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Research Article

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The Effects of Anhydrous Ammonia on the Leaf Nitrogen and Leaf Color in Wheat

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Abstract To study the effect of anhydrous ammonia application on the leaf nitrogen and leaf color components of wheat a field experiment was conducted in Tekırdag, Turkey during 2014-2016. Three different methods were planned in the field experiment. Anhydrous ammonia application methods (M1), traditional methods (M2) and control methods (M3). Anhydrous ammonia application was made once before the sowing period at M1. The traditional method (M2) was the method used by local farmers. The control method (M3) was no nitrogen fertilization. Leaf nitrogen and nutrients, leaf colors were measured in three periods every year. Results showed that Anhydrous ammonia application has a positive effect on leaf nitrogen and leaf color.

Keywords Anhydrous ammonia, Anhydrous ammonia application, Wheat, Nitrogen, Leaf color, leaf nitrogen

Introduction

Anhydrous ammonia containing the highest nitrogen (%82) is a chemical compound used as a fertilizer in agriculture. Anhydrous ammonia is used for fertilizer in the U.S. over the years [1]. Anhydrous ammonia will stay in liquid form when stored under its own pressure which is dependent on temperature. It turns to a gas when applied to the soil [2]. Physical and chemical properties of anhydrous ammonia, which create problems for the application and storage of anhydrous ammonia. Special tools and equipment are needed at the storage and application stages due to the chemical properties. Therefore, the use of the anhydrous ammonia for fertilizer is undeveloped in Turkey agriculture [3].

Nitrogen fertilization in agriculture is an inevitable application for plant growth and yield. The use of urea (46%) and nitrate (23-26%) for nitrogen fertilization is common in our country's agriculture. Nitrogen fertilization is carried out two or three times in different periods to meet the nitrogen requirement of the soil in wheat farming [4]. Nitrogen fertilization is performed once in the pre-sowing period in developed countries such as America and Canada [5].

The chlorophyll content in plant leaf is closely related to the N content in the leaf. This is reflected in differences in leaf color. The leaf color measurements using a chlorophyll meter could be used as an index for ranking the grain protein content [6]. Farmers generally use leaf color as a visual indicator to determine the N need of wheat [7]. They generally prefer to keep leaves of the crop dark green, it leads to over application of fertilizers N resulting in low recovery efficiency [8].

It is understood that there is a relationship between nitrogen content and leaf color. In this study, the effects of anhydrous ammonia on leaf color and leaf nitrogen were investigated.

Material and methods

Anhydrous ammonia (AA)

Anhydrous ammonia is rich in nitrogen (%82). Chemical and physical properties of AA are shown in Table 1 [5].

Table 1: Physical and chemical properties of Anhydrous ammonia

Physical Form	Gas (liquid under pressure)
Chemical formula	NH_3
Color	Colorless gas and liquid,
Odor	Strong
Boiling Point	-33^o C at 1 atm
Melting point	-78^o C
Ph	Approximately 12.0 (neat)
Density	0.696 g/L

Experimental Design

The experiments were arranged in the field using a randomized complete block design with three replications. In this research, three different methods were used;

- Anhydrous ammonia (M1)
- Traditional conditions (M2) and
- Control (M3)

At the M1 method were used 18 kg da^{-1} total nitrogen both year. The M2 method is the method used by local farmers. Total nitrogen applied at M2 both years are shown in Table 2. Nitrogen fertilization is not carried out in the M3.

Table 2: Total nitrogen rate used in at M1 and M2

Application period	**I YEAR**	**II YEAR**
	Total nitrogen rate used in at M1	
Before the sowing	18.0 kg da^{-1}	18.0 kg da^{-1}
Total nitrogen	18.0 kg da^{-1}	18.0 kg da^{-1}
	Total nitrogen rate used in at M2	
Pre- sowing	10 kg urea (%46)	10 kg TSP + 10 kg urea
Tillering	18 kg urea (% 46)	20 kg urea (% 46)
Stemelongation	23 kg CAN (% 26)	25 kg nitrate (% 26)
Total nitrogen	18.9 kg da^{-1}	20.3 kg da^{-1}

CAN (Calcium Ammonium Nitrate), TSP (Triple Super Phosphate).

Application of Anhydrous ammonia

Injection unit of anhydrous ammonia equipment is traditional knife type. Anhydrous ammonia was injected with 50 cm spacing and 20 centimeters beneath the soil surface [9, 3, 4]. The anhydrous ammonia application equipment used in the experiments is illustrated in Figure 1.

