Response of tomato to some fertilization recipes under Gezira conditions

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Abstract

Response of tomatoes (Lycopersicon esculentum Mill.) to some fertilization recipes including different sources of soil added nitrogen and foliar sprayings with ADB liquid fertilizer was evaluated in a field experiment on El Remeitab benchmark soil series of Gezira Vertisols, during the 2003-04 and 2004-05 winter seasons. Fertilization recipes varied in their effect on increasing tomato total and marketable yields. Irrespective of nitrogen source, moderate levels of soil added fertilizers(43 kg N/ha) supplemented with four sprayings of ADB at moderate concentration (325 ml/100 litres of water) resulted in similar yield increases as those of the higher nitrogen level (86 kg/ha). At the moderate nitrogen level supplemented with ADB, ASN and AS statistically out-performed NPK and urea. Economically the same two recipes proved to be more cost effective and profitable than all other recipes. Urea, however, at the high nitrogen level produced acceptable returns at a lower cost. Hence, the three recipes are proposed for recommendation as other fertilization options for tomato growers in the Gezira. Some evidences that ASN slightly depressed the fruit sugar content were discussed as well.

Introduction

Horticultural crops (vegetables and fruits) have for long time been considered as luxury food in Sudan as well as in other parts of Africa. They have been mainly consumed by the expatriate population. Therefore, small-scale farms scattered around major cities and along the River Nile constitute the bulk of production area. However, in the last two decades, shortages in food supply linked to expanding urbanization and increase in the general awareness of the importance of a balanced healthy diet, resulted in escalating demand for horticultural products. Moreover, globalization opened avenues for export of horticultural crops and products, particularly tomato paste, to European, COMESA Group and Arab markets. To meet the rising needs, production of horticultural crops, mainly onion and tomatoes, started to expand inside the irrigated schemes of central Sudan.

Soils of these schemes are mostly vertisolic in nature according to the U.S. Soil Taxonomy (Soil Survey Staff, 1999). They are characterized by high clay content (54 – 65%), moderate alkalinity (pH 8 – 8.4) and low chemical fertility status. Nitrogen and available phosphorus are predominantly low, whereas indications of potassium deficiency are detected in the colluvial alluvial vertisols of Rahad Scheme. At current conditions, they are evaluated as moderately suitable land for irrigated agriculture (El Tom, 1972; El Sharif, 1992; SMSS-USDA/SSA, 1982).

Tomato yield is relatively low in these schemes as compared to the average yield in Sudan (Faki et al., 1994) and similar production systems of Africa. For optimum and economic yield carefully studied balanced fertilization regimes should be adopted.

Nutritional programs of vegetables in Sudan, since 1960, depend mostly on urea as a fertilizer to provide a single element; nitrogen. However, there is no established

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fact about the response of tomato yield to added urea nitrogen in Sudan. Some reports stated that nitrogen fertilization did not affect tomato yield to appreciable degree and its effect is limited only to the vegetative stage (Taha, 1984, Hassan, 1978). Recently some reports indicated a positive response to urea and other nitrogenous fertilizer forms including foliar fertilizer formulations (Abu-Sarra et al., 2001 and Ahmed et al., 1992).

Worldwide, tomato yield usually increases with moderate dressing of nitrogen (Azzam and Samuels 1964, Garrison et al., 1967 and Adams, 1986). Wilcox (1964) found no response to nitrogen applied before planting, whereas Reeve et al., (1962) reported little response of field grown tomatoes to supplementary nitrogen dressing. Nevertheless, a high response to nitrogen was noted for field grown tomatoes suffering from considerable weeds competition (Garrison et al., 1967). Heavy applications of nitrogen were reported to depress the yield of the tomato crop (Adams ,1986).

Numerous reports stated that nitrogen uptake, by vegetables and other crops, from urea is inefficient in alkaline soils (Terman, 1979; Ayoub, 1984; Mengel and Kirkby, 1982). Volatilization as NH_3 among several other mechanisms, were reported to cause severe losses from the applied urea-N in the Gezira soils (Ayoub, 1984; Ali et al., 1990). Tomato growers apply as much as 380 - 440 kg N/ha to Gezira soil equivalent to 830 – 950 kg urea perhaps to compensate for these losses.

The inputs for vegetable production in Sudan are generally imported by the private sector. In the past decade the private sector started introduction of different forms of compound fertilizers that include soil and foliar applied formulations. The introduced formulations are proposed to meet the demand of the expanding vegetable production in the irrigated schemes of central Sudan as well as in other production areas. The purpose of the current trial, therefore, is to formulate balanced fertilization recipes using the different nitrogen sources and foliar sprayings with the intention of boosting tomato yield and quality in the Gezira, central Sudan and to reduce the environmental hazards resulting from excessive use of soil applied fertilizers through the adoption of more efficient and cost effective fertilization technologies.

