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Responce of European Wheat to Weed Competitiveness as Affected by Potassium Fertilizer Levels

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ABSTRACT

Purpose: *The significance of potassium has been well documented as one of the major macronutrients for many crops, particularly wheat. Herbicide resistance in weeds and other environmental issues in the wheat crop has encouraged researchers to find alternative methods for weed management.*

Research Method: *A field experiment was conducted during the winter season 2021-2022 at a private farm in North Samawah city, Iraq to examine the competitive ability of two European wheat cultivars against weeds as affected by potassium (K) levels. Treatments included two wheat cultivars (Milano and Pick-row), and three K fertiliser levels (0, 200 and 400 Kg K_2O/ha).*

Findings: *The results showed that Pick-row was a superior cultivar in terms of crop competitive ability with weeds compared with Milano. Pick-row was taller, produced the largest number of spikes, had the greatest grain yield, greatest crop biomass and least weed biomass about 61.5 cm, 70 spike/m^2, 0.66 t/ha, 2.29 t/ha, and 52.5 g/m^2 respectively. The increased K fertiliser level has a positive effect on crop production and weed biomass reduction, especially with Pick-row cultivar.*

Originality/ Value: *It is implicated that Pick-row can be useful as a competitive cultivar under Al-Muthanna Province environments. Potassium K fertiliser is better to be increased and split into a number of equal doses and applied at different growth stages of wheat to avoid critical competitive timing risks.*

Keywords: *potassium fertiliser, weed management, wheat competitiveness*

INTRODUCTION

Potassium (K) is one of the most significant macronutrients for many crops (Zhao *et al*., 2014) including cereals and wheat in particular. It is important for many plant physiological functions and for maintaining yield quantity and quality (Dong *et al*., 2010; Pettigrew, 2008). Potassium was reported to have an important advantage for crop metabolism (Dong *et al*., 2010; Read *et al*., 2006). In addition, it is considered as an enzyme activator for about 60 enzymes that are anticipated to be effective for significant growth processes such as photosynthesis (Dong *et al*., 2004; Pettigrew, 2008). Soil fertility amendment has been well considered as an important management tool in integrated weed management approaches. However, it is still hard to combine it into a single decision-making approach (Little *et al*., 2021). The main challenge of fertiliser application of macronutrients is that

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both weeds and crop plants have the advantage, but they are most likely to increase the pace of nutrient uptake. This may lead to greater weed competition affecting plant height and biomass that can be most responsive characteristics to nutrients such as potassium (Little *et al*., 2021). Previous studies have reported that the effect of nutrient levels on crop growth, yield components and the competitive process among weeds and crop plants are quite variables (Kaur *et al*., 2018). Little *et al.* (2021) have reported that there are several factors can determine the impacts of nutrient fertilisation on weed crop competition, and these may include placement, application timing and source of the nutrient.

