Annals of Plant and Soil Research 22(2): 166- 171 (2020)

Suppressibility of nutrient and water use efficiencies of wheat (*Triticum aestivum*) under weed infestation

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Received: October, 2019; Revised accepted: February, 2020

ABSTRACT

Nutrient use efficiency (NUE) and water use efficiency (WUE) both are critically important physiological parameters to evaluate the performance of crop production. Present study was designed to understand the performance of wheat crop under weed infestation (*Avena* and *Phalaris* combinations) during *rabi* season of 2014-2017 at Panjab University, Chandigarh.This experiment was established with water and fertilizer treatments following the Latin Square Matrix (LSM) model. Results indicated that under mixed combination (wheat with both *Avenasativa* and *Phalarisminor* weeds) significantly hampered both efficiencies and grain yield of the wheat crop that resulted in more suppression up to 72.25% NUE and 78.03% WUE. Along with this, more suppressibilty of corresponding parameters were found under combination when wheat mixed with both the weeds and when full doses of fertilizers and water were applied showed 78.75% and 83.97% reduction, respectively. Due to which, nutrient and water demand of wheat crop under domain of the weeds had faced high competition. Furthermore, it is found that the *Avena* showed more overpowering nature with maximum absorption of nutrients and water than *Phalaris.*

Keywords: *Avena*, *Phalaris*, nutrient use efficiency, water use efficiency, wheat

INTRODUCTION

Wheat is one of the most grown cereal crops and makes more than 40% of the cereal calorie intake for humans through direct consumption. Moreover, the productivity of wheat in the future will have a significant persuade on global food security. Weed interference in the agro-ecosystem is the main constraint that lowers the production and yield of the crops. Weed-crop competition is one of the main reasons for lower nutrient use efficiency, which ultimately leads to lower grain yield and increased the cost of production. Crop-weed mixture showed improved biomass and nutrients uptake by crops as compared to monoculture with limiting inorganic nutrients availability, showing that weed-crop proportion greatly influenced by competition for nutrient uptake. Weed and crop share the same aboveground viz. sunlight, space, atmospheric gases, etc. and underground resources from the soil such as water and nutrients. Competitive ability of less nutrient-responsive weeds species with wheat was not affected by increased nutrient rate, regardless of highly nutrient-responsive weed species, that become more competitive with wheat crop. Improper fertilizer application rates can negatively affect the yield of the crop particularly winter wheat production (Weih*et al.,* 2018).

The parameter, NUE is largely affected by application methods, source, time and rate of fertilizers in the weed-infested field of wheat but has little effect in weed-free fields. It has been reported that addition of fertilizers may increase the competitive ability of weeds more than crops, and crop yield remained unchanged or decreased in some cases. Similar to this, competition for water in a crop-weed interaction increases water stress for the crop due to presence of weeds. The effect of water stress on crop may influence the developmental stage of a crop, its long duration, severity of stress and weed species present may augment more severity of water stress and also it is a most limiting factor for wheat in rain-fed agricultural systems worldwide (Pouri *et al.,* 2019). Under weedy situations, crop plants may face water stress symptoms (i.e. lower leaf water potential, reduced leaf stomatal conductance, reduced leaf photosynthesis) earlier than when grown in the absence of weeds, suggesting that limited water availability conditions may exist for a crop plant. Hence, a study was carried out to study the ability of weeds (*Avena sativa* L. and *Phalaris minor* Retz.) which hamper the nutrient and water use efficiencies of wheat crop.

