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Research Article

A different method of using nitrogen in agriculture; Anhydrous ammonia

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ABSTRACT

Nitrogen fertilization in vegetable production 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. Nitrogen fertilization is performed once in the pre-sowing period in developed countries such as America and Canada. Studies have also been carried out in order to ensure the use of similar nitrogen fertilization methods under the conditions of our country. Anhydrous ammonia, which is a raw material of nitrogenous fertilizers with 82.2% nitrogen content, was used for fertilizing as an environmental and economic method. The biggest problem in this application is the lack of equipment that can place the fertilizer into the soil due to the chemical properties of Anhydrous ammonia. In our work, we have developed equipment for the application of anhydrous ammonia and have carried out experiments on wheat farming in the region. Two different methods have been studied in the research; Anhydrous ammonia methods and traditional methods. The anhydrous ammonia method is a more advantageous method than the farmer condition method in terms of the parameters examined. Anhydrous ammonia method is a more environmentally and economical method due to the use of less fertilizer.

1. Introduction

The use of nitrogen fertilizer is necessary to ensure that production in agriculture is efficient and profitable. In our country, only 2 971 000 tones of nitrogenous fertilizer is used to meet 661 000 tones of pure nitrogen demand in cereal production [3]. As is known in our agriculture for the purpose of nitrogen fertilization; urea (46%), ammonium nitrate (26-34%), ammonium sulphate (21%) and compound fertilizers are used. In wheat production, fertilization is carried out in three different periods using different nitrogenous fertilizers. Anhydrous ammonia has been used for many years as a nitrogen source in cereal production especially in developed countries such as USA and Canada. Anhydrous ammonia accounts for 32% of the nitrogenous fertilizers used in agriculture [7]. In this study, traditional fertilization method and anhydrous ammonia fertilization method are compared. Nitrogen fertilizers and nitrogen content used in agriculture are given in Table 1.

Table 1. Nitrogenous fertilizers used in agriculture

Fertilizer	Formula	N content (%)
Ammonia	NH_3	82.2
Ammonium nitrate	NH_4NO_3	26-34
Ammonium sulphate	$(NH_4)_2SO_4$	21
Ammonium chloride	NH_4Cl	26
Urea	$(NH_2)_2CO$	46
Calcium nitrate	$Ca(NO_3)_2$	15.5
Sodium nitrate	$NaNO_3$	16
Calcium cyanamide	$CaCN_2$	20.6

Anhydrous ammonia (NH_3) has the highest amount of nitrogen with 82.2%. However, it is used as a raw material of nitrogenous fertilizers. Due to the chemical properties of anhydrous ammonia, its use is very limited [1]. Ammonia, classified as a chemical substance, is liquid under pressure. When the effect of the pressure is removed, it is in gas form [5,8]. Because of its chemical properties, ammonia application equipment must be in special construction. Due

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to all these factors, the use of anhydrous ammonia as a nitrogen fertilizer is not yet available.

Within the scope of the project (TAGEM / 13-AR-GE / 45), we designed an equipment capable of applying ammonia fertilizer to the soil for nitrogen fertilization and we used for wheat farming. In this study, the advantages and disadvantages of traditional and anhydrous ammonia fertilization methods were evaluated.

2. Material and Method

2.1 Anhydrous ammonia

The physical and chemical properties of the anhydrous ammonia fertilizer used in the nitrogen fertilization method are given in Table 2 [5].

Because of these properties, anhydrous ammonia, which is assessed in the chemical class, requires the use of materials resistant to storage and abrasion under special conditions. Ammonia is used as a coolant in the air conditioning in our homes. For this reason, the most suitable use area for ammonia is agricultural fields with open application area.

2.2 Anhydrous ammonia application equipment

The anhydrous ammonia application equipment developed by our project team under the project is shown in Fig 1.

The equipment is arranged so that anhydrous ammonia fertilizer can be applied under the soil. The Knife type injection unit is shown in Fig 2.

Table 2. Physical and chemical properties of anhydrous ammonia

Physical form	Gas (liquid under pressure)
Color	Colorless
Smell	Heavy
Molecular weight	17.031 g / mol
Gas density	0.73 kg / m^3
The liquid density (-33.3 ° C)	681.9 kg / m^3
Critical temperature	132.44 ºC
Critical pressure	113 bar

Figure 1. Anhydrous ammonia application equipment

Figure 2. Knife type injection unit

Table 3. The properties of the equipment

Width	2200	mm
Tank volume	500	liter
Tank pressure	10	bar

The equipment consists of main frame, tank, feet, fasteners, dosing unit and control valves [2]. All the materials used in the equipment were resistant to anhydrous ammonia. The properties of the equipment are given in Table 3.

The main frame is made of 4 + 5 + 5 and the anhydrous ammonia is applied to the soil with only 4 front legs. The task of the rear legs is to cover the soil and prevent possible nitrogen losses.

2.3 Anhydrous ammonia application method (AAM)

In this method, anhydrous ammonia was applied once to the soil before sowing. Ammonia was applied at a dose of 22 kg da^{-1} according to soil analysis results. The anhydrous ammonia was injected 15-20 cm beneath the soil surface with application equipment and between 50 cm rows.