Weed plant populations are described as the most problematic issue in many crops, especially in cereal cropping systems resulting in approximately 45% of total yield losses (Korav *et al*., 2018). The increasing world's demand for high yielding characteristics in modern wheat crops needs mineral fertilisation and the use of herbicides to control weeds and maintain greater production. However, the frequent use of herbicides in weed management has led to the maximum risk of environmental pollution and encouraged farmers and researchers to consider more sustainable approaches, particularly integrated weed management (IWM) (Guarda *et al*., 2004). The problem of weed infestation in cereal crops such as wheat has been well documented worldwide, especially the evolvement of herbicide resistance (Ingegneri *et al*., 2016). Although herbicides have been an effective tool for weed control in wheat, they have become a highly significant challenge with many disadvantages (Gerard *et al*., 2022). For example, over the past thirty years, herbicides costed wheat production about $150 million per year in Canadian wheat cropping systems, whereas the uncontrolled weed fields resulted in yield losses of about $200-$1000 million (Ashford and Hunter, 1986; Gerard *et al*., 2022; Holm and Kirkland, 1986). At present, in contrast, around $2224 million are estimated to be resulted from pesticides, and herbicides formed over 72.9% of these costs in Canadian agricultural production (Gerard *et al*., 2022). Weed competition with the crop for essential elements such as nutrients is another challenge in crop production. For instance, it was reported by previous literature that plant uptake of K along with N and P increases with the crop during the critical competitive period, which occurs in the early growth stage of the cereal crop, and this was attributed to the accumulation of weed total dry matter within the unit area (Korav *et al*., 2018; Safdar *et al*., 2016). Such problems in cereal cropping systems have led researchers and grain growers to consider alternative ways for better weed management and sustainable crop production. Crop competitive ability against weeds has been studied and well reported in many cereals globally such as barley, wheat, canola, and triticale (Khalaf *et al*., 2018). Crop varietal variation is considered as an effective tool in weed management through the determination of their competitiveness against weeds and can be combined with other factors that can minimise the negative impacts of weeds and alter herbicides (Khalaf *et al*., 2018).

One of the potassium benefits for crop growth behaviour is to improve or maximise water use efficiency (WUE) in crops and balance between shoot and root growth (Grzebisz *et al*., 2013; Khalaf *et al*., 2018). Although there were many studies on the effects of potassium on crops functions and yield production, studies that concentrate on the combination of crop varietal and potassium fertiliser levels on wheat's competitive ability against associated weeds are quite limited. Therefore, this research aims to examine the role of potassium fertiliser addition at different growth stages on the competitive ability of European low-yielding wheat cultivars against weeds in Al-Muthanna Province environments.

MATERIALS AND METHODS

A Field experiment was conducted during the winter season of 2021-2022 at a private farm in Al-Muthanna Province about 255 Km south of Baghdad, Iraq. The experimental farm is located about 34 Km north of Al-Muthanna University. The soil of this area is described as sandy loam soil and non-saline, and the experimental field was sown with mung bean during the summer season immediately prior to this experiment.

The treatments included two European wheat cultivars (Milano and Pick-row) and three potassium (K) fertilizer levels: 0, 200 and 400 Kg K_2O/ha. Both K_1 and K_2 were split into three equal doses and were applied at 30, 60 and 90 days after sowing. A randomized completely blocked design (RCBD) with a Factorial arrangement and three replicates were used in this experiment. The crop cultivars were planted on 13th November 2021 with a seeding rate of 140 Kg/ha, and all crop management processes including field preparation, sowing, and irrigation were applied as needed. A mixed non-selective herbicide of Gold Topik 80EC and Cleanfield 75DF was applied at the recommended dose four weeks after sowing to control the invasive weed species in this experiment. The purpose of using herbicide to control weeds is to evaluate their survival and their competitiveness with crop cultivars. The aphid insect was controlled on 4th February 2022 using Aster 20^{SL} pesticide as needed. The potassium fertilizer amounts were divided into three equal applications throughout the growing season at 30, 60 and 90 days after the sowing date. The plots were sized as 2 by 3 m^2 and contained 10 rows with 20 cm row spacing. Plant destructive samples were harvested at the conclusion of the experiment on 7th May 2022 through collecting two 50 cm long rows and the weeds within the selected sample area to record the data.

Weed species were identified and recorded throughout the growing season and are shown in (Table 1). Plant height, number of spikes, number of grains per spike, grain yield, crop biomass and weed biomass were measured at the harvest stage. The collected data were analysed in R i386 v 3.5.2 (R Core Team, 2022). The data were analysed using analysis of variance (ANOVA) for significant four difference at α= 0.05 (Table 2) and significantly different means separated using 95% confidence intervals (Brennan and Acosta-Martinez, 2017). The assumption of normal distribution and homogenous variances were checked and confirmed.

Table 01: The identified weed species in the experiment throughout the growing season.

