that P-use efficiency differed significantly among barley varieties. Dry matter yield of root and shoot at low P-levels also differed significantly among varieties. B12-3 had the highest P-use efficiency while Tramilo had the lowest one. Based on the dry matter production (root plus shoot) at low P levels and P-use efficiency (Table 1), barley varieties were classifies into four groups figure (3) according to the methodology proposed by Fageria and Baliger (1993). This groups were as follows:

1. Efficient and responsive (ER): varieties which produced dry matter yield of four varieties at the low P level and responded well to the addition of P application (average P-use efficiency was higher than the average P-use efficiency of the four varieties): M97 and B12-3 representing this group.
2. Efficient and non-responsive (E-NR): varieties which produced dry matter yield higher than the average dry matter yield of the four varieties but P-use efficiency was lower than the average P-use efficiency of the four varieties Raihan fall into this group.
3. Non-efficient and responsive (NE-R): varieties which produced dry matter yield less than average dry matter yield of four varieties, but P-use efficiency was higher than the average P-use efficiency of the four varieties: no varieties fall into this group.
4. Non-efficient and non-responsive (NE-NR): varieties which produced dry matter yield lower than the average dry matter yield of the four varieties, as well as P-use efficiency was lower than the average of P-use efficiency of the four varieties; cultivars Tramilo , fall into this group.

Barley varieties	Dry matter yield of roots and shoots (mg/pot)		P-accumulation in roots and shoots (mg/pot)		P-use efficiency (mg dry matter/mg K absorbed)
	At low P level	Across medium and high P levels	At low P levels	Across medium and high P levels	P use efficiency
Raihan	8400	10200	149.2	275.6	14.3
Tramilo	1400	15400	231.4	404.2	8.1
M97	11300	14900	121.8	267.9	24.6
B12-3	9200	13800	108.3	253.9	31.6
Mean	7575	13575	152.7	300.4	19.7
LSD at 5%	8.20	144.00	10.03	13.33	2.35

Table 1: Dry matter yield of roots and shoots, P accumulation and P use efficiency of different barley varieties

P-use efficiency = (dry matter yield of roots and shoots across medium and high P levels – dry matter yield of roots and shoots at low P levels) / P accumulation in roots and shoots across medium and high P levels – P accumulation in roots and shoots at low P level).

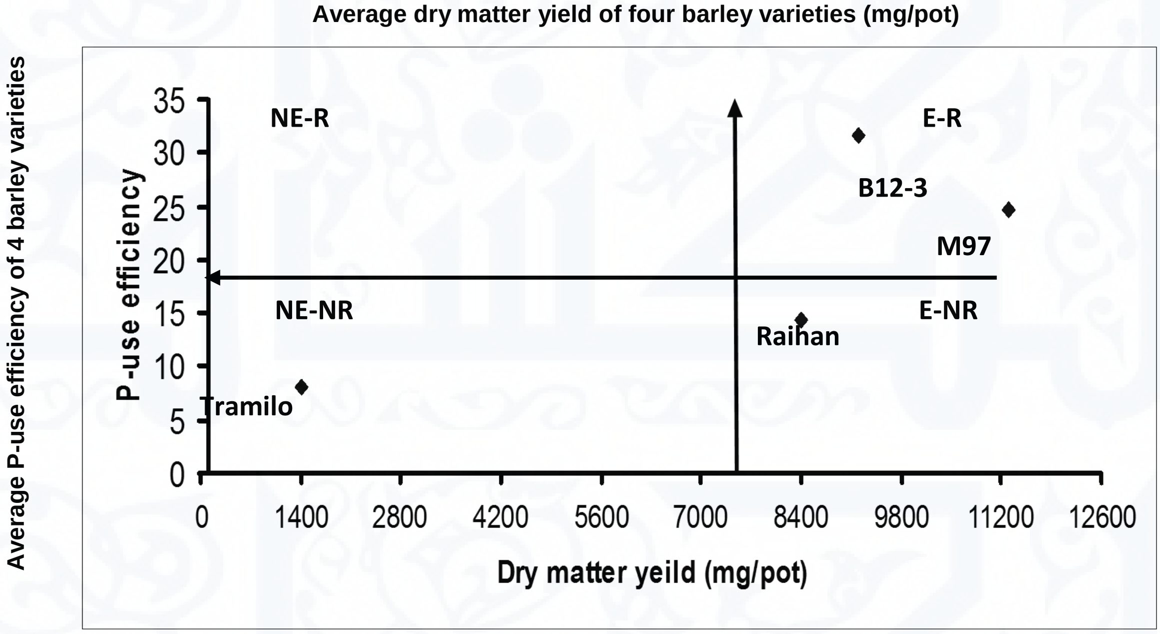


Fig.3. Classification of four barley varieties according to phosphorous use efficiency

From a practical point of view, varieties which fall under the group efficient and responsive are most desirable. These varieties can produce well under low P levels and responded well to P application. This means that these varieties can be utilized under low as well as high technology with reasonably good yield. The second most desirable group, which can be used under low P level and can produce more than average yield, is the efficient and non-responsive. The varieties non-efficient and responsive sometimes can be used in breeding programs for their P-responsive and non-responsive type (Fageria et al., 1996).

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