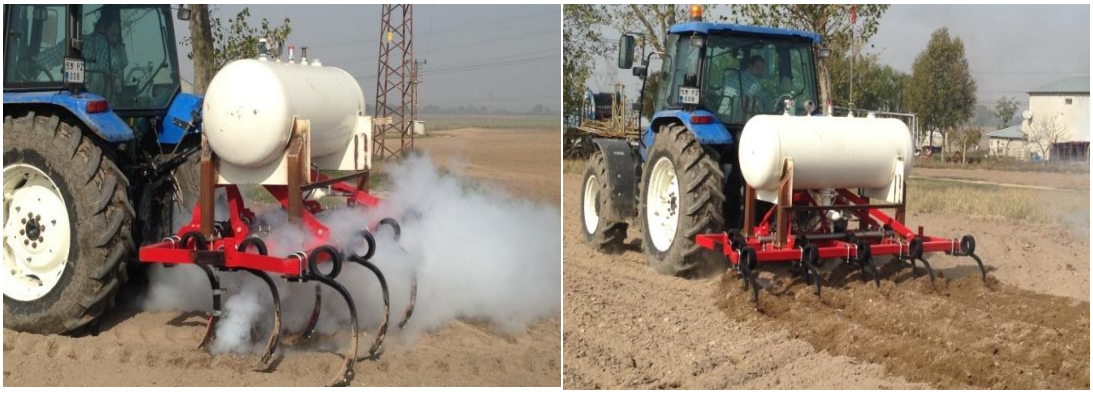

Figure 1: Application of Anhydrous ammonia

Analyzes and measurements

Leaf nitrogen and nutrients were measured in three periods (Table 3).

Table 3: Dates of period

	Year I	Year II
Period I	14.02.2014	09.03.2015
Period II	03.04.2014	06.05.2015
Period III	12.06.2014	01.06.2015

Nitrogen, phosphorus, potassium, calcium, magnesium, copper, zinc and manganese were determined.

Leaf color of wheat was measured with colorimetric system. This system CIE (L*a*b*) is the most widely used. L* represents brightness (0, black;100 white), a* represents hues from red to green(+a*,red;-a*green) and b* represents hues from blue to yellow (-b*, blue; +b*, yellow) [10].

Result and discussion

Leaf Nitrogen and Nutrient Content

The leaf nitrogen and nutrient content analyzed in three different periods is given in Table 4 (Year 1) and Table 5 (Year 2).

Table 4: The leaf nitrogen and nutrient content in year 1

Period I								
	Value range	Unit	M1		M2		M3	
			Result	Value*	Result	Value*	Result	Value*
N	3-5	%	4,23	+	3,31	+	2,8	-
P	0,3-0,6	%	0,48	+	0,46	+	0,37	+
K	3,5-5,5	%	2,95	-	2,73	-	2,45	-
Ca	0,4-1	%	0,55	+	0,64	+	0,48	+
Mg	0,15-0,3	%	0,11	-	0,12	-	0,096	-
Cu	7-15	Ppm	9,3	+	8,0	+	7,72	+
Zn	25-70	Ppm	30	+	14,2	-	13	-
Mn	35-100	Ppm	144	>	106	>	47	+
Period II								
	Value range	Unit	M1		M2		M3	
			Result	Value*	Result	Value*	Result	Value*
N	1,75-3	%	3,17	>	2,41	+	1,93	+
P	0,21-0,5	%	0,36	+	0,30	+	0,33	+
K	1,51-3	%	2,37	+	2,29	+	2,21	+
Ca	0,21-1	%	0,59	+	0,38	+	0,38	+
Mg	0,16-1	%	0,15	-	0,11	-	0,11	-
Cu	5-50	Ppm	8,9	+	6,66	+	6,45	+
Zn	21-70	Ppm	17,7	-	12,8	-	9,0	-
Mn	16-200	Ppm	115	+	39,6	+	36	+
Period III								
	Value range	Unit	M1		M2		M3	
			Result	Value*	Result	Value*	Result	Value*
N	2-3	%	2,97	+	2,58	+	1,62	-
P	0,2-0,5	%	0,19	-	0,19	-	0,16	-
K	1,5-3	%	1,27	-	1,21	-	1,19	-
Ca	0,2-0,5	%	0,8	>	0,76	>	0,55	+
Mg	0,15-0,5	%	0,23	+	0,2	+	0,17	+
Cu	5-25	Ppm	5,75	+	4,88	-	4,88	-
Zn	15-70	Ppm	7,93	-	5,0	-	4,18	-
Mn	25-100	Ppm	168	>	64	+	53	+

N (Nitrogen), P (Phosphorus), K (Potassium), Ca (Calcium), Mg (Magnesium), Cu (Copper), Zn (Zinc) and Mn (Manganese); *+ (Sufficient), - (Insufficient), > (Excessive)

The leaf nitrogen was found to be highest in three periods at the anhydrous ammonia application both years. The lowest leaf nitrogen and nutrient content were M3 methods. Although 20.3 kg da^{-1} total nitrogen was applied in M2 method, leaf nitrogen was found lower than M1 method. Anhydrous ammonia has a positive effect on leaf nitrogen of wheat.