Common name	Botanical name	Family
Rigid ryegrass	*Lolium rigidum* L.	Gramineae
Hairy-node bear grass	*Dichanthium annulantum* L.	Gramineae
Bur weed	*Medicago polymorpha* L.	Leguminosae
Milk thistle	*Silybium marianum* L.	Compositae
Common sow thistle	*Sonches oleranceus* L.	Compositae
Narrow leaved plantain	*Plantago lonceolate* L.	Plantaginaceae
Blind weed	*Convolvulus arvensis* L.	Convolvulaceae

Table 02: Table of significance levels from ANOVA tables for each of yield components.

Growth traits	Factors		
	Cultivars	K levels	Cultivars *K Levels
Plant height	*	**	**
Number of spikes /m^2	***	***	***
Number of grains per spike	NS	NS	***
Grain yield (t/ha)	*	NS	***
Crop biomass (t/ha)	**	NS	**
Weed biomass (g/m^2)	***	*	NS
Significance	*= P<0.05	**=P<0.01	***=P<0.001

RESULTS AND DISCUSSION

The results showed that there are significant differences between crop cultivars (P<0.05) in the plant height, where Pick-row was significantly taller than Milano about 61.5 cm (Table 02. and Figure 01.). The results also showed that there were highly significant differences (P<0.01) between K fertiliser levels in crop plant height (Figure 01).

The crop plants were generally shorter at both K_1 and K_2 about 59.15, and 60.55 cm respectively in comparison with the control treatment about 62.25 cm. However, K_2 treatment had taller crop plants than those at K_1 for both cultivars. Similarly, there was a highly significant interaction between crop cultivars and K treatments in crop plant height. Pick-row plant height significantly declined from about 63.77 to about 59.20 cm as the K fertiliser levels increased from 0 to 400 Kg/ha. In contrast, Milano cultivar has responded to K fertiliser differently where its plants were significantly taller at K_2 than K_1, but they were still shorter than the control treatment. Comparing both cultivars, Pic-row appeared to be significantly taller than Milano at the control level, whereas it was shorter at the highest fertiliser level (Figure 01). Plant height can be considered as one of the competitive growth characteristics, however, crop competitive ability may vary depending on other growth traits and seasonal environments. Mason and Spaner (2006) have reported that plant height is one of the growth characteristics that may enable wheat cultivars to outcompete weed populations in organic systems. But this is quite possible to be applicable in conventional cropping systems. Similarly, Mason *et al*. (2008) stated that plant height is one of the characteristics involved in weed biomass reduction. Murphy *et al*. (2008) found that selecting wheat cultivars based on their plant height is very likely to be influential in crop weed suppressive ability. This point supports our key finding that Pick-row was a taller cultivar with less weed biomass than Milano.

The analysis of variance showed that Pick-row produced a significantly (P<0.001) greater number of spikes than Milano (Table 02. and Figure 02). Pick-row produced about 70.0 spike/m^2, whereas Milano produced only about 28.9 spike/m^2. The number of crop spikes has responded to K fertiliser addition differently to plant height although there were as highly significant variations (P<0.001) as that with plant height.

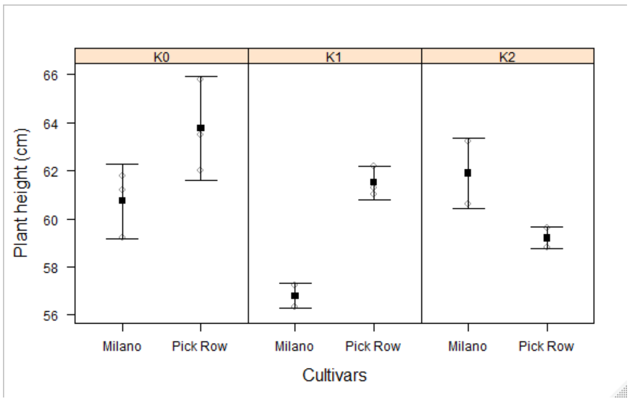

Figure 01: The effect of crop cultivars and K fertiliser levels on crop plant height (cm) (P<0.01) at harvest (maturity) stage. The black squares represent the mean plant height of the individual cultivars at each fertiliser level, and the vertical bars are 95% confidence intervals.