Material and methods

Liquid NPK (8:8:6) fertilizer manufactured by ADB Spezialdůnger GmbH & Co KG, Germany and supplied by Gaddris Trade Co. Ltd, Khartoum North, Sudan, was tested for tomato yield promotion in the Gezira. The fertilizer composes of 8% N, 8% P_2O_5, 6% K_2O, 0.001% MgO, 0.001% B, 0.002% Fe, 0.001% Cu, 0.001% Mn, 0.005% Zn and 0.005% Mo. Field experiments were conducted in the Horticultural Research Farm of the Gezira Research Station over two consecutive seasons (2003-04 and 2004-05).

Treatment structure comprised the flowing fertilization recipes:

1- Four nitrogen sources (AS, ASN, NPK and urea) each at a level of 86 kg N/ha, applied at two equal doses, three and seven weeks after planting (4 recipes).
2- Half the previous level (43 Kg N/ha) of the four nitrogen sources applied as single dose three weeks after planting supplemented by four sprayings of ADB liquid fertilizer at a concenteration of 325 ml/100 litres of water applied at two weeks intervals starting from the fifth week after planting (4 recipes).
3- Weekly sprayings of three concenterations of ADB (50, 325 and 600 ml/100 litres of water) starting from the third week after planting and continued for 10 weeks (3 recipes).
4- Control, reciving no fertilizer.

The twelve treatments were arranged in a randomized complete block design with four replications. The plot size consited of two raised beds, 120 cm wide and 7 m long and the net harvest area was 7.2 m^2. Seeds of the tomato variety Super Strain B were directly planted in the field in the 4^{th} and 6^{th} of December of the first and second season respectively; at 30 cm in-row spacing at both sides of the raised beds. Plants were thinned to single plant per hole after three weeks prior to fertilizer application. Plots were hand weeded twice and Actara, Bayleton, Topas and Diazinon were used for pests and disease control as recommended by ARTC. Plots were irrigated at 8 – 12 days intervals. Data were collected on growth, yield, yield related characters, quality, nutrients uptake, dry matter accumulation, cost and returns.

Results

Analysis of variance of the tomato total yield combined over the two seasons of the experiment (2003 – 2005), model presented in Table 3, revealed highly significant difference between the seasons, but this was not reflected in the treatment X season interaction. The differences between the effects of the various fertilization recipes on total yield were very highly significant. These effects were partitioned into signal degree of freedom orthogonal contrasts to answer the questions raised as expressed in the objectives of the experiment.

Data indicated that addition of fertilizers is essential for getting higher tomato yield in the Gezira as reflected in the very highly significant (P=<.001) differences shown in table 4. Treatments receiving soil added fertilizers supplemented with foliar or not were significantly (P<.001) superior to those receiving only foliar sprayings. Soil dressed with high nitrogen level (86 kg N/ha) produced tomato yield similar to soil dressed with moderate nitrogen level (43 kg N/ha) supplemented with ADB foliar sprayings.

Partitioning of the effect of the moderate nitrogen level (43 kg N/ha) recipes supplemented with ADB foliar fertilizer revealed that AS and ASN were significantly superior than NPK and urea, whereas the differences between AS and ASN were not significant at P=0.05.

Despite the highly significant difference (P= 0.017) between the two seasons of the experiment, partitioning of the significant treatments effect observed in the two seasons revealed trends resembling each other and similar to that of the combined analysis and this proved the stability of the results across different environments.

Dry matter accumulation as affected by the fertilization recipes is presented in Table 5. Highly significant differences were detected between treatment means. Fertilizer application significantly increased the tomato dry matter accumulation (P= <.001) and soil applied fertilizers supplemented or not with foliar significantly (P= <.001) out-performed the foliar fertilizers when applied alone. No significant differences were detected between recipes containing high nitrogen level and those containing the moderate N level supplemented with ADB foliar fertilizer. Within this last group ASN significantly (P=0.049) out-performed the others.

Results of N uptake closely followed those of total yield and dry matter accumulation (Table 5). Fertilizer application significantly increased nitrogen uptake and soil added nitrogen significantly scored higher values than foliar alone, whereas AS and ASN supplemented with ADB significantly out-performed urea and NPK supplemented with ADB. The N uptake from the high level of soil applied nitrogen was significantly (P=0.005) higher than that of the moderate level supplemented with ADB.

Uptake differences of P_2O_5, among the recipes containing some fertilizers, were not significant at P = 0.05 and only the control showed significantly (P<.001) lower values. On the other hand significantly (P=.001) higher K uptake values were associated with recipes of higher level of soil added N followed by those of the moderate N level supplemented with ADB sprays. Among the last group ASN was associated with significantly (P=.037) higher values of K uptake.

The effects of the fertilization recipes on the yield components of the tomato are depicted in Table 6. Differences were highly significant for marketable yield and fruit number per plant, whereas non-significant differences were observed in average fruit weight. Partitioning the treatment effects for marketable yield and number of fruits produced per plant, revealed trends similar to that of total yield. Therefore, the increase in yield of tomato in response to the tested fertilization recipes can be explained by the differences in number of fruits produced per plant rather than differences in average fruit weight.