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MATERIALS AND METHODS

Present experiments were conducted consecutively for three years during the rabi season of 2014-2017 at Panjab University, Chandigarh, India, located at 30.76° N latitude and 76.76° E longitude. The climate of the experimental area is humid subtropical. The maximum temperature during this season was 16ºC to 25ºC, while the minimum temperature was 9ºC to 18ºC. The average annual rainfall is about 1100 mm. The experimental design for the present study was established as Latin Square Matrix (LSM). Fixed size of each plot (50 cm × 50 cm) in a quadrat shape was maintained into three replicates for each combination. Therefore, total numbers of sixty plots were maintained to monitor intensively to record data of selected parameters of plant functional traits such as NUE and WUE of wheat crop and weeds. Tested seeds used for the present experiments were procured from CCS Haryana Agricultural University, Hisar (Haryana), India. Before sowing, seeds of wheat crop and weeds were processed and weighed and then sown under different combinations in respective plots. The soil of the experimental plot was sandy loam in texture with pH 7.7. Other physico-chemical properties of the soil such as soil organic C (SOC, 11.4 g kg^{-1}), total N (0.22%) and total P (0.35%) were also analysed. To ensure maximum seedling emergence, the soil depth of seed was sown at 4 to 5 cm in depth. According to the experimental design, total four combinations were prepared i.e. (1) monoculture (W) (100 % of *Triticum aestivum* L.) (2) mixed-culture plots as (W+A) (50:50%) seeds of wheat and *Avena* (3) *mixed* culture as (W+P) (50:50%) seeds of wheat and *Phalaris*and (4) wheat with both *Avena* and *Phalaris* (W+A+P) (33:33:33%). Five treatments were applied in this study which are (1) Control (2) full dose of NPK (120:60:60) kg ha^{-1} (3)half dose NPK (60:30:30) kg ha^{-1}. Further, water treatment that was further categorized into two parts viz: (4) full dose water treatment (FW) which was maintained to the saturation point and (5) half dose water treatment (HW). Data sampling and observations on selected parameters (Grain yield, nutrient use efficiency and water use efficiency) were carried out. All kinds of statistical analyses were conducted through statistical software (SPSS-PC, 2005, VERSION 14.0).

RESULTS AND DISCUSSION

Effect of Combinations

The maximum grain yield of wheat was observed in monoculture and minimum in the mixed combination (W+A+P) (Table 1 and Fig.1). The presence of weeds in wheat crop aggravated a marked reduction in grain yield. The important reproductive attribute was higher in crop grown under weed-free conditions than in crop grown under competitions with weeds. Chandra *et al.* (2018) observed that weeds reduced the grain yield of wheat crop by 30.7 per cent. It has been observed that *Phalaris minor* causes severe reduction in grain yield as compared to *Avena sativa* in same infestation level.The lowest grain yield was estimated due to more weeds and hard competition between crop plants and weeds for abiotic resources such as nutrients, minerals, moisture and water, etc. which ultimately affected the same parameter of wheat crop (Shah *et al.*, 2019). This might be due to the decrease in tiller number and number of grains of wheat directly affects the grain yield of wheat crops under competition. Thus, competition prominently reduced the nutrients mobility towards the grains which ultimately affected the grain and tiller development potential of the plant.

Table 1: Average grain yield of wheat crop (pooled data of three years)

Combinations/ Treatments	Control	FNPK	HNPK	FW	HW	Average	CD(*p=0.05*)
W	214.42	501.01	292.08	126.36	105.45	247.86	45.53
W(W+A)	99.66	210.49	143.31	53.03	36.82	108.66	31.86
W(W+P)	114.90	269.41	186.84	63.70	45.70	136.11	27.84
W(W+A+P)	37.73	125.10	88.52	33.83	20.20	61.08	17.03
Average	116.67	276.50	177.69	69.23	52.04		
CD (*p=0.05*)	21.87	44.37	24.25	13.30	10.48		