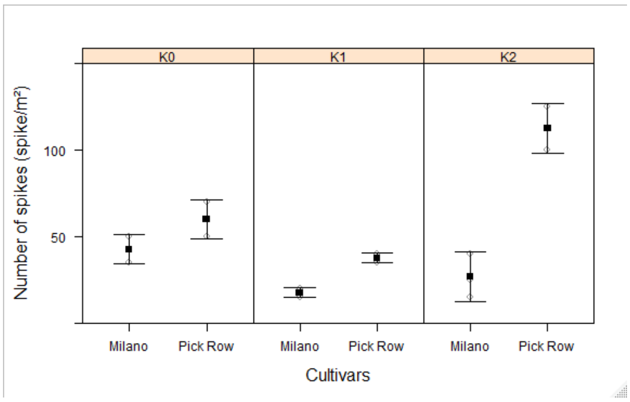

Figure 02: The effect of crop cultivars and K fertiliser levels on crop number of spikes (spikes/m^2) (P<0.001). The black squares represent the mean number of spikes of the individual cultivars at each fertiliser level, and the vertical bars are 95% confidence intervals.

For example, the number of spikes at K_2 was the largest about 69.6 spike/m^2 compared with K_1 and K_0 treatments about 27.5 and 51.3 spike/m^2 respectively (Figure 02). The interaction between crop cultivars and K treatments was highly significant (P<0.001). Both cultivars produced a larger number of spikes at K_0 than at the recommended rate (K_1), however, they both produced a significantly larger number of spikes at the doubled fertiliser rate (K_2). Pick-row produced the largest number of spikes about 112.5 spike/m^2 at K_2, whereas Milano had the lowest number of spikes about 26.7 spike/m^2 (Figure 02).

There were no significant differences between crop cultivars in the number of grains per spike (Table 02). Likewise, there were no significant differences between K fertiliser levels in this trait. The results showed that there was a highly significant interaction between crop cultivars and K fertiliser levels (P<0.001) in the crop number of grains per spike.

The crop number of grains has increased for Milano from 32.4 to 49.3 as the K fertiliser levels increased from 0 to 400 Kg/ha, in contrast, Pick-row number of grains per spike has decreased significantly from 44.1 to 24.3 at the same fertiliser treatments (Figure 03).

The results showed that crop cultivars have significantly varied in the grain yield (P<0.05) (Table 02), where Pick-row had a greater grain yield of about 0.66 t/ha in comparison with Milano which had about 0.49 t/ha (Figure 04). The K treatments did not differ significantly in their effect on the crop grain yield. However, there was a significant interaction between crop cultivars and K fertiliser treatments (P<0.001). The greatest grain yield was recorded at the control treatment for Pic-row about 1.03 t/ha, whereas the lowest grain yield was 0.33 t/ha for Milano at the same treatment (Figure 04). The grain yield of Milano increased at the recommended K level (K_1), but it decreased as the K level was doubled. On the other hand, Pick-row grain yield decreased when K recommended level was applied, but it increased as the K level was doubled. Both Milano and Pick-row had grain yield of about 0.50 t/ha at doubled K fertiliser level.

