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Research Article

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Effect of waste ammonia and urea on leaf nitrogen, phosphorus and potassium contents of sorghum (*sorghum bicolor* L.) grown on a clay soil

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Abstract A field trial was carried out at the University of Khartoum farm, Shambat, Sudan, for two consecutive seasons (2006-2007) and (2007-2008).The aim of the research was to determine the effect of the time and depth of application of aqueous waste ammonia, as a nitrogen fertilizer, on a leaf of nitrogen, phosphorus and potassium of forage sorghum (Sorghum bicolor L.) and its efficiency as compared to urea fertilizer. The split block design was used for the layout of 76 experimental plots representing 19 treatments replicated four times each. Eighty kg N/ha of urea and of ammonia were applied at different depths: 5, 10, and 15cm into the soil at different times of application: one week before sowing , two weeks after sowing and four weeks after sowing . The results showed that the nitrogen, phosphorus and potassium were significantly ($P \leq 0.05$) increased by application of both ammonia and urea. In conclusion, waste ammonia produced by Khartoum Refinery can be disposed of safely in soil by using it as a cheap nitrogen fertilizer for forage sorghum and that it is practically as efficient as urea fertilizer.

Keywords Time of application, Depth of application, waste ammonia, urea, sorghum.

Introduction

Environmental pollution has occurred in our earth for centuries and only to be a remarkable quantity following the industrial revolution in the nineteenth century and then gradually increased, thus, nowadays the environmental pollution become serious problems facing human race on our planet. Human activities and natural causes are the main cause of the pollution in our planet. The industries activities among other anthropogenic activities could pollute soil, water, and air resources causing serious risks to our ecosystems. One of the main industrial activities that contribute highly to the pollution of the environment is the petrochemical one. The emission of poisonous and harmful fumes and inadequate disposal of waste products are only some examples that cause a huge disruption in the earth remispheres. Disposal of these wastes presents serious challenges. Application of industrial and mining waste to land as an amendment is a useful technique as it is a way to get rid of industrial waste; a big problem facing many countries. Petroleum industries in Sudan used ammonia to refine Crude oil. During refining process into various commercial products, anhydrous ammonia waste is produced. A large amount of ammonia waste was producing every year, and these amounts are disposed of, causing serious environment hazards to both refinery workers and villager's inhabitants near[1].This discharge of anhydrous ammonia waste to surrounding area may be polluted soil, water, and air [1].

Plant tissue diagnosis is an important tool to investigate the general nutritional status of the plants. Since the science of plant nutrition was founded, the chemical analysis test was used to determine the total nutrient for plant leaves or plant parts at certain time or stage of morphological development [2-3]. This procedure made correlate well between the nutritional status of the plants, plant growth and yield [4]. Nitrogen (N), phosphorous

(P) and potassium (K) in that order are three major nutrients essential for the cultivation and should be used in proper proportion. Nitrogen is one of the important elements in plants because its key role in the plant life cycle. For instance, Chlorophyll content, which is important for the photosynthesis process, is positive correlation with nitrogen concentration in plant leaves and also nitrogen is regarding a part of different enzymatic proteins that catalyze and regulate plant growth processes [5-6]. In addition to this N content is affecting both growth and yield and reproduction of the plant, In spite of N being one of the most abundant elements on soil, N deficiency is the most common nutritional problem affecting the plants throughout the world, and applying the N fertilizers corrects N deficiency in soil [6-7]. Phosphorus is regarding the second to N as important element needed for plant growth; it is inevitable element for all living protoplasm organisms because it's a constituent of nucleic acids, bone, cytoplasm membranes phospholipids and ATP [8-10]. The third important macronutrient to the plant is K, and second to N regarding the amounts required by plant, and is a principal component of various plant roles, like enzyme activity, transpiration and nutrient absorption [11].
Sorghum (Sorghum bicolor L.) used as fodder for livestock and is a tolerant fodder crop to drought and salinity, so is suitable crop to grow in arid and semi-arid region, similar to the climatic conditions in Sudan. It is well known that the soils of Sudan are poor in N due to low amount of organic matter, and the imported urea is widely used as N fertilizer [12-13]. So, looking for low-cost local sources of N fertilizers should be suitable strategy to decrease cost production which leads increase farmer income. Thus, the research on study the possibility of useful and environmentally safe disposal of waste ammonia produced by Khartoum refinery is one best way to achieve this strategy. However, there is little published research on application of waste aqueous ammonia in Sudanese soil [1,14]. Therefore, the purpose of this research was to investigate the effect of waste ammonia and urea on N, P and K leaf contents of sorghum (sorghum bicolor L.) grown on a clay soil.

