Relative Grain Yield of Two Wheat Genotypes and Its relationship to Law of Diminishing Return

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Abstract

Factorial field experiment was conducted to evaluate response relationship between two local wheat genotypes (*Triticum aestivum*) and phosphorus soil test values. The M 0.5 $NaHCO_3$ based (Olsen phosphorus) extractant was carried out on soils taken from the plots. The experiment was conducted at western region of Libya. Soil pH at the experimental site was 8.1 and the texture is sandy. The experiment was performed using a randomized complete block design (RCBD) method with three replicates for each treatment of phosphate fertilizer at concentrations of 0, 60, and 120 kg P_2O_5 ha^{-1} for both genotypes. Results were expressed by relative values (Relative Yield). Relative yield (RY) of the two wheat cultivars showed similar significant responses to both soil test values and the grain yield. Linear relationship between relative yield and the grain yield at 0 kg P2O5 ha^{-1} for both genotypes was found, whereas, non-linear relationship was noticed among treatments that received 120 kg P_2O_5 ha^{-1}. Both the linear and non- linear relationship have explained by tendency curves and showed how both genotypes response to phosphate fertilizer.

Key wards: Wheat genotypes, Olsen soil phosphorus test, phosphate fertilizer, Relative yield.

Introduction

Wheat is grown on more land area than other commercial crops and continue to be one of the most important food grains source for humans. Wheat with rice and maize represent the essential food for 80% of the World's population [1]. Wheat provides vitamins, minerals, essential amino acids and fibers [2]. Wheat products important in increasing red blood cell counts, curing anemia and normalizing blood pressure [3]. There are many cultivars of wheat which are grown in many countries around the world based on wheat adaptability. In 2020, Statistics estimated the average global production value of wheat was 765.4 million metric tons [4].

Phosphorus is considered one of the major macronutrients after nitrogen and potassium which are very significant elements for the higher plants nutrition. Phosphorus (P) exists in the soil in large number of chemical forms, these forms contribute to varying quantity of plant available P [5]. The concentration of the phosphorus in the soil solution is ranged between (10^{-6}-10^{-4} M) in most Arable lands [6]. Phosphorus is taken up from soil solution as orthophosphate ions, typically H_2PO^{-4} and HPO_4^{-2} [5][6], and the availability of these forms are totally depended on the pH of the soil solution. The relationship between soluble P and less available forms can be determined by different soil tests, which are chemical methods for extracting and estimating plant available nutrient from the soil [7].

Soil tests have been developed to provide an indication of the level of soil P that is available to the plant. These relationships have been thoroughly reviewed and established based on the modern soil testing. Generally, some soil tests are more appropriate for extracting available phosphorus from acid soils such as Bray, Acetic Acid, and Mehlich. Bicarbonate extractants. Olsen test is better suited to calcareous and alkali soils [8]. Several experiments [9] [10] [11] [12] [6] were performed over the world to evaluate the correlation between soil nutrient tests and crops yield, and concluded that there is a positive relationship between the fertilization and crop production. Crop response to nutrients (e.g. phosphorus, potassium…. etc.) is usually predicted using soil test information.

Fertilizing recommendations obtained from soil test results are commonly based on calibration curves. These curves can be used to compare any crop production at a specific soil test level to yield where the relevant nutrient is not limiting [13]. When different soil test levels are made with yield inspections in numerous sites, a calibration curve is developed where relative yield is schemed against soil test level. Direct relationships among calibration curves is that decreasing soil test level leads to decrease relative yield [13]. Relative yield, which is calculated by Billaid in 1995, (grain yield at nil applied phosphorus / maximum grain yield) x 100 [11]. The objectives of this work were to evaluate the effect of phosphorus on the final crop of two local wheat cultivars.

Material and Methods

Factorial field experiment was conducted to evaluate the response relationship between two local wheat genotypes (*T. aestivum*) and soil phosphorus test values. The two wheat cultivars 'Acsad 901' and 'Salamboo' were used. The experiment was conducted at the research farm in Tripoli countryside (Janzour located is about 10 km west Tripoli, Libya). Table (1) demonstrates some chemical and physical properties of the experimental sites [14]. The soil texture of the experimental site is sandy; sand 87.8%, silt 11% and clay 1.2%. For Both genotypes, the experiment was performed in a randomized complete block design (RCBD) [15] with three replicates for each treatment of phosphate fertilizer at 0, 60, and 120 kg P_2O_5 ha^{-1} as triple superphosphate (46% P_2O_5). The experimental parameters were tested at ($P \leq 0.05$) [15].