Table 5: The leaf nitrogen and nutrient content in year 2

Period I								
	Value range	Unit	M1		M2		M3	
			Result	Value*	Result	Value*	Result	Value*
N	3-5	%	4,79	+	4,45	+	3,59	+
P	0,3-0,6	%	0,35	+	0,31	+	0,31	+
K	3,5-5,5	%	3,19	-	2,56	-	2,63	-
Ca	0,4-1	%	0,59	+	0,54	+	0,46	+
Mg	0,15-0,3	%	0,13	-	0,16	+	0,13	-
Cu	7-15	Ppm	10	+	7,78	+	8,45	+
Zn	25-70	Ppm	26	+	11,75	-	13,78	-
Mn	35-100	Ppm	46	+	40	+	40	+
Period II								
	Value range	Unit	M1		M2		M3	
			Result	Value*	Result	Value*	Result	Value*
N	1,75-3	%	3,64	>	2,91	+	2,1	+
P	0,21-0,5	%	0,17	-	0,16	-	0,16	-
K	1,51-3	%	2,44	+	2,3	+	1,88	+
Ca	0,21-1	%	0,54	+	0,44	+	0,32	+
Mg	0,16-1	%	0,11	-	0,09	-	0,073	-
Cu	5-50	Ppm	10,8	+	8,6	+	7,91	+
Zn	21-70	Ppm	15,46	-	13,7	-	10	-
Mn	16-200	Ppm	39	+	21,8	+	14,8	-
Period III								
	Value range	Unit	M1		M2		M3	
			Result	Value*	Result	Value*	Result	Value*
N	2-3	%	2,63	+	1,82	-	1,68	-
P	0,2-0,5	%	0,12	-	0,099	-	0,1	-
K	1,5-3	%	1,78	+	2,52	+	2,51	+
Ca	0,2-0,5	%	0,91	+	0,61	+	0,57	+
Mg	0,15-0,5	%	0,2	+	0,13	-	0,085	-
Cu	5-25	Ppm	9,24	+	8,1	+	8,88	+
Zn	15-70	Ppm	10	-	6,81	-	9,21	-
Mn	25-100	Ppm	37	+	19	-	11	-

*N (nitrogen), P (phosphorus), K (potassium), Ca (Calsium), Mg (magnesium), Cu (copper), Zn (zinc) and Mn (manganese); **+ (Sufficient), - (insufficient), > (excessive)

Leaf Color

Leaf color was significantly affected by methods (Figure 2). The darkest leaf color is the M1 method, which has a high N content in the leaf. This shows that there is a relationship between leaf color and leaf nitrogen [6,7,8].

Significant color differences were observed in wheat leaf both periods [6]. Color analysis of leaf wheat is given in Table 6.

M1 M2 M3

Figure 2: Leaf color according to methods

Table 6: L* a* b* value of leaf the wheat

App.	C*	L*	a*	b*	ΔC*	ΔL*	Δa*	Δb*	ΔE
Period I									
M1	18,56	37,87	-8,93	16,26	7,78	6,22	-0,17	8,39	10,44
M2	20,43	40,71	-9,14	18,26	5,01	3,38	-0,04	6,39	7,22
M3	26,34	44,09	-9,1	24,65					
Period II									
M1	15,18	37,25	-7,28	13,29	12,85	10,54	-1,13	13,42	17,10
M2	22,78	43,65	-8,14	21,25	5,25	4,14	-0,27	5,46	6,85
M3	28,03	47,79	-8,41	26,71					
Period III									
M1	14,14	38,82	-7,34	12,05	14,1	12,02	0,42	14,92	19,16
M2	19,92	43,2	-8,59	17,94	8,32	7,64	1,67	9,03	11,94
M3	28,24	50,84	-6,92	26,97					

Color differences were evaluated according to the control method. The darkest color measurement was found in the M1 method in all three periods. The greatest color difference was in M1 and M2 respectively. The measured color difference increased with the development period of the plant. The color difference between the methods continued until the harvest period. The M1 and M2 methods have a higher chroma (saturation) than the M3 method.

Conclusions

Results showed that anhydrous ammonia has a positive effect on leaf nitrogen and leaf color of wheat. The highest leaf nitrogen was found in the application of anhydrous ammonia. Leaf nitrogen measured in three periods was determined at a sufficient level. The rate of intake of other nutrients (P, K, Ca, Mg, Cu, Zn and Mn) has been increased by the application of anhydrous ammonia. Leaf color was affected by methods. In all periods, the darkest leaf was detected in the anhydrous ammonia method.

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