Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

European Journal of Experimental Biology, 2012, 2 (4):960-964

ISSN: 2248 –9215
CODEN (USA): EJEBAU

Study of weed-crop competition by agronomic and physiological nitrogen use efficiency

Amir Aynehband, Sara Asadi and Afrasyab Rahnama

Agronomy & Plant Breeding Department, Agriculture Faculty, Shahid Chamran University, Ahvaz, Iran

ABSTRACT

A field experiment was conducted to study the effect of different competition patterns on nitrogen balance in wheat agroecosystem. Experimental design was split–plot based on randomized complete block with four replications. The main plots consisted of different nitrogen rates (i.e. 0, 50, 100 and 150 kg N ha^{-1}) and sub-plots consisted of the four different competitiveness patterns including: no competition, intraspecific competition, interspecific competition and intra- and interspecific competition. Our results showed that wheat grain yield had no significant increase when N application rates exceeded 50 kg ha-1 (in spite of improved with increasing N rates). All nitrogen use efficiencies diminished as N fertilizer rates increased (except N reliance index), with significant difference among competition types. In addition, NPE and APE were lowest in the intra- and interspecific competition treatment than others. The differences between each intra and interspecific competition treatments were not significant for NPE, APE and NAE. We suggested that greatly increased suppression of weeds through increased crop density for reducing the use of herbicide can play an important role in a change in both crop yield (reduced) and crop N use efficiencies.

Keywords: Agrophysiological, nitrogen use, agronomy, plant density, weed.

INTRODUCTION

Applied fertilizer nitrogen is partly taken up and used by the crop and partly "lost" to the environment. Nitrogen Use Efficiency (NUE) is a term used to indicate the relative balance between the amount of fertilizer N taken up and used by the crop versus the amount of fertilizer N "lost". Another way of thinking about NUE is in terms of the number of grain harvested versus of N applied. In other words, a high NUE value is desirable (more of N in the plant, less of N to the environment). While fertilizers are effective in driving crop yield improvements, they also frequently have a negative impact on the environment [1]. Since most plants are able to utilize less than one-half of the nitrogen fertilizer applied by growers, much of the remaining nitrogen fertilizer leaches into the air, soil and water and pollutes lakes, rivers, aquifers and oceans [2].

Therefore, an assessment of agroecosystem N use should include indicators that evaluate: (1) agronomic practices and their influence on major soil and plant physiological processes that effect N use; (2) economic factors and the optimization of agronomic inputs to achieve crop performance goals; and (3) environmental consideration including the sustainability of the agricultural resource base and the potential for resource degradation [3]. In fact, cereal producers are under pressure to increase yields and maintain profitability against a background of environmental constraints and high fertilizer costs. High yields require high inputs of N, and excessive N can lead to pollution of watercourses [4]. Moreover, Wheat crops with increased NUE will be of economic benefit to farmers and will help to reduce environmental contamination associated with excessive inputs of N fertilizers [5]. The main goal of this study is evaluation the efficiency of nitrogen fertilizer applied by some agrophysiological indicators.

MATERIALS AND METHODS

The trial was run at the experimental field of the Agriculture Faculty of Shahid Chamran University of Ahvaz, Iran, (31º20′ N latitude and 48º41′ E longitudes) at an elevation of 20 m above mean sea level during the 2010 to 2011 wheat growing season. The soil type was sandy loam with PH 7.9 and a 0.53% average organic matter concentration. The 0-30 cm soil layers contained 0.043 % nitrogen, 15 mg kg^{-1} phosphorus rate and 165 mg kg^{-1} potassium exchange. Field experiment was planted on 23 Nov. 2010. Four old competition types including 1- no competition (i.e. D_1: optimum planting density and W_0: no weed density), 2- intraspecific competition (i.e. D_2: high planting density), 3- interspecific competition (W_1: high weed density), 4- intra- and interspecific competition (i.e. W_2D_1: high plant and weed density) were studied under four N-input regimes of 0, 50, 100 and 150 kg N ha^{-1} in a randomized complete block design with a split plot arrangement and four replications. Each plot included of 8 rows, 4 m in length, interrow spacing was 20 cm and interplant spacing was 3cm. A 1 m^2 portion at anthesis and maturity was also collected from the center of each plot to determine the N content of straw and grain (total dry matter) by standard macro-Kjeldahl procedure. Soil samples were taken on all plots, prior to wheat sowing, and after wheat harvest, at a depth of 60 cm, and analyzed for nitrate content. Soil and plant data collected as inputs for the procedure were: Nitrogen supply (N_s) was estimated according to [3] by the summation of aboveground plant N (N_t) in control plots, postharvest soil nitrate (N_h) in control plots, and applied N (N_f). The following N efficiency parameters were calculated for each treatment follows [2, 5-9]:

1- N Agronomic Efficiency = (grain yield of fertilized plot - grain yield of unfertilized plot) / applied N fertilizer
2- N Physiological Efficiency = (total biological yield of fertilized plot - total biological yield of unfertilized plot) / (aboveground plant N of fertilized plot - aboveground plant N of unfertilized plot)
3- N Agrophysiological Efficiency = (grain yield of fertilized plot - grain yield of unfertilized plot) / (aboveground plant N of fertilized plot - aboveground plant N of unfertilized plot)
Data were statistically treated by ANOVA, in order to test the main effects of nitrogen rates and cultivars and their interaction. A Fisher LSD test ($P \leq 0.05$) was used to test differences between treatments means. The SAS PROC REG Procedure was used to calculate linear regressions between the nitrogen efficiency indices with cultivar year of release.

RESULTS AND DISCUSSION

Nitrogen efficiencies

N agronomic efficiency (NAE): defined as the economic production obtained per unit of nitrogen applied. In other words, quantifying the response of a crop/cultivar to applied fertilizer. For instance, significantly increasing of wheat grain yield with increase of N rates ($R^2 = 0.96$, $p < 0.0001$) (Figure 1). In contrary, NAE linearly reduced by increasing of N rates ($R^2 = 0.82$, $p < 0.0001$) (Figure 2) and was significantly influenced by competition type and N rates (Table 1). The competition type × N rate interaction shows that in higher N (N_{100} and N_{150}) fertilizer applied; NAE was influenced by competition types. A significantly ($r = 0.68$, $p < 0.0001$) higher NAE value was recorded for no competition plot than other competition types. Interspecific competition had the same situation for the low NPE, APE and NAE values recorded for competition types. NAE had a lower value with increasing in N fertilizer rates. Although, no significant ($p \geq 0.05$) different were observed between 100 and 150 Kg N ha^{-1}. The effect of N rate on NAE was most evident in N_{50} for all competition types (ranged from 37.56–74.41 kg kg^{-1}) (Table 1). Lopez-Bellido and Lopez-Bellido [10] reported that increase in N fertilizer rates resulted in a decline in NAE, but in this study this index had an optimum peak. Although, NAE values in our study was as the same range as reported by Fageria [5] and Lopez-Bellido and Lopez-Bellido [10]. The progressive rise in N accumulation is also corroborated by the yield enhancement in relation to the nitrogen taken up by the crop (NPE) and in the plants ability to increase yield in response to N supply (NAE). It is reported that, NU_tE decreased as N applied increased. While NU_tE at N0 was 44 kg of grain kg^{-1} of N_t, it dropped to 36 for N_{140} and 31 for N_{210}. Also, the NHI showed the same results between the N_0 and N_{140} with a lower value at N_{210}. Variations of AE and RF at different N rate were not significant, while PE decreased from 19 (N_{140}) to 16 (N_{210}) kg of grain kg^{-1} N. Moreover, because only about 50% of the N applied to the soil is absorbed by plants, then a large amount of N is lost through leaching [11]. A plant's high-yield ability as related to N fertilization is usually assessed as nitrogen agronomic efficiency (AE), an indicator of the amount of yield per unit of N fertilizer applied [11]. Therefore a better understanding of the plant N response is the main target to improve N utilization, optimize the mineral fertilization and reduce risk of ground-water pollution [8].