Soil samples (0–20 cm) were collected to determine available soil phosphorus levels. Available soil phosphorus was determined at the beginning of the experiment. Olsen soil test (0.5 M of $NaHCO_3$ at pH 8.5) procedure was used for soil extracting [16]. Wavelength of spectrophotometer was 880 µm for measuring of available soil phosphorus. The area of experimental unit was 16 m^2. Basic applications of nitrogen, potassium, and other micronutrient were made since they are essential to sustain plant growth. Weeds were controlled manually in all plots. Corrective measures were taken for control of insect pets and diseases. The soil was watered to 80% of its water holding capacity at least three times per week throughout the growing period of the crop. Two square meters in the central of each unit were harvested at the end of the season.

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 = Soil Available Phosphorus, CEC= Cation Exchange Capacity, F= Field, B= Bulk, O. M= Soil Organic Matter, K= Soil Available Potassium

Statistical analysis

Data was analyzed by Excel software. The correlation between relative yield and soil test values was used. For actual grain yield, comparisons between 'Acsad ' and 'Salamboo' wheat genotypes was done using the Student's t-test.

Results and Discussion

Results in Table 2 refers to actual grain yield and Table 3 to relative grain yield of 'Acsad' and 'Salamboo' wheat genotypes. For the final crop, after soil were treated with phosphate fertilizer at 0, 60, and 120 kg P_2O_5 ha^{-1}, a significant increase in grain yield was observed for 'Salamboo' wheat genotype, where the average actual grain yield value on 'Salamboo' was 1053, 2081, and 3694 Kg ha^{-1} at Y_0, Y_{60}, and Y_{120}, respectively. The average grain yield across Y_0, Y_{60}, and Y_{120} was 2276 Kg ha^{-1} for 'Salamboo' and 2029 Kg ha^{-1} for 'Acsad'.

Table 2. Actual grain yield of 'Acsad ' and 'Salamboo' wheat genotypes. Soil was treated with phosphate fertilizer at 0, 60, and 120 kg P_2O_5 ha^{-1} as triple superphosphate (46% P_2O_5).

Soil test (μg P mg^{-1})	Actual Yield (Kg ha^{-1}) Y0		Y60		Y120	
	Acsad	Salamboo*	Acsad	Salamboo*	Acsad	Salamboo*
2.3	410.4	628.9	1017.6	1175	3158.4	3281.1
3.5	505.9	776.1	1213.3	1420.5	3112.8	3305.3
3.6	529.4	791.9	1346	1522.1	3304.1	3549.4
5.9	761.5	972	2026.9	2180.3	3419.7	3599.4
7.7	1002	1209.3	2246.8	2550.5	3670.8	3884.8
8.4	1004.5	1434.8	2271.5	2661.4	3697.5	3985.9
9.8	1190.6	1559.2	2812.1	3055.4	3925.8	4253.3

The significance of differences between actual grain yield of 'Acsad' and 'Salamboo' was determined using Student t-tests. $p < 0.05$ was considered statistically significant (*).

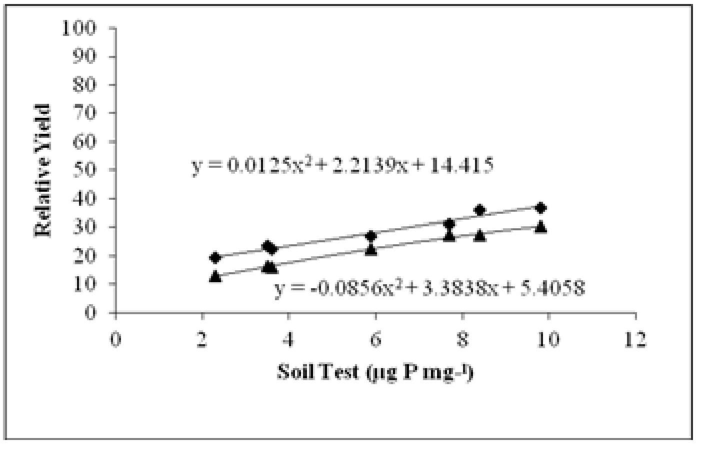

Figure 1. Wheat relative yield for both localized genotypes 'Acsad' (Triangle) and 'Salamboo' (Diamond) at unfertilized treatments

The curves of relative yield for both genotypes were trend to non-linear relationship at high phosphate rates (Figure 2). Non-linear relationship among fertilized treatments mean all treatments responded to more phosphate fertilizer until limited point, this point is known by a critical level for a nutrient, which was 9.8 µg P mg^{-1}. the grain yield decreased gradually with increasing in fertilizer rates (Law of diminishing return). The curves of relative yield for both genotypes started to be flat after the value 9.8 µg P mg^{-1} . The critical level value was performed about 71.8 % of maximum yield.