Materials and Methods

Field trial site description of the

The trial was carried out in two successive growing seasons (2006–2007 and 2007–2008) in the University of Khartoum Experimental farm (latitude 15°40′N and longitude 32°32′E), Shambat, Khartoum, Sudan. The climate of the study area is a semi- desert type. The rainfall occurring mostly during July and August with annual Average of 160 mm [15]. Average minimum and maximum temperatures range for both seasons between 27°C and 36°C in august (autumn-Kharif-season) and between 25°C and 41°C in May (summer season). (Shambat Agro-meteorological observatory).

Analysis of waste aqueous NH_3

Khartoum Refinery is located North of Khartoum City at a distance of about 70 Km. The refinery is owned by Khartoum Refinery Company Limited. The company is a joint venture established with investment by China National Petroleum and Gas Corporation, and Ministry of Energy and Mining of the Sudan.
According to El Tayeb (2005), NH_3 and H_2S produced during the refining process can dissolve into water and be ionized [16]. The solubility of ammonia in water is higher than that of H_2S (the solubility of both being inversely proportional to temperature. NH_3 gas and then withdrawn (from tray 24) and the NH_3vapour pressure is thereby reduced to facilitate the flow of more and more NH_3 gas towards the middle of the tower. This process will result in decreasing the pH of sour water by getting rid of sour H_2S gas through the flare and in the production of anhydrous ammonia (1500 tons/year). The anhydrous ammonia is then mixed with water and its concentration is thus reduced to about 9-10%, where it is stored in tank before its disposal. The resulting aqueous ammonia is pumped out of these tanks and fed into pipe 503/ABC extending from the refinery site to the liquid waste ammonia dumping site located far from the refinery area. In the dumping site aqueous ammonia is discharged into an open land of semi- desert.

Soil analysis

Prior to sowing, soil samples were taken from the experimental site at 0- 30 and 30- 60 cm depths. The soil samples were air dried and ground to pass a 2 mm sieve. Particle size distribution was determined by the hydrometer method [17]. Soil pH was measured by using Analogue pH meter. The electrical conductivity of soil extract was obtained by Electrical conductivity meter.Soluble cations and anions were determined according to the procedure of [17-18]. Soil available P was determined by using spectrophotometer as described by Ryan et al., (2001), soil N was determined by micro kjeldahl [17, 19].The method used for the determination of organic carbon was described by Jackson [20]. Cation exchange capacity was determined by the method described by Richards [18]. Some selected chemical and physical properties of soil are tabulated in Table 1**.**

Table 1: Some of the physical and chemical properties of the soil

The properties	0-30cm			30-60cm		
Particle size distribution %	**clay**	**Silt**	**sand**	**clay**	**Silt**	**sand**
	47.62	**33.38**	**19.00**	**44.92**	**36.08**	**19.00**
pH(25°C)	8.10			7.9		
EC_e at 25°C (dSm^{-1})	0.9			0.25		
CEC meq/100g.	61.95			67.40		
Ca (me/l)	5.0			1.6		
Mg (me/l)	1.0			0.2		
K (me/l)	0.13			0.13		
Na (me/l)	5.3			6.3		
CO_3 (me/l)	0.00			0.00		
HCO_3 (me/l)	7.0			7.0		
Cl (me/l)	67.5			57.5		
P mg/kg^{-1}	4.2			4.00		
Organic matter%	1.88			0.54		
SAR	3.07			7.08		
Total nitrogen %	0.020			0.0060		
Air-dry moisture content%	5.00			5.20		

Land preparation and layout of the experiments

Three times of fertilizer application were used for both aqueous ammonia and urea. The first application (T1) was one week before sowing, the second application (T2) was two weeks after sowing, and the third application (T3) was four weeks after sowing. One rate of fertilizer application used for both waste ammonia and urea was 80kgN/ha. Three depths of application were used for both ammonia and urea fertilizer: D1 5cm depth into the soil, D2 10 cm, and D3 15cm into the soil. The fertilizer was applied about three days after irrigation in each case. About 60kg/ha seed of forage sorghum were drilled manually on side of each ridge, at the specific depths. Sowing was done on the middle of august 2006 with respect to the first season (autumn - kharif -season) and on March.2007 with regards to the second season (summer season). The sowing operation was done 7 days after the date of fertilizer application. Weeding was performed manually twice when needed during the growing season.