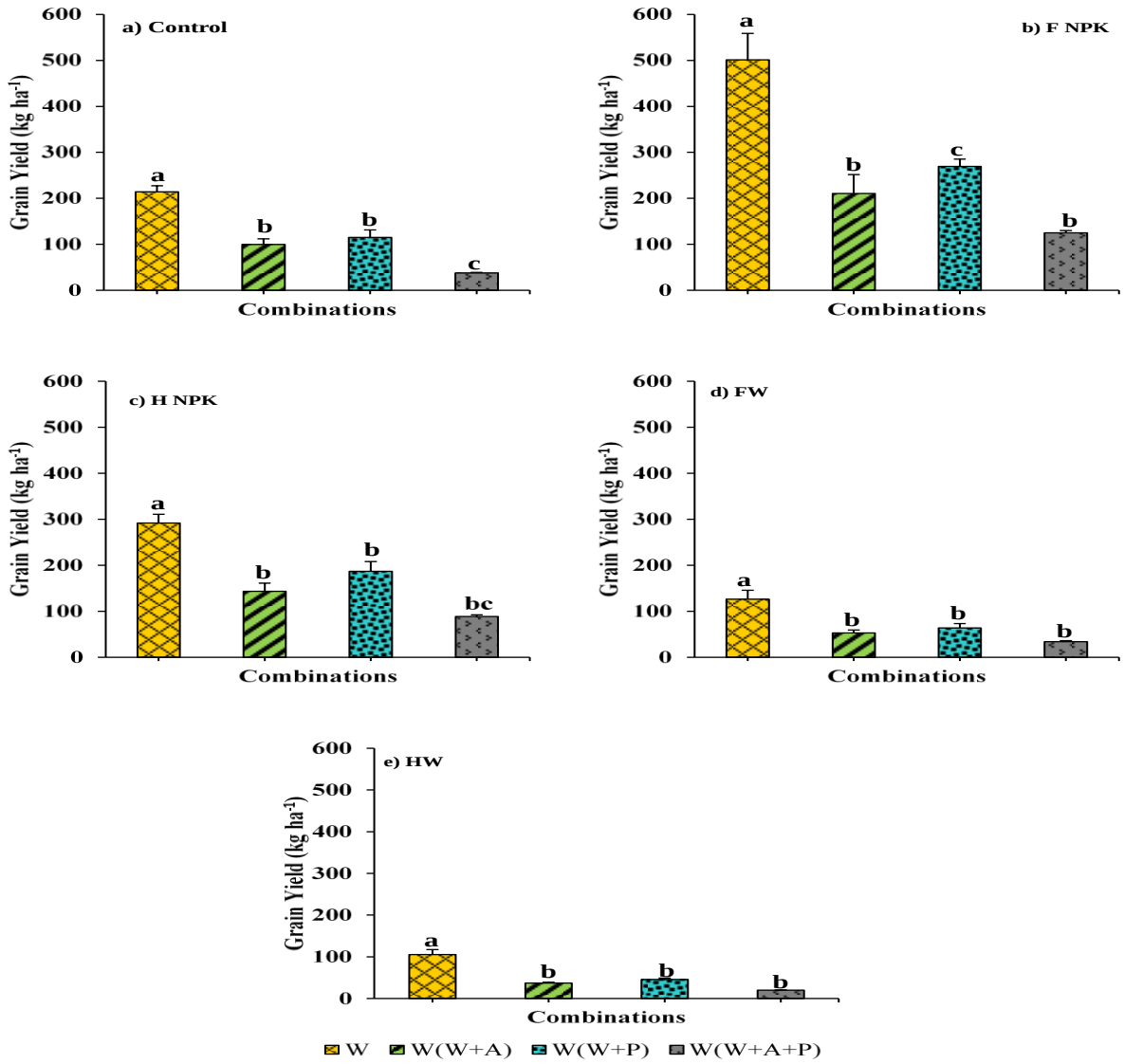

Fig. 1: Interaction effect on grain yield of wheat crop under weed-crop interactions

The maximum NUE of wheat was observed in monoculture while minimum was estimated in the mixed combination (W+A+P) which suppressed the NUE of wheat crop by 72.2% followed by wheat and *Avena (*W+A) and wheat and *Phalaris* (W+P) combinations which showed 55.0 % and 40.9 % reduction (Fig. 2). *A. sativa* showed more overpowering behaviour with the NUE of the wheat crop than the other weed *P. minor* (Table 2). Nadeem *et al.,* (2018) found less quantity of NUE for wheat crop under mixed combination that can be attributed to more absorption of nutrients by weeds. More amount of NUE of wheat crop in monoculture might be due to increase in fertilizers level, higher grain yield and absence of weeds.

Table 2: Average nutrient use efficiency of wheat crop (pooled data of three years)

Combinations/ Treatments	FNPK	HNPK	Average	CD (*p=0.05*)
W	128.65	151.16	139.90	7.24
W(W+A)	51.945	73.69	62.82	6.14
W(W+P)	69.18	96.07	82.62	6.60
W(W+A+P)	32.12	45.52	38.82	2.95
Average	70.47	91.61		
CD (*p=0.05*)	11.39	12.46		

The maximum WUE of wheat was observed in monoculture while minimum was found in the mixed combination of wheat along with both species of weeds (W+A+P) that suppressed the corresponding parameter by 78.0% followed W+A and W+P combinations showing 62.4% and 54.0% reduction due to overpowering absorption capacity of weeds in mixed culture from monoculture (Fig. 3). *A. sativa* had more tending efficiency to reduce WUE of the wheat crop than *Phalaris minor* (Table 3).Present results further indicated that water use efficiency of wheat crop was significantly decreased with interference of weeds Similar findings were recorded by Kumari *et al.* (2018).