On the other hand, curves of both genotypes showed different trends, however the curves of grain yield at 0 kg P_2O_5 ha^{-1} for both genotypes were linear relationship (Figure 1), thus increasing in grain yield was dependent on soil test values and phosphate applications. So, there is a fairly good linear correlation of 'Acsad' and 'Salamboo' at grain yield on P unfertilized soil.

Table 3. Relative grain yield of 'Acsad ' and 'Salamboo' wheat genotypes. Soil was treated with phosphate fertilizer at 0, 60, and 120 kg P_2O_5 ha^{-1} as triple superphosphate (46% P_2O_5). Relative yield was calculated as : grain yield at nil applied phosphorus / maximum grain yield x 100.

Soil test (µg P mg^{-1})	Relative yield					
	Y0		Y60		Y120	
	Acsad	Salamboo	Acsad	Salamboo	Acsad	Salamboo
2.3	13	19.2	32.2	35.8	100	100
3.5	16.3	23.5	39	43	100	100
3.6	16	22.3	40.7	42.9	100	100
5.9	22.3	27	59.3	60.6	100	100
7.7	27.3	31.1	61.2	65.7	100	100
8.4	27.2	36	61.4	66.8	100	100
9.8	30.3	36.7	71.6	71.8	100	100

Hence, our observations corresponded with those reported by Billaed [7], Varvel *et al*. [17]. beyond the critical level point for phosphorus in the soil, the yield curve will be flat before it to be concave down. Most treatments responded to fertilizer rates, but the grain yield might be decreased.

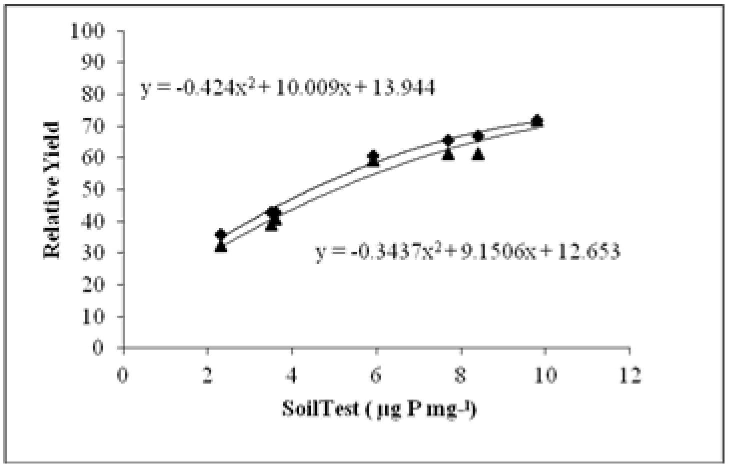

Figure 2. Wheat relative yield for both localized genotypes Acsad (Triangle) and Salamboo (Diamond) at 60 kg P_2O_5 ha^{-1} treatments

Conclusion

The current study has concluded that the relative yield is suitable representative to determine soil nutrients critical level. The critical level for phosphorus in the study was found 9.8 µg P mg^{-1}. The current study and previous one for own author emphasized the importance of using the critical nutrient level concept in fertilizer recommendations. Using this concept with fertilizer programmes will lead to: (i) conversion of the simple entry variance of yield across sites to a practical, agronomic stability measure, allowing easy comprehension of the genotype-by-environment (G×E) structure, and (ii) ease in comparing of large numbers of entries tested in different experiments at the same site and year. Plant breeders are encouraged to use routinely relative yield, to adopt the variance of relative yield across sites as a powerful, yet simple, and stable measure. The study recommended the use of good agricultural practices and farming operations to increase the productivity of the crop per hectare. Selection of drought-tolerant and salinity-tolerant varieties are significant factors for obtaining high productivity under local conditions.

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