Plant mineral composition

Leaf samples collected at harvest were cleaned and placed in the oven at a temperature of 65°C for 24 hours and ground pass through 0.5mm sieve and stored in polythene bags for chemical analysis. Leaf N was determined using micro Kjeldahl, leaf P was determined calorimetrically using ammonium molybdate and ammonium metavanadate and Leaf potassium K was determined by flamephotometer [18].

Statistical analysis

Analysis of variance and test of significance were done according to standard procedure for split plot design [20]. Means were differentiated according to Duncan's Multiple Range Test (DMRT).

Results

Nitrogen

The results showed no significant effect of time of application on nitrogen content in the plant in the first season, whereas in the second season the data shows a significant ($P \leq 0.05$) effect.In two seasons the N content in T2 was higher than T1 and T3, and results as follows; nitrogen content in T2 (2.265%) was higher than that T1 (2.176N%) and T3 (2.167N%) and nitrogen content in T2 (2.324%) was higher than that T1 (2.154N%) and T3 (2.142N%) for urea and ammonia in first and second season respectively (Tables 2 and 3).

In the first season Tables 2 and 3 also show no significant difference between depth of application on nitrogen % in the plants for both fertilizers: but in depth of application main effect for both fertilizers increased nitrogen in plant, as D3 was significantly better than D1 and D2; The main effect of the two fertilizers increased from 2.109% and 2.176% for D1and D2, respectively, to 2.323N% in D3.The main effect of both fertilizers was significantly different from the control which gave 1.450N% in the plant as compared to 2.838 and 2.950N% given by ammonia and urea.Whereas, in second season Tables 2 and 3 also show a significant ($P \leq 0.05$) effect of depth of application on nitrogen % in plant: generally, nitrogen increased in plant with increasing depth of applicationfor both urea and ammonia, as D3 was significantly better than D1and D2; the mean effect of fertilizers increased from 2.084% and 2.235%for D1 and D2, respectively, to 2.301 N% in D3.The main effect of both fertilizers was significantly different from the control which gave 1.393N% in the plant as compared to 2.860 and 2.940N% given by ammonia and urea.

Table 2: Effect of time, depth of application and fertilizer on plant N content (%) the first season

Time	Depth	Ammonia	Control	Urea	Time means	Depth means
T1	D 1	2.273^{a}	1.450^{b}	2.428^{a}		D 1=2.109 ^{b}
	D2	2.485 ^{a}	1.450^{b}	2.580^{a}	2.176^{a}	
	D 3	2.673 ^{a}	1.450^{b}	2.798^{a}		
T2	D 1	2.530 ^{a}	1.450^{b}	2.695^{a}		D2=2.176^{b}
	D 2	2.803 ^{a}	1.450^{b}	2.220^{a}	2.265^{a}	
	D 3	2.838 ^{a}	1.450^{b}	2.950^{a}		
T3	D 1	2.250 ^{a}	1.450^{b}	2.455^{a}		D3=2.323^{a}
	D 2	2.513 ^{a}	1.450^{b}	2.635^{a}	2.167^{a}	
	D 3	2.608 ^{a}	1.450^{b}	2.693^{a}		
Fertilizer Mean		2.552 ^{a}	1.450^{b}	2.606^{a}	CV% 12.40	

Means in each column having the same latter's are not significantly different at 0.05 level of probability, according to the Duncan s Multiple Range Test.