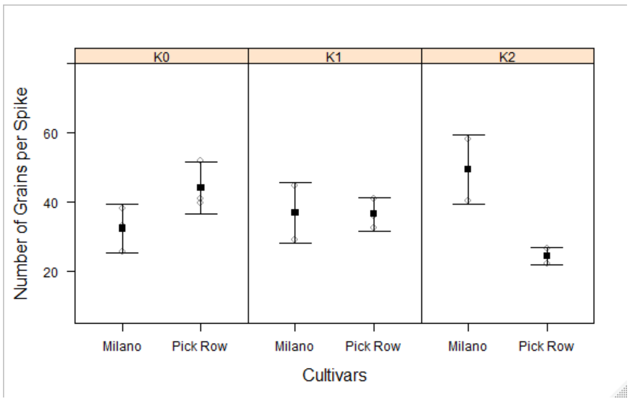

Figure 03: The effect of crop cultivars and K fertiliser levels on crop number of grains per spike (P<0.001). The black squares represent the mean number of grains per spike of the individual cultivars at each fertiliser level, and the vertical bars are 95% confidence intervals.

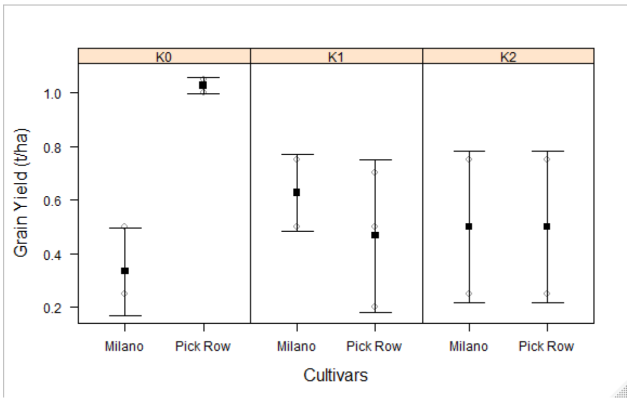

Figure 04: The effect of crop cultivars and K fertiliser levels on crop grain yield (t/ha) (P<0.001). The black squares represent the mean grain yield of the individual cultivars at each fertiliser level, and the vertical bars are 95% confidence intervals.

The crop cultivars have significantly differed in their biomass ($P<0.01$) as shown in Table 2), where Pick-row had significantly greater biomass about 2.29 t/ha than Milano which had only about 1.42 t/ha (Figure 05). The analysis of variance showed that there were no significant differences between K fertiliser treatments in the crop biomass, however, the doubled K level (K_2) had greater crop biomass than the recommended K level. The results showed that there was a highly significant interaction ($P<0.01$) between crop cultivars and K fertiliser treatments in the crop biomass (Table 02). Although the Pick-row had less crop biomass at the recommended K fertiliser level than at the control treatment, it had the greatest biomass at the doubled K fertiliser level about 2.88 t/ha. Milano, on the other hand, had less biomass at the doubled K fertiliser level than the recommended K level. However, its biomass was greater at the recommended level than at the control treatment (Figure 05).

The results showed that the crop cultivars had highly significant variances ($P<0.001$) in weed biomass (Table 02), where the greatest weed biomass was recorded with the cultivar Milano about 166.61 g/m^2 in comparison with Pick-row which had about 52.50 g/m^2 (Figure 06). The K fertiliser levels also differed significantly in their effect on weed biomass ($P<0.05$), where K_1 had the greatest weed biomass followed by K_2 and K_0 at about 136.25, 106.17 and 86.25 g/m^2 respectively (Figure 06). The results showed that there were no significant variations between crop cultivars and K fertiliser treatments in weed biomass (Table 02).

It is clear from the results of this research that both cultivars are low yielding crop cultivars, but their productivity attribute may vary depending on the seasonal and growing circumstances. It was indicated by Guarda *et al*. (2004) that wheat crop yield is most likely to be dependent on crop cultivars and their nutrient use efficiency (NUE) throughout the growing season. The cultivar Pick-row was taller and had a greater number of spikes, greater grain yield, greater biomass and less weed biomass than Milano. These results indicate that Prick-row is more competitive or more suppressive against weeds than Milano, where it has significantly reduced weed biomass and produced greater yield. This can be attributed to genetic and morphological characteristics.

