EFFECT OF WARMING ON WHEAT VARIETY RESPONSE TO NITROGEN APPLICATION IN 2014

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Wheat is an important component of the national and global food supply. As population growth continues, worldwide demand for wheat will increase. However, productivity of wheat worldwide is being threatened by global climate change. It has been predicted that temperatures will rise 1.4-5.8^{o} C over the next 30-50 years.

One of the main factors that influence grain yield and quality is nitrogen. Nitrogen (N) is a critical nutrient for canopy growth, and it is canopy photosynthesis that drives grain yield and grain quality. In a warming environment, N may be limiting. However, adding additional N may not be an economically viable option for growers. Further, the possibility of N runoff has triggered environmental concerns. Breeding for nitrogen use efficiency (NUE) may be one approach that addresses these issues. However we need to understand how NUE works under higher temperatures.

NUE is defined as yield of grain per unit of available N in the soil (including residual and fertilizer N). There are two components of NUE: uptake efficiency (NupE; capability of plant to remove N from the soil as nitrate and ammonium ions) and utilization efficiency (NutE; capability to use N to generate grain yield). It is necessary to select genotypes that can utilize and take up N efficiently under different climatic environments without the need of adding excess fertilizer N. Our objective is to identify genotypes that have high NUE under warmed and control environments.

MATERIALS AND METHODS

Forty soft red winter wheat lines were planted in 1.5 m individual rows in a randomized block design with two replications under warmed and controlled environments at Spindletop farm Lexington, KY. A total of 100 lb/a N was applied in a 30 lb/a and 70 lb/a split on March 13th and April 9th, respectively. Soil heating cables were used to simulate climate change effects in the warmed environment. Cables were inserted and buried at a depth of 1 inch between the rows after planting to insure root zone differences of 5.0^{o} C between control and warmed treatments. A Campbell weather station was placed at the site to measure soil temperature and air temperature within each treatment. Soil moisture probes were also placed in each treatment to measure percent soil moisture content throughout the duration of the study.

Heading date, flowering date, height, biomass, protein content and yield were measured for each genotype within each treatment. N content in the vegetative tissue at flowering and maturity were measured along with N content in the grain. For each genotype, total plant N concentration was determined by summing plant N concentration in grain and vegetative tissue at maturity. NUE and NUE components were calculated as follows: nitrogen-use efficiency (NUE) = yield/soil N supply (soil N and fertilizer N), nitrogen uptake efficiency (NUpE) = Total plant N/ soil N supply (soil N and fertilizer N), nitrogen utilization efficiency (NUtE) =yield/Total plant N.

RESULTS AND DISCUSSION

Temperature and soil moisture in the warmed environment were consistently higher than the control which caused accelerated plant development in the warmed treatment (Figure 1, Tables 1 and 2). As a result, plants in the warmed treatment were shorter and had lower yields (Table 2). NUpE and %N at anthesis were not affected by warming. This is likely because both treatments had the same N supply (127.6 kg/ha) and were not N limited (Table 3). NUtE and NUE were lower in the warmed than control treatment; this is likely related to developmental differences. Increased development may have reduced the length of time allowed for N remobilization to the grain, causing more N to be left in the biomass, thus causing a reduction in yield (Table 3).

Among the genotypes, KY02C-3005-25 had the highest NUE and yield in both environments. It was also the most stable among the genotypes and did not change rank between treatments (Table 4). Foster's NUE and yield experienced the largest decrease in the warmed treatment. This was due to a decrease in uptake efficiency under warming. Allegiance and KY03C-1237-01 decreased in yield and NUE in the warmed treatment due to reduced utilization efficiency. Pembroke 2014 and KY05C-1617-17-17-3 experienced increases in NUE and yield in the warmed treatment (Table 4), possibly due to an increase in uptake efficiency under warming.