Table 3: Effect of time, depth of application and fertilizers on N content (%) in the second season

Time	Depth	Ammonia	Control	Urea	Time means	Depth means
T1	D 1	2.243^{a}	1.393^{bc}	2.430^{ad}	2.154^{b}	D1= 2.084^{c}
	D2	2.480^{abde}	1.393^{bc}	2.645^{d}		
	D3	2.680^{bde}	1.393^{bc}	2.735^{d}		
T2	D 1	2.538^{d}	1.393^{bc}	2.695^{e}	2.324^{a}	D 2=2.235^{b}
	D 2	2.815^{d}	1.393^{bc}	2.890^{de}		
	D 3	2.860^{d}	1.393^{bc}	2.940^{d}		
T3	D 1	2.225^{a}	1.393^{bc}	2.445^{ad}	2.142^{b}	D 3=2.301^{a}
	D 2	2.523^{bd}	1.393^{bc}	2.588^{bd}		
	D 3	2.625^{bd}	1.393^{bc}	2.693^{bd}		
Fertilizer Mean		2.554^{b}	1.393^{c}	2.673^{a}	C.V% 14.46	

Means in each column having the same latter's are not significantly different at 0.05 level of probability, according to the Duncan s Multiple Range Test.

Phosphorus

Table 4 and 5 showed a significant ($P \leq 0.05$) effect of time and fertilizer on P% in the plant: phosphorus content in T2 (0.237%) was higher than that in T1 (0.226P %) and T3 (0.224 P%) for urea and ammonia, respectively. In first season ,whereas **,**no significant effect of timeof application and fertilizer on P% in plant:phosphorus content in T2 (0.256%) was slightly higher than that T1 (0.240 P%) and T3 (0.241P%) for urea and ammonia, but the mean effect is not statistically significant, in the second season.

Tables 4 and 5 also show no significant difference of depth of application on phosphorus % in the plant, for both seasons. In the first season, the main effect of both fertilizers was significantly different from the control which gave 0.213P% in the plant as compared to 0.250 and 0.280% given by ammonia and urea. Whereas, in the second season, the mean effect of fertilizers increase from 0.238% and 0.242% for D1and D3, respectively, to 0.253% in D2, but the difference not significant. The main effect of both fertilizers was not significantly different from the control which gave 0.243P% in the plant as compared to 0.280 and 0.260P% given by ammonia and urea.

Table 4: Effect of time, depth of application and fertilizers on P % in *the first season*

Time	Depth	Ammonia	Control	Urea	Time means	Depth means
T1	D 1	0.218^{a}	0.213^{a}	0.263^{bc}	0.226^{b}	D 1=0.230^{a}
	D2	0.230^{abc}	0.213^{a}	0.243^{ab}		
	D 3	0.230^{abc}	0.213^{a}	0.213^{ab}		
T2	D 1	0.248^{ac}	0.213^{a}	0.240^{ac}	0.237^{a}	D 2=0.230^{a}
	D 2	0.250^{abc}	0.213^{a}	0.260^{cb}		
	D 3	0.220^{ac}	0.213^{a}	0.280^{c}		
T3	D 1	0.220^{abd}	0.213^{a}	0.245^{abcd}	0.224^{b}	D 3=0.228^{a}
	D 2	0.225^{abd}	0.213^{a}	0.223^{abd}		
	D 3	0.230^{abd}	0.213^{a}	0.238^{abd}		
Fertilizer Mean		0.230^{b}	0.213^{c}	0.245^{a}	C.V% 8.28	

Means in each column having the same latter's are not significantly different at 0.05 level of probability, according to the Duncan s Multiple Range Test.

Table 5: Effect of time, depth of application and fertilizers on P % in the second season

Time	Depth	Ammonia	Control	Urea	Time means	Depth means
T1	D 1	0.225^{a}	0.243^{a}	0.245^{a}	0.240^{a}	D 1=0.238^{a}
	D2	0.233^{a}	0.243^{a}	0.523^{a}		
	D 3	0.230^{a}	0.243^{a}	0.248^{a}		
T2	D 1	0.225^{a}	0.243^{a}	0.253^{a}	0.256^{a}	D 2=0.253^{a}
	D 2	0.280^{a}	0.243^{a}	0.215^{a}		
	D 3	0.233^{a}	0.243^{a}	0.260^{a}		
T3	D 1	0.238^{a}	0.243^{a}	0.230^{a}	0.241^{a}	D 3=0.242^{a}
	D 2	0.233^{a}	0.243^{a}	0.258v		
	D 3	0.220^{a}	0.243^{a}	0.260^{a}		
Fertilizer Mean		0.235^{a}	0.243^{a}	0.266 a	C.V% 8.34s^{a}	

Means in each column having the same latter's are not significantly different at 0.05 level of probability, according to the Duncan s Multiple Range Test.