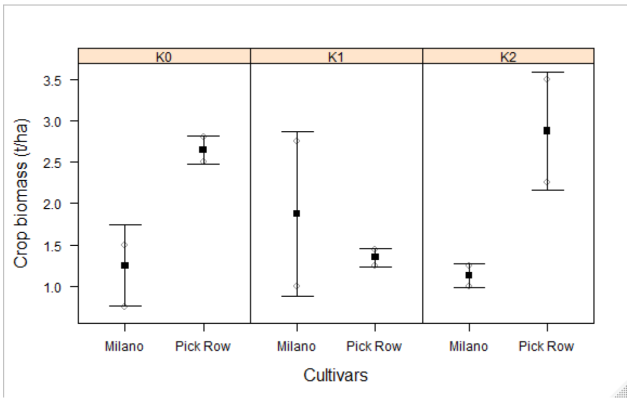

Figure 05: The effect of crop cultivars and K fertiliser levels on crop biomass (t/ha) (P<0.01). The black squares represent the mean biomass of the individual cultivars at each fertiliser level, and the vertical bars are 95% confidence intervals.

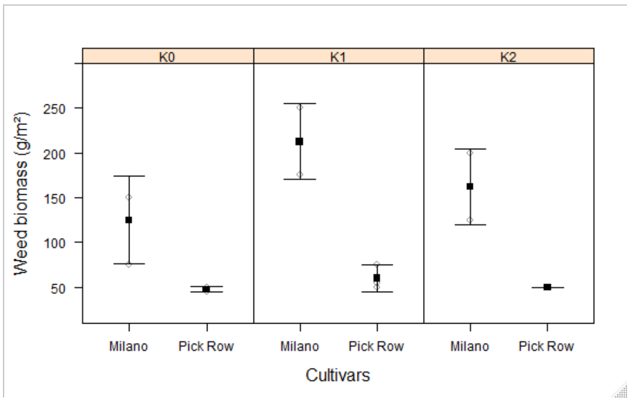

Figure 06: The effect of crop cultivars and K fertiliser levels on weed biomass (g/m^2) (P=NS). The black squares represent the mean weed biomass of the individual cultivars at each fertiliser level, and the vertical bars are 95% confidence intervals.

The K fertiliser treatments did not significantly affect the number of grains per spike neither grain yield nor crop biomass. However, the application of K fertiliser at the recommended level may have caused competitive pressure on the crop plants which, in return, resulted in growth reduction. It was observed that increasing the K fertilizer level has increased crop plant height, number of spikes and reduced weed biomass. In such a case, it is very likely that crop plants have increased their competitive ability to maintain their yield in the presence of weed population. The evidence of this is the significant interaction between the cultivars and K fertiliser levels which has shown that Pick-row had greater biomass and lowest weed biomass at the doubled K level. This finding may partially agree with Tahir et al. (2008) that increasing K fertiliser level in combination with crop cultivars increases grain yield. This study finds that splitting K fertiliser into three equal applications throughout the growing season is most likely to be useful for wheat cultivars to improve their competitive ability and grain yield. Wani *et al*. (2014) concluded that adding K fertiliser in two split and equal applications of the total basal rate can be preferable for the wheat crop.

CONCLUSION

It is concluded that Pick-row was more competitive or suppressive with associated weeds compared with Milano crop cultivar. Pick-row was taller, produced a larger number of spikes, greater grain yield, greater biomass and least weed biomass. It is recommended to split the K fertiliser level with higher rate as it has improved crop grain yield and reduced weed biomass possibly due to higher crop competitiveness. Future studies with international wheat cultivars with further K levels are recommended to be evaluated since the current study has proved an observable response of such cultivars to K increased rate. Such approach can be useful for sustainable weed management approaches, particularly under Southern Iraqi region environments such as Al-Muthanna Province and other surrounding areas.

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