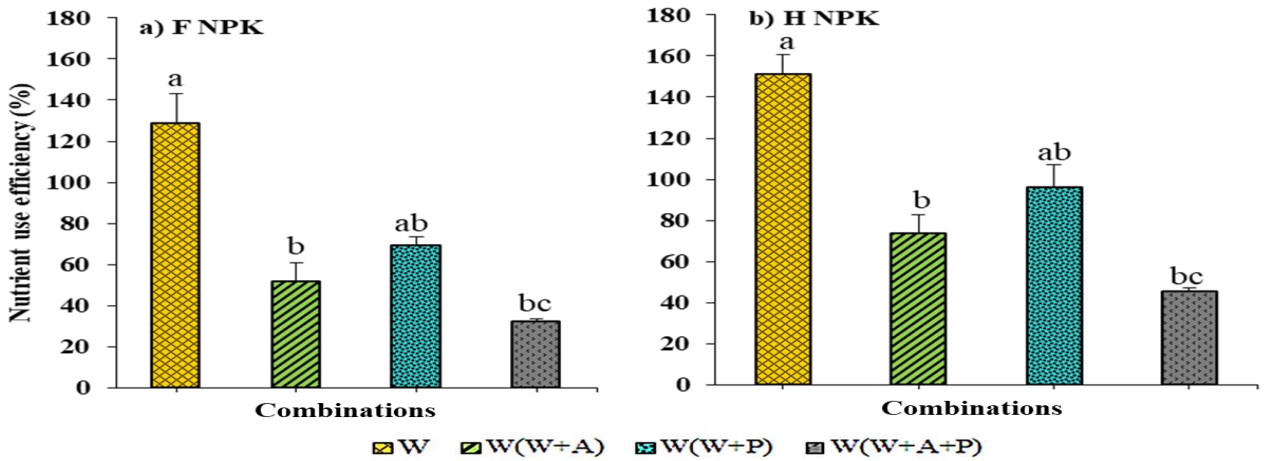

Fig. 2: Interaction effect on nutrient use efficiency of wheat

Effect of Treatments

Results showed that the highest grain yield was observed for wheat in FNPK, and minimum found in HW (Table 1 and Fig.1). Grain yield of wheat increased from control by 136.9% in FNPK, 52.2% in HNPK and decreased 40.6% in FW and 55.2% in HW (Singha*et al.* 2018). This may be due to enhancement in availability of nutrients from applied fertilizers. On the other hand, FW has more grain yield than HW but both have less grain yield than control. The highest nutrient use efficiency of wheat was observed in HNPK and lowest in FNPK (Table 2). NUE of wheat was more pronounced in HNPK than FNPK treatment. The NUE of wheat differed significantly due to treatments (Fig. 2). Results are in accordance with findings by Sheoran *et al.,* (2017) At the lower NPK doses, the crop utilized most of the supplied nutrients while at higher doses, which caused excessive vegetative growth that hindered the reproductive growth, and consequently, the crop failed to utilize the supplied nutrients effectively.

The highest WUE was seen for wheat in HW and minimum in FW treatment (Table 3). Actually, water use efficiency of wheat differed significantly due to various treatments. A higher amount of water use efficiency was found in HW than FW treatments.The efficiency of water use in the wheat crop for grain yield decreased with increasing water input (Singha *et al.* 2018). This might be due to more use of water, but yield did not increase relative to the water input.A similar trend as of nutrient use efficiency found between grain yield and water use efficiency where half dose water showed more significant results than full dose water. The same findings were also reported by Kumari *et al.,* (2018).