Potassium

Tables 6 and 7 showed a significant ($P \leq 0.05$) effect of time of application on K% in the plant in both seasons: as shown in the tables 6 and 7, the potassium content in T2(2.143%) was higher than that T1(2.031%K) and T3 (2.113%K) for urea and ammonia and potassium content in T2 (2.325%) was higher than that in T1(2.191K%) and in T3 (2.178K%) for both urea and ammonia in first and second season respectively.

Table 6: Effect of time, depth of application and fertilizers on K % in the first season

Time	Depth	Ammonia	Control	Urea	Time means	Depth means
T1	D 1	2.093^{a}	1.713^{b}	2.113^{c}	2.031^{b}	D 1= 2.069^{b}
	D2	2.183^{a}	1.813^{b}	2.158^{c}		
	D3	2.225^{a}	1.813^{b}	2.175^{c}		
T2	D 1	2.288^{a}	1.813^{b}	2.313^{a}	2.143^{a}	D 2=2.092^{ab}
	D 2	2.350^{a}	1.813^{b}	2.288^{ac}		
	D 3	2.263^{a}	1.813^{b}	2.350$_{ae}$		
T3	D 1	2.253^{a}	1.813^{b}	2.225^{ac}	2.113^{a}	D 3=2.126^{a}
	D 2	2.275^{a}	1.813^{b}	2.138^{ac}		
	D 3	2.300^{a}	1.813^{b}	2.385^{ac}		
Fertilizer Mean		2.248^{a}	1.801^{b}	2.238^{a}	C.V% 6.58	

Means in each column having the same latter's are not significantly different at 0.05 level of probability, according to the Duncan s Multiple Range Test.

Table 7: Effect of time, depth of application and fertilizers on K % in the second season

Time	Depth	Ammonia	Control	Urea	Time means	Depth means
T1	D 1	2.163[a]	1.925[b]	2.388[d]	2.191[b]	D 1= 2.185[b]
	D2	2.275[a]	1.925[b]	2.455[d]		
	D3	2.325[a]	1.925[b]	2.338[d]		
T2	D 1	2.423[c]	1.925[b]	2.403[d]	2.325[a]	D 2=2.242[a]
	D 2	2.500[c]	1.925[b]	2.575[c]		
	D 3	2.600[c]	1.925[b]	2.648[c]		
T3	D 1	2.225[a]	1.925[b]	2.288[a]	2.178[a]	D 3=2.268[a]
	D 2	2.290[d]	1.925[b]	2.305[a]		
	D 3	2.313[a]	1.925[b]	2.410[adc]		
Fertilizer Mean		2.346[b]	1.925[c]	2.423[a]	C.V% 4.30	

Means in each column having the same latter's are not significantly different at 0.05 level of probability, according to the Duncan s Multiple Range Test.

Tables 6 and 7 also show a significant ($P \leq 0.05$) difference between depths of application on potassium % in plant in both seasons: potassium generally increased in the plant with increasing depth of application for both urea and ammonia, as D3 significantly was better than D1and D2. The mean effect of fertilizers is increase from 2.069% and 2.092% for D1 and D2 to 2.126K% in D3, in the first season. Whereas in the second season, the mean effect of fertilizers increased from 2.185% and 2.242% for D1and D2, respectively, to 2.268K% in D3.