2.4 Traditional method (TM)

In the traditional method practiced by farmers, the application periods of fertilizers, the types of fertilizers used and the amount of fertilizers applied were recorded. It has not been intervened in the application condition of the farmer. The amounts and periods of fertilizer applied in wheat cultivation in the traditional method are given in Table 4.

As shown in Table 4, nitrogen fertilization in the traditional method was carried out in three different periods.

Table 4. The amounts and the periods of fertilizer applied in the traditional method

Period	I	II
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}
Total fertilization	51 Kg	55 Kg

3. Results and Discussion

According to soil analysis, the amount of nitrogenous fertilizer that should be given to the soil was determined as 18 kg da^{-1}. The types of fertilizer used and the amounts used are given in Table 5. The total fertilizer usage amounts according to the methods are shown in Fig 3.

As shown in Table 5, 22 kg da^{-1} of anhydrous ammonia was used in the AAM method in two years to apply 18 kg da^{-1} pure nitrogen.

The total amount of nitrogen fertilizer used in the TM method was calculated as 51 kg in the first year and 55 kg in the second year. In TM method, the most used fertilizer type as nitrogen fertilizer was urea.

Fertilization was done three times in the TM method, but fertilization was done only once in the AAM method. This causes the farmer to use the tractor + equipment three times. This causes the consumed human energy and fuel consumption to be much higher.

The application of fertilizer in three periods also causes many disadvantages. These can be listed as cost increase, deterioration of soil porosity, increase of field traffic, use of excess fuel and negative environmental effects. It also causes the farmer to spend a lot more time.

Table 5. Quantities and types of fertilizers used in methods

Year	AAM	TM
I	Anhydrous ammonia	10 kg urea (46%) 18 kg urea (46%) 23 kg CAN (26%)
Application	1	3
Total	22 kg da^{-1}	51 kg da^{-1}
Difference	29 kg da^{-1}	
II	Anhydrous ammonia	10 kg TSP + 10 kg urea 20 kg urea (46%) 25 kg nitrate (26%)
Application	1	3
Total	22 kg da^{-1}	55 kg da^{-1}
Difference	33 kg da^{-1}	

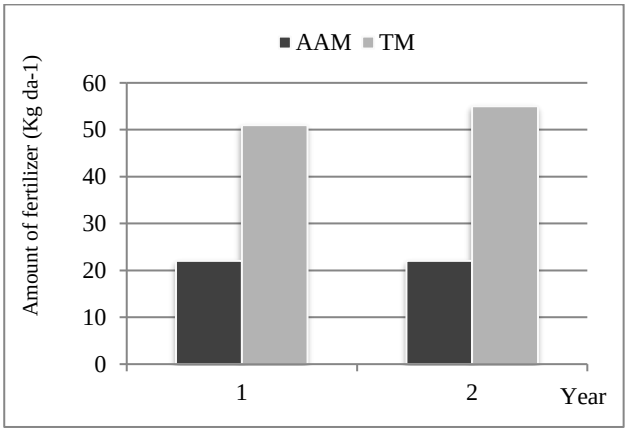

Figure 3. Amount of fertilizer according to methods

In the TM method, more fertilizer use was determined than in the AAM method. This amount was determined as 29 kg in the first year and 33 kg in the second year. It is clear from the results that in the TM method, much more fertilizer was used compared to the AAM method.

The grain yields according to the methods are shown in Table 6.

The AAM method showed positive results in terms of all the parameters examined according to TM method. Farmers usually prefer varieties with higher plant height. This is due to the increase in wheat stalk prices used in animal feeding in recent years. Wheat stalk is an important feedstock for livestock operations. However, due to insufficient production, wheat stalks gain value.

According to the AAM method, the plant height was 10 cm longer than the TM method.

In the AAM method; the most positive results were calculated in terms of characteristics such as spike length, number of grain in spike and grain weight in spike, which are important effects on yield.

Total grain yields (kg da^{-1}) according to the methods are shown in Fig. 4.

Table 6. The grain yields according to the methods

	Parameter	AAM	TM	Diff.
I	Plant height (cm)	103.56±6.1	93.40±2.6	10
	Spike length (cm) (cm)	8.54±0.82	8.11±1.0	0.43
	Number of grain in spike (number/spike)	42.56±7.14	33.80±8.66	8.76
	Grain weight in spike (g/spike)	2.41±0.47	1.93±0.59	0.48
	Gluten (%)	35.33±2.06	30.83±3.0	4.5
	Grain yield (kg da^{-1})	**892.15**	**728.33**	**163.82**
II	Plant height (cm)	95.73±10.1	90.08±4.5	5.65
	Spike length (cm) (cm)	8.36±0.84	7.11±1.0	1.25
	Number of grain in spike (number/spike)	43.73±7.18	35.63±9.11	8.1
	Grain weight in spike (g/spike)	1.59±0.29	1.28±0.42	0.31
	Gluten (%)	29.83±3.6	24.5±2.6	5.33
	Grain yield (kg da^{-1})	**744.80**	**695.44**	**49.36**