Figure 1. Average Monthly Temperature in Warmed and Control Treatments

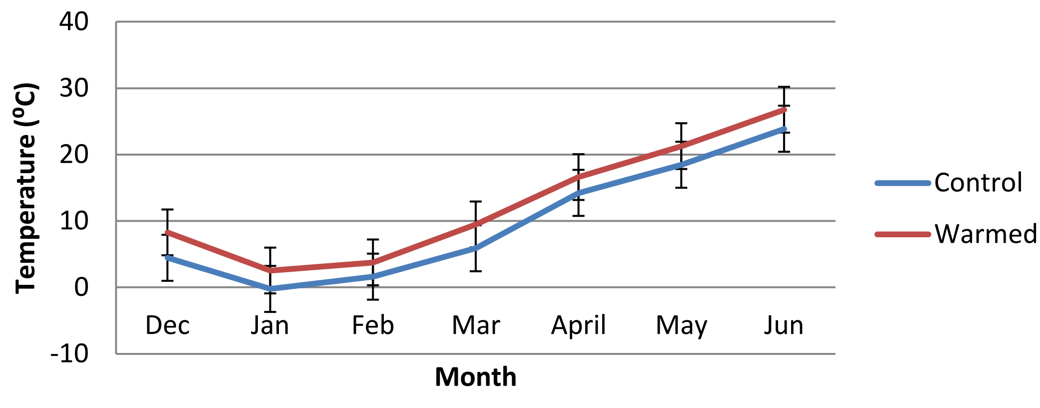

Table 1. Average Monthly Percent Soil Moisture in Warming Study, Lexington, KY 2014.

Month	Control	Warmed
March	9.5	8.7
April	17.6	16.3
May	16.1	14.8
June	6.3	6.3

Table 2. Treatment Differences for Agronomic Traits from ANOVA for 2014 Warming Study Winter Wheat Genotypes.

Trt	Heading Date	Flowering Date	Harvest Maturity Date	Height (in)	Yield (bu/ac)
Control	9-May **a***	13-May **a**	15-June **a**	31.9 **a**	107.6 **a**
Warmed	5-May **b**	9-May **b**	7-June **b**	29.9 **b**	93.9 **b**

*** Means followed by different letters are significantly different at P<0.05**

Table 3. Treatment Differences for N Traits from ANOVA for 2014 Warming Study Winter Wheat Genotypes.

Trt	%N Flowering	%N Maturity	NUpE (kg/kg)	NUtE (kg/ha)	NUE (kg/ha)
Control	1.79 **a***	.49 **a**	1.3 **a**	43.7 **a**	54.8 **a**
Warmed	1.74 **a**	.66 **b**	1.2 **a**	36.4 **b**	47.8 **b**

*** Means followed by different letters are significantly different at P<0.05**

Table 4. Estimates of NUE, NUtE, NUpE and Yield in a Subset of the 40 Winter Wheat Lines. An Example of the Variation Observed in the Relationship Between NUE and its Components and Yield Among the Genotypes.

Variety	Environment	NUE (kg/ha)	NUtE (kg/ha)	NUpE (kg/kg)	Yield (kg/ha)
Pembroke 2014	**Control**	32.5	38.16	0.90	4154.71
KY05C-1617-17-17-3	**Control**	36.4	45.47	0.80	4643.58
FOSTER	**Control**	46.9	40.26	1.16	5982.23
ALLEGIANCE	**Control**	64.0	46.19	1.39	8165.56
KY03C-1237-01	**Control**	64.0	42.75	1.49	8168.30
KY02C-3005-25	**Control**	78.3	43.06	1.82	9993.19
FOSTER	**Warmed**	27.4	32.36	0.79	3504.20
KY05C-1617-17-17-3	**Warmed**	40.5	39.21	1.03	5173.73
ALLEGIANCE	**Warmed**	42.7	37.71	1.17	5446.80
KY03C-1237-01	**Warmed**	44.0	34.20	1.31	5617.40
Pembroke 2014	**Warmed**	46.0	36.45	1.25	5867.66
KY02C-3005-25	**Warmed**	59.4	36.68	1.72	7579.14