Discussion

Nitrogen

Both NH_3 and urea fertilization gave significant increases in the N% content from deficiency in the control (1.45%) to sufficiency on addition of 80KgN/ha for both fertilizers. The arid soils are encountered are deficient in N due to their low content of organic matter worldwide, Similar low amounts of organic matterin most arid soils of the Sudan [12-13]. It is clear that the unfertilized control soil was deficient in nitrogen as the N% in the whole sorghum plant was about 1.45%. Fertilization with 80kg N%/ha by both ammonia and urea brought N% content to 2.6% which is considered sufficient [22]. This sufficiency may be related to a significant increase in the fresh and dry matter yield as compared to the control (Data not shown). It is clear that the time of application produced no significant effect upon the nitrogen% content in soil at the end of the sowing season. The soil under cultivation (Table 1) is clay soil and it is not expected to lose significant N by leaching. Also, the loss of nitrogen by ammonia volatilization may be low under the wet irrigated conditions. It seems that the effect of time of application may be due to providing higher nitrogen concentration at times of critical demand for N by the plant.

On the other hand depth of application of both ammonia and urea produced significant effects on N% content. D3 produced the highest N % content. The deeper the fertilizer application will provide higher moisture content, lower temperature and a larger soil fertilizer contact values. All these factors are known to reduce nitrogen loss by ammonia volatilization. With respect to nitrogen source, similar results were reported by Mason and Rowley, (2003) when they applied N as either anhydrous ammonia or urea to wheat plant and obtained increased yield by both fertilizers but, with no significant difference in yield between the treatments. In efficiency of aqueous ammonia as fertilizer when compared with urea, Mason and Rowley, (2003) reported positive significant influence over the control of nitrogen on crop yield and yield of components of *Sorghum bicolor* L. irrespective of the nitrogen source used, which in this trial, using aqueous ammonia or urea. Thus, the results of this experiment and research others elsewhere positively compare aqueous ammonia with urea, effects on crop growth [22-24].

Phosphorus

Effect of nitrogen fertilizer application on P content (P% content) in sorghum is shown Tables 4 and 5. It is clear that there is a positive interaction between nitrogen fertilizer and phosphorus content in plant in both seasons. It is known from the literature that phosphorus is effected by soil pH, climatic conditions, amount of N and P and yield potential. These factors may be related to phosphorus use efficiency (PUE) and on plant phosphorus content in sorghum. The result of the present experiment agreed with Cayley *et al.* (1998) who found that nitrogen responses increased with increasing fertility of the soil [25]. A significant interaction between N and P application was observed by Eghball and Sander, (1989) for both seven- leaf and ear – leaf stages of corn indicating that at least up to silking adequate N supply was important for plant to utilize P. Miller, (1974)

reported that nitrogen can increase phosphorus contents in plant by increasing the ability of roots to absorb and translocate P, and by decreasing soil pH as result of NH_4 and thus, increasing solubility of fertilizer P [25-27]. Also he found that P X N interaction for corn illustrated interactive effects of nitrogen and phosphorus in yield, and leaf nitrogen and phosphorus content of corn growth. The highest yield was obtained at the highest rates of N and P. Sumner and Farina, (1986) found that nitrogen stimulated the uptake of phosphorus and *Vice versa* because increased growth requires more nutrient to maintain tissue composition within acceptable limits [28]. Mutually synergistic effects as shown here for N and P promote growth even more. The economic importance of interactions such as these become clear in less developed areas where fertilizers are in short supply, costs are high and soils are frequently deficient in N and P. Recently Kassem, (2012) reported that amount of P leave increase in date palmdue to application of nitrogen fertilizer [28].
And the anhydrous ammonia increased significantly values of P content of grain rice, straw rice yield compared to urea fertilizer [24]. Addition to these the P contents in broccoli [23]. Sorghum is grown in the present experiment and thus positive P and N interaction found is expected and supported by the literature cited above.