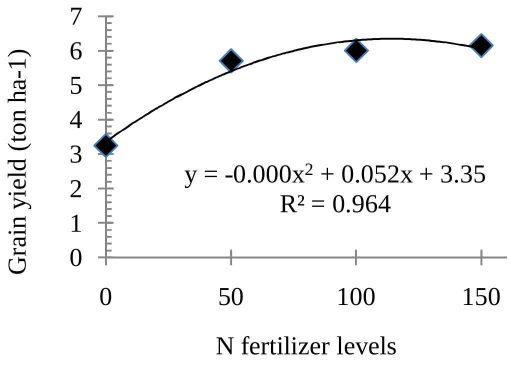

Figure 1. Relationship between grain yield and different nitrogen fertilizer levels.

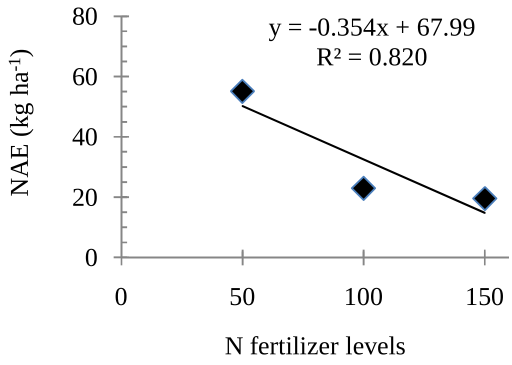

Figure 2. Relationship between nitrogen agronomy efficiency and different nitrogen fertilizer levels.

Table 1 Grain yield, N physiological efficiency (NPE), Agrophysiological efficiency (APE) and N agronomic efficiency (NAE) of competition types at different N rates.

Treatments	Grain yield	NPE	APE	NAE
	Ton ha^{-1}		Kg Kg^{-1}	
Plant × Weed density				
D_1W_0	5.74 a δ	54.99 b	24.03 ab	31.27 a
D_1W_1	4.96 b	54.13 b	16.23 b	19.17 b
D_2W_0	5.53 ab	57.14 b	20.74 ab	22.58 b
D_2W_1	4.88 b	94.74 a	28.57 a	24.53 b
Interactions				
$N_0D_1W_0$	3.9 de	-	-	-
$N_0D_1W_1$	2.81 e	-	-	-
$N_0D_2W_0$	3.05 e	-	-	-
$N_0D_2W_1$	3.25 e	-	-	-
$N_{50}D_1W_0$	6.53 bc	77.20 cd	35.86 a-c	74.41 a
$N_{50}D_1W_1$	5.13 cd	76.88 cd	25.18 bc	37.56 b-d
$N_{50}D_2W_0$	6.47 bc	102.75 bc	35.32 a-c	51.28 a-c
$N_{50}D_2W_1$	5.89 bc	147.00 ab	50.31 a	56.91 ab
$N_{100}D_1W_0$	7.15 a	82.10 cd	38.36 a-c	20.56 d-f
$N_{100}D_1W_1$	5.1 cd	91.60 cd	21.90 b-d	18.45 d-f
$N_{100}D_2W_0$	5.47 cd	59.77 cd	30.10 a-c	30.00 c-e
$N_{100}D_2W_1$	5.33 cd	161.15 a	43.35 ab	22.78 d-f
$N_{150}D_1W_0$	7.32 a	60.42 cd	21.92 b-d	30.10 c-e
$N_{150}D_1W_1$	6.35 bc	48.29 de	17.86 cd	20.66 d-f
$N_{150}D_2W_0$	5.69 bc	66.03 cd	17.55 cd	9.05 ef
$N_{150}D_2W_1$	5.24 cd	70.80 cd	20.64 b-d	18.44 d-f

δ D_1: 180 kg ha^{-1} (optimum wheat density), D_2: 300 kg ha^{-1} (high wheat density), W_0: control (absent weed), W_1: weed present (30 weed.m^{-2}).
¶ In each section, means followed by the same letter within columns are not significantly different ($p < 0.05$) according to LSD test.