Table 3: Average water use efficiency of wheat crop (pooled data of three years)

Combinations/ Treatments	FW	HW	Average	CD(*p=0.05*)
W	12.48	20.84	16.66	1.30
W(W+A)	5.24	7.27	6.25	0.60
W(W+P)	6.29	9.03	7.66	0.89
W(W+A+P)	3.34	3.99	3.66	0.37
Average	6.84	10.28		
CD(*p=0.05*)	1.31	2.07		

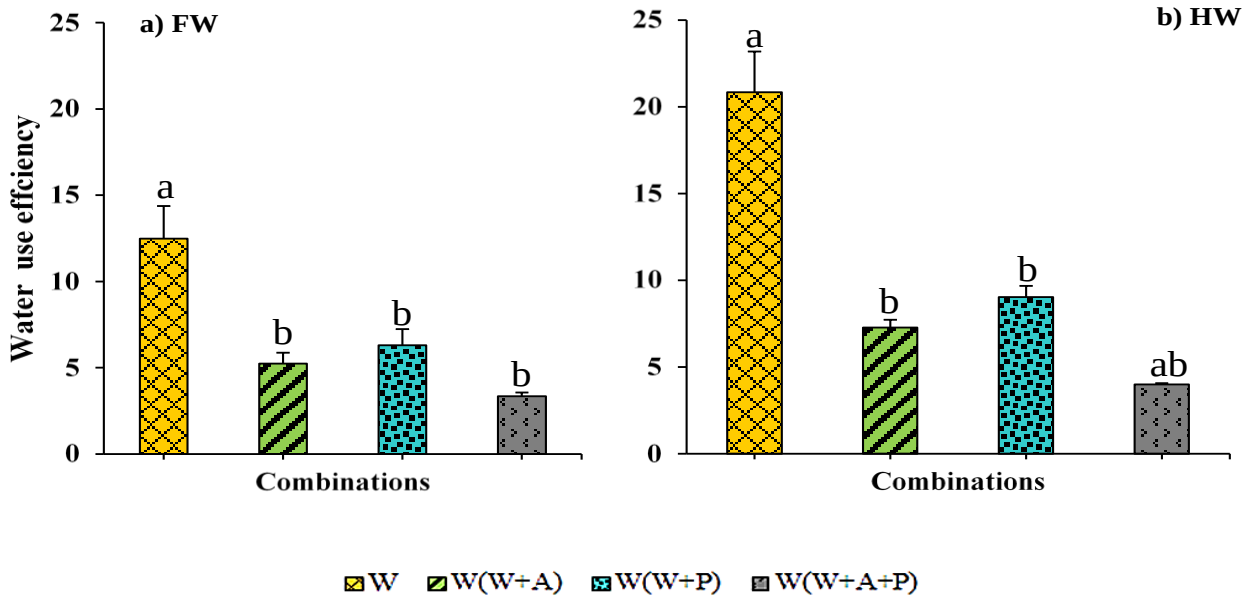

Fig. 3: Interaction effect on water use efficiency of wheat

Interaction effect

The maximum grain yield of wheat was observed in monoculture in FNPK and minimum found in W+A+P in HW which showed 95.9% reduction (Fig. 1 and Table 1). Similar findings were reported by Babu and Jain (2012). The maximum NUE of the wheat crop was observed in monoculture in HNPK treatment and minimum in mixed combination (W+A+P) in FNPK treatment (Fig. 2 and Table 2).This might be due to existing competition for space, moisture, light and nutrients, etc. Similarly, maximum WUE of wheat was observed under monoculture in HW treatment and minimum in mixed combination of *A. sativa* and *P. minor* (W+A+P) in FW treatment. This might be due to inefficient growth at elevated temperature under water deficit conditions (Lara and Andreo, 2011).

This study concludes that the nutrient and water use efficiencies of wheat crop suppressed due to interference of both weeds (*A. sativa* and *P. minor*) and more reduction was observed with higher doses of nutrient and water conditions. Improving nutrient use efficiency (NUE) and water use efficiency (WUE) of the crop under weed-crop interference have been considered as more advantageous idea to learn mechanism of weed-crop interactions as nutrients and water both regulating but essential factors for growth and development of crop plant. Therefore, understanding of NUE and WUE of weed-crop may be useful parameters to understand complex mechanisms of weed-crop interactions.

ACKNOWLEDGEMENT

We are very thankful to the Chairperson, Department of Botany, Panjab University, Chandigarh for providing all the required facilities during research work. AK is gratefully acknowledged the University Grants Commission, Government of India, New Delhi for financial support in the form of RGNF fellowship (Rajiv Gandhi National Fellowship).

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