Effect of nitrogen fertilizers on %K content in plant:
Effect of nitrogen fertilizer application on potassium content (% K content) in sorghum shown (Table 6 and 7). It is clear that a positive interaction between nitrogen fertilizer and potassium content in plant is obtained in both seasons. The results of the present experiment agreed with MacLeod (1969) that nitrogen and potassium are macronutrients which are required in greatest quantity for most plants [28]. Consequently, availabilities vary greatly in soils which have been cropped over extended periods. Interaction having economic significance occurs when one of these two nutrients in present at near deficiency levels, and the other at high or toxic level. MacLeod,(1969) found the importance of K in promoting barley grain and straw yield response's to N in hydroponic culture together with depressive effect at different levels. Also, he reported interactive effects of nitrogen and potassium supply on barley grain and straw yield [29]. Kemp (1983) found that the effect of increasing nitrogen bioavailability on tissue potassium concentrations depends on potassium bioavailability in the root zone. Under the condition of high K availability, increasing nitrogen supply increases potassium concentration and uptake, whereas, without potassium application, potassium concentrations decrease at high nitrogen rates because of growth dilution or another limiting factor into plant. Increasing nitrogen supply enhances growth, and consequently, increases the demand for the other nutrient. This demand can translate into plant concentrations less or greater than that needed for sufficiency, depending on the nutrient supply in the root zone [30]. Many searchers have been reported a positive interaction between N and k [23-24, 31]. In consistence with the results reported, Wilson (1993) confirmed the generalization that the response to a nutrient depends on the sufficiency level of another nutrient [32].

Conclusions
Waste ammonia damage to human health and/or environment can be reduced by suitable application of NH_3 in soil as fertilizer for forage sorghum and possibly for other crops.
Aqueous ammonia as fertilizer used should be applied when the soil is relatively wet at a depth 10-15cm, and in this case it is as efficient as urea in terms of N content in sorghum and increase in crop yield.
The best time of nitrogen fertilizer application was found during the stable period of rapid growth and hence rapid crop uptake, two weeks after sowing, according to the result of this study.
Stop disposing of NH_3 by dumping in desert land and use it as nitrogenous fertilizer at least for forages.
Stop atmospheric burning of NH_3 as this forms nitrogen oxide harmful to environment and human health.

References
[1]. Ahmed, I. A.M. Eltilib, A. M.A. Ganawa, F. H.S. Erenoglu, E.B. and Islam, K.R.(2016) Utilization of industrial waste aqueous ammonia for irrigated forage sorghum production, Archives of Agronomy and Soil Science. 62(1): 93-107.
[2]. Wang, S.H., Zhu, Y. Jiang, H.D, and Cao, W.X. (2006) Positional differences in nitrogen and sugar concentrations of upper leaves relate to plant N status in rice under different N rates. Field Crops Research. 96: 224-234.
[3]. Mallarino, A.P., and Higashi, S.(2009) Assessment of potassium supply for corn by analysis of plant parts. Soil Science Society of America Journal. 73: 2177-2183.
[4]. De Datta, S.and Mikkelsen, D.(1985) Potassium nutrition of rice. Potassium in Agriculture.665665–699.699. ASA-CSSA-SSSA, USA .
[5]. Evans, J. R. (1983) Nitrogen and photosynyhesis in the flag leaf of wheat (Triticumaestivum L.). Plant Physiology. 72: 297-302.