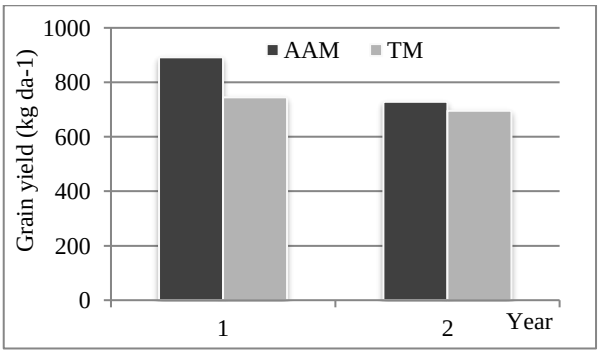

Figure 4. Total grain yields (kg da^{-1}) according to the methods

The grain yield in the AAM method were 163.82 kg da^{-1}, 49.36 kg da^{-1} higher than the TM method in year I and II, respectively. Similar results were found by [8, 9]. While it is known that nitrogen fertilizer application increases grain yield, application method and amount is also important [6 ,1, 9].

Compared with the TM, the number of grain in spike increased by 8.76 (number/spike) in year I and by 8.1 (number/spike) in year II.

Gluten values (%) according to the methods are given in Fig 5. The gluten value, which is a quality parameter, was found to be high in the AAM method. It was stated that the content of gluten for high-quality dough in bread making should be 28% [4].

In this respect, although nitrogen fertilization was applied once in the AAM method, the gluten content of wheat in AAM method was higher than the TM method. The gluten content in the AAM method were 4.5%, 5.33% higher than the TM method in year I and II, respectively.

The fertilizer and fertilizer costs according to the methods are given in Table 7.

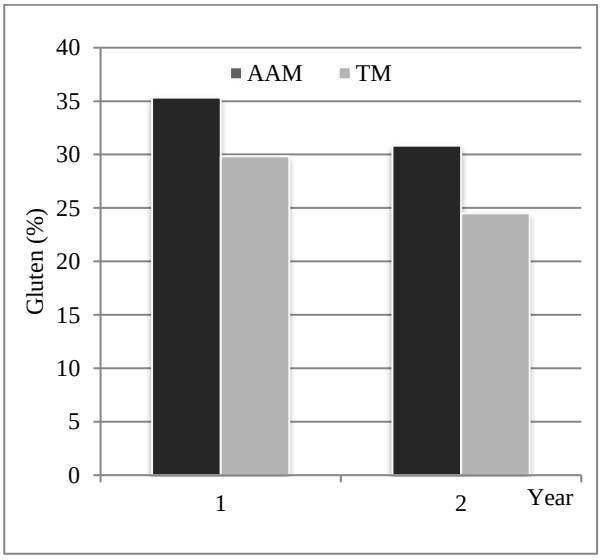

Figure 5. Gluten values (%) according to the methods

Table 7. The fertilizer costs according to the methods

Year		AAM	TM
I	Cost per unit ($/Kg)	0.25	0.32
	Fertilizer Cost($/da)	22.19	25.43
	Total Fertilizing Cost ($/da)	28.58	39.13
	Total cost ($/da)	165.57	176.12
II	Cost per unit ($/Kg)	0.25	0.29
	Fertilizer Cost($/da)	17.86	21.73
	Total Fertilizing Cost ($/da)	23.01	32.76
	Total cost ($/da)	151.69	161.43

* Prices are calculated according to the unit prices of the year 2014-2015.

There are significant differences between the methods in terms of cost for nitrogen fertilizer in wheat farming.

Total Fertilizing Costs in the AAM method were 10.55 $, 9.75 $ more economical than the TM method in year I and II, respectively. This shows that farmers spend more money on unit product costs. The advantages and disadvantages of methods are given in Table 7.

When the advantages and disadvantages of the methods are listed in terms of the examined parameters, the AAM method is found to be more advantageous than the TM method.

When all these results are evaluated; anhydrous ammonia can be used in the cultivation of our country for nitrogen fertilization. However, the biggest problem in the use of anhydrous ammonia in agriculture is that the application equipment is not available on the market. Anhydrous ammonia application areas in agriculture should be increased. In addition, intensive chemical use in agricultural applications causes environmental and groundwater pollutions. The use of fertilizer in intensive quantities increases the harmful effects by contamination of both soil and groundwater. It is known that the use of fertilizer is inevitable for high yield. For this reason, effective use of fertilizer is important.

In this study, positive results were determined in the anhydrous ammonia method according to the parameters examined.

3. Conclusions

According to the results of this study; use of anhydrous ammonia is recommended in terms of yield parameters and economic factors.

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Table 8. Advantages and disadvantages of methods

	AAM	**TM**
Amount of fertilizer	🙂	🙁
Human work power	🙂	🙁
Environmental impact	🙂	🙁
Field traffic	🙂	🙁
Yield	🙂	🙁
Cost	🙂	🙁

Nomenclature

AA	:	Anhydrous ammonia
AAM	:	Anhydrous ammonia method
TM	:	Traditional method
TSP	:	Triple super phosphate
CAN	:	Calcium ammonium nitrate
NH_3	:	Ammonium

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