N physiological efficiency (NPE): also called internal efficiency and is commonly used to test the comparative efficiencies of crops/cultivars and management treatments. NPE was significantly reduced by increasing of N rates (R^2 = 0.79, $p < 0.0001$) (Figure 3). Highest N rates (N_{150}) exerted a significant influence on NPE. The competition type × N rate interaction showed that intra- and interspecific competition (D_2W_1 = 161.15 kg kg^{-1}) (r = 0.78, $p <$ 0.0001) in optimum nitrogen application (N_{100}) had the highest NPE value (Table 1). Over the four competition type as a whole, no competition, intra and inter treatments had the lowest NPE values, with no significant difference between the three. But, intra- and interspecific competition treatments was significantly (r = 0.95, p = 0.011) different with others and had the highest NPE values that were recorded. Finally, the competition type × N rate interaction revealed differences in the influence of N rate on the NPE of the various treatments Degree of NPE may be attributed to its ability to exploit N in the deeper soil horizons, part of this mineral N being restored to the soil and becoming available for the following crop. The year × rotation interaction showed that wheat-chickpea and wheat-fallow were the most sensitive to inter annual variations in the NPE index [9]. Aynehband et al [12] reported that this value declined as N supply rates.

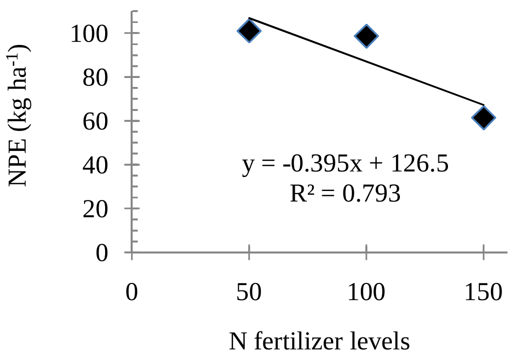

Figure 3. Relationship between nitrogen physiological efficiency and different nitrogen fertilizer levels.

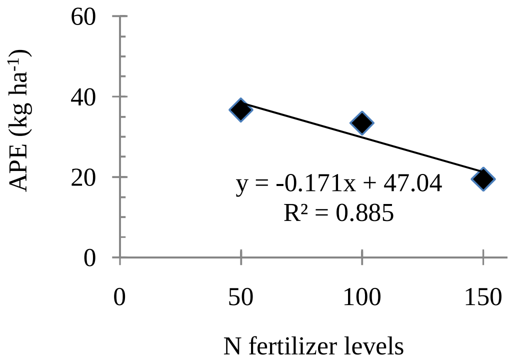

Figure 4. Relationship between agrophysiological efficiency and different nitrogen fertilizer levels.

Agrophysiological efficiency (APE): is defined as the economic production (grain yield in case of annual crop) obtained per unit of nutrient uptake. APE reduced by increasing of N rates ($R^2 = 0.885$, $p < 0.0001$) (Figure 4). In other words, as was the case with NPE, effect of N rate in this index had the same trend. Also, NPE was significantly influenced by competition types ($r = 0.63$, $p < 0.0001$) (Table 1). Lower N rate (N_{50} and N_{100}) did not exert a significant influence on APE, but the competition type × N rate interaction was significant ($r = 0.68$, $p < 0.0011$). The competition type × N rate interaction showed that interspecific competition (D_1W_1), in all N application rates had the lowest APE value. Over the four competition type as a whole, intra- and interspecific competition (D_2W_1 = 28.57 kg kg^{-1}) had the highest APE value, followed by control and intraspecific competition type, with no significant ($r = 0.63$, $p < 0.17$) difference between the three. Interspecific competition (D_1W_1 = 16.23 kg kg^{-1}) treatment had the lowest APE value that was recorded. Finally, the competition type × N rate interaction revealed differences in the influence of N rate on the APE of the various treatments. In the other words, all competition type had the lowest APE, in the highest N rate. Similarly, Fageria [5] and Aynehband et al [12] reported that APE was declined by increase in N fertilizer rates.