[6]. Tremblay, N., Fallon, E., and Ziadi, N. (2011) Sensing of crop nitrogen status: Opportunities, tools, limitations, and supporting information requirements. H*orticultural Technology.* 21: 274-281.
[7]. Mu-oz-Huerta, R.F., Guevara-Gonzalez, R.G., Contreras-, L.M., Torres-Pacheco, I., Prado-Olivarez, J., and Ocampo-Velazquez, R.V. (2013). A review of methods for sensing the nitrogen status in plants: advantages, disadvantages and recent advances. Sensors. 13:10823-10843.
[8]. Arai, Y. and Sparks, D.L. (2007) Phosphate reaction dynamics in soils and soil minerals: a multiscale approach.*Advances in Agronomy*.94: 135-179.
[9]. Elsheikh, M.A., Abidin, Z. Matsue, N. and Henmi, T. (2008) Competitiveadsorption of oxalate and phosphate on allophane at low concentration. Clay Science.13 (6)**:**181-188.
[10]. Yao, Y. A., Sun, H. Y., Xu, F. S., Zhang, X. J., and Liu, S. Y. (2011)Comparative proteome analysis of metabolic changes by low phosphorus stress in two *Brassica napus* genotypes. Planta *.233: 523-537.*
[11]. Yang, T. Zhang, S. Hu, Y. Wu, F. Hu, Q. Chen, G. Cai, J. Wu, T. Moran, N. Yu, L. et al., (2014).*The role of OsHAK5 in potassium acquisition and transport from roots to shoots in rice at low potassium supply levels*. Plant Physiology. 166: 945-959.
[12]. Buursink, J. (1971) Soils of Central Sudan. Ph. D. thesis, State University Utrecht.
[13]. Elamin, A. E.and Elagib, M. A. (2001) Comparative study of organic and inorganic fertilizers on forage corn (Zea mays L.) grown on two soil types. Qatar University Sciences Journal. 21: 47-54.
[14]. Adam, I.A. and El Mahi, Y. E.(2012)Transformations of wasteaqueous ammoniain soil. Peace University Journal. 2:139-154.
[15]. Whiteman, A.J. (1971) The geology of the Sudan Republic. Clarendon Press, Oxford, UK, 290.
[16]. El Tayeb, A. I.(2005).Environmentally safe disposal in soil of waste ammonia produced by Khartoum Refinery, Sudan. D. Thesis, Faculty of Agriculture, U of K.
[17]. Hesse, P.R. (1971) A text book of soil chemical analysis. William Clowes and Sons Limited London, Baccles and Colchester, UK.
[18]. Richards, I.A. (1969) Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Hand Book No. 60. United State Salinity Laboratory Staff. United States of America.
[19]. Ryan, J., Estefan, G. and Rashid, A. (2001) Soil and Plant Analysis Laboratory Manual. International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria.
[20]. Jackson, M.L.(1958) Soil Chemical Analysis. Consable and Co. LTD. London: 183- 203.
[21]. Gomez, K.A. and Gomez, A.A. (1976). Statistical Procedures for Agricultural Research with emphasis on rice.The International Research Institute. LosBaños Philippines.
[22]. Mason, M. G. and Rowley, A.M. (2003). The rate of anhydrous ammonia and urea applied to wheat crop belt of Western Australia .Australian Journal of Experimental Agriculture and Animal Husbandry 9 (41): 630-635.
[23]. Yildirim, E., Guvenc, I., Turan, M., and Karatas, A., (2007). Effect of foliar urea application on quality, growth, mineral uptake and yield of broccoli (Brassica oleracea L., var. italica). *Plant Soil* and *Environment.* 53(3); 120-128.
[24]. Osman, E.A.M, EL-Masry, A.A, and Khatab, K.A. (2013) Effect of nitrogen fertilizer sources and foliar spray of humicand/or fulvic acids on yield and quality of rice plants. Advances in Applied Science Research. 4(4):174-183.
[25]. Caley, J., McCaskill M., Montgomey J., Lewis B., and Scholz T. (1998) Pasture response to nitrogen in late winter depends on phosphorus. Proceeding from the Victorian Grassland Association 39: 149.
[26]. Eghball, B. and Sander, D.H. (1989) Band spacing effect of dual-placed nitrogen and phosphorus fertilization on corn. Agronomy Journal. 81 (2): 178-184.
[27]. Miller. M.H.(1974) Effect of N on P absorption by plant. In E.W. Carson (ed.). The Plant Root and its Environment. ProceedingsInstitute, Southern Regional Education Board, Virginia Polytechnic Institute and State University, 5-16.1971 .University Press of Virginia. Char lottesville. VA.,643- 683.
[28]. Sumner, M. E. and Farina, M.P.W.(1986) Phosphorus interaction with other nutrients and lime in field cropping systems. Advances in *Soil Science*.5:201- 236.
[29]. MacLeod , L. B.(1969)Effect of N, P and K and their interaction on the yield and kernel weight of barley in hydroponic culture. Agronomy Journal .61: 26 -29.
[30]. Kemp,A.(1983)The effect of fertilizer treatment of grassland on the biological availability of magnesium to ruminants.143-157. In. J. P. Fontenot, G.E. Bunce, K. E.Weeb, Jr V.G. Allen (ed.). Role of Manisium in Animal Nutrition. VPISU. Blaks - burg. VA.
[31]. Kassem, H. A.(2012) The response of date palm to calcareous soil fertilization. Journal of Soil Science and Plant Nutrition:12 (1): 45-58.
[32]. Wilson, J.B. (1993) Macronutrient (N P K) Toxicity and Interactions in the Grass *Festucaovina, Journal* of *Plant Nutrition*.16: 1151-1159.