Relationships between yield and nitrogen indices

Correlations between grain yield and protein with N indices also showed that grain yield was positively correlated with NPE, APE and NAE. But, grain protein was not significantly correlated with all indices (Table 2). NAE was more correlation with APE than NPE. Also, correlation between grain yields with all indices was higher than correlations for grain protein. Sãulescu et al [4] reported that nitrogen use efficiency correlated positively with grain yield and negatively with protein concentration.

Table 2 Simple correlation coefficient between grain yield and protein with nitrogen indices.

	NPE	APE	NAE	Grain yield	Grain Protein
NPE	1				
APE	0.84 **	1			
NAE	0.55 **	0.72 **	1		
Grain yield	0.51 **	0.53 **	0.56 **	1	
Grain Protein	0.12 NS	0.23 NS	0.28 NS	0.51 **	1

NPE = N physiological efficiency, APE = N agrophisiological efficiency, NAE = N agronomic efficiency.
*** (P<0.01), * (P<0.05), NS: non-significant (P≥0.05).*

In conclusion, wheat grain yield had no significant increase when N application rates exceeded 50 kg ha^{-1} (in spite of improved with increasing N rates). Therefore, reducing benefits of fertilizer application, In fact, all nitrogen use efficiencies diminished as N fertilizer rates increased (except N reliance index), with significant difference among competition types. In addition, NPE and APE were lowest in the intra- and interspecific competition treatment than others. The differences between each intra and interspecific competition treatments were not significant for NPE, APE and NAE. We suggested that greatly increased suppression of weeds through increased crop density for reducing the use of herbicide can play an important role in a change in both crop yield (reduced) and crop N use efficiencies. Also, higher intraspecific competition reduced NAE indices but, had no significantly effect on NPE and APE. In addition, the inclusion of weed in competition with wheat had negative impacts on all three N efficiency indices. Finally, at sustainable agriculture point of view, from 50 to 150 kg N ha^{-1} economic yield of wheat was not significantly differences, but it had seems than only attention to traditional production criteria (i.e., grain yield) will not comprehensive and must to be seek a new (or other) indicators with more accurate and higher sensitivity analysis range like efficiency indices, especially for N.

REFERENCES

[1] L. M. Arregui, M. Quemada, *Agron. J.*, **2008**, 100, 277–284.
[2] R. H. Moll, E. J. Kamprath, W. A. Jackson, *Agron. J.*, **1982**, 74, 562–564.
[3] D. R. Huggins, W. L. Pan, *Agron. J.*, **1993**, 85, 898-905.
[4] M. A. Semenov, P. D. Jamieson, P. Martre, *Europ. J. Agron.*, **2007**, 26, 283–294.
[5] N. K. Fageria; The use of nutrients in crop plants, CRC Press, New York, **2009**.
[6] M. C. Cox, C. O. Qualset, D. W. Rains, *Crop Sci.*, **1986**, 26, 737–740.
[7] J. I. Ortiz-Monasterio, K. D. Sayre, S. Rajaram, M. McMahon, *Crop Sci.*, **1997**, 37, 898-904.
[8] G. Delogu, L. Cattivelli, N. Pecchioni, D. De Flacis, T. Maggiore, A. M. Stanca, *Eur. J. Agron.*, **1998**, 9, 11-20.
[9] D. R. Huggins, W. L. Pan, *J. Crop Prod.*, **2003**, 8, 157–185.
[10] R. J. Lopez-Bellido, L. Lopez-Bellido, *Field Crops Res.*, **2001**, 71, 31-46.
[11] E.T. Craswell, D. C. Godwin, *Adv. Plant. Nutr.*, **1984**, 1, 1–55.
[12] Aynehband, M. Sabet, A. A. Moezi, *American-Eurasian J. Agric. & Environ. Sci.*, **2010**, 10(4), 574-586.