Effect of the tested fertilization recipes on growth and quality attributes of tomatoes in the Gezira were depicted in Table 7. Plant canopy as measured by the growth index (average of height and width) and number of leaflets or branches produced per plant, were not significantly affected by the fertilization recipes.

Fruit quality expressed as percent total sugars was significantly (P=0.017) affected by the fertilization recipes and most of the observed variation was found to be due to the effect of ASN containing recipes (Table7).

The value/cost ratio approach was used to assess the profitability of the promising fertilization recipes. The value of the increment in yield due to the treatment is divided by the cost of the treatment and a ratio of 1 means that the increment in yield just cover the cost of the fertilizer application, whereas a ratio of 2 means 100% profit, while a ratio of 10 indicates that fertilizer cost is one tenth of the value of the increase in yield. Results in Table 8 showed that the highest ratio was attained by 43 kg N/ha of ASN supplemented with 3 litres of ADB foliar fertilizer followed by 43 kg N/ha of AS supplemented with 3 litres of ADB, then 86 kg N/ha of urea followed by 43 kg N/ha urea supplemented with ADB and 86 kg N/ha of ASN. The ASN + ADB recipes also fetched the highest net returns per hectare followed by AS + ADB, then the high dose of ASN followed by the high dose of urea.

Discussion

Tomato yield usually increases with moderate application of nitrogen (Azzam and Samuels 1964, Garrison et al., 1967 and Adams 1986). In Sudan there is no established fact about the response of tomatoes to added nitrogen. Some reports stated that nitrogen fertilization did not affect tomato yield to appreciable degree and its effect is limited only to the vegetative stage (Taha, 1984 and Hassan, 1978). Results of the current trial indicated very highly significant yield increases due to nitrogen application (Table 4). This confirmed the early report of Abu-Sarra et al., (2001) and is in harmony with the finding of Adams, (1986), Azzam and Samuels (1964) and Garrison et al., (1967). Failure of previous workers, in Sudan, to detect the significant response of tomato yield to nitrogen application can be attributed to the fact that most of them used urea as nitrogen source only. Urea is well documented to be subjected to excessive nitrogen losses particularly under conditions of high soil pH, high temperature, excessive soil drying and wetting and high clay content (Ayoub, 1984; Ali et al., 1990; Terman, 1979 and Mengel and Kirkby, 1982). Such conditions are prevalent in the Sudan Central Clay Plain. Moreover, application of urea was carried out in the early stage of plant growth and this renders urea-N unavailable to latter crop stages when fruit growth and maturation are actively functioning. Hester and Shelton (1939) reported that of the total 31-40 kg nitrogen absorbed by the tomato plant to produce 10 tons of tomatoes only 1.3 -1.6 kg are taken up in the first month of growth and 8.9-11.1 kg in the second month.

Applications of different formulations of foliar fertilizers as supplements to soil nitrogen were reported to induce significant increases in the yields of vegetables, including tomato, in Gezira, Shambat and Hudeiba Research Stations (Ahmed et al., 1992). Yield increment of up to 116% was achieved. In the present study tomato yield increased significantly with the application of ADB foliar fertilizer and the optimum yield was obtained by the moderate concentration of ADB when applied as supplement to 43 kg N/ha of either ASN or AS (Table 4).

Data in Table 4, also indicated non-significant differences in tomato yields between tested sources of soil applied nitrogen (86 kg N/ha level) except for AS and urea in the first season. This is in agreement with the finding of Abu-Sarra et al., (2001). DE Geus (1967) stated that tomatoes have apparently no market preference for either nitrate or ammonium nitrogen. Nevertheless, for very alkaline soils, Adams et al (1986) reported that tomato plant weight and fruit yield were much higher with potassium nitrate than with urea, whereas Albasel et. al (1978) obtained 35% increase in tomato yield with calcium nitrate than with urea.

There is great evidence that sulphur containing fertilizers are the most appropriate for tomato nutrition in the alkaline vertisols of central Sudan particularly when supplemented with foliar sprayings. ASN (14% S) and AS (24% S) supplemented with four applications of moderate concentration of ADB significantly out-yielded NPK (3% S) and urea (0% S) supplemented with the same concentration of the same foliar fertilizer (Table 4). Higher tomato yields were also reported for AS and ASN at Gezira, Rahad and New Halfa (Abu-Sarra, et al., 2001). DE Geus (1967) stated that tomatoes seem to have fairly high sulphur requirement and he recommended sulphur containing fertilizers for tomato nutrition in soils with low available sulphur content.

Dry matter accumulation, N and K uptake as affected by the tested fertilization recipes followed similar pattern to that of the total yield, whereas the increase in P_2O_5 uptake was similar for the different fertilizers recipes (Table 5). ASN and AS supplemented with ADB scored the highest dry matter, N and K values among the moderate level of soil added N recipes. This indicated superiority of the two nitrogen sources when foliar ADB is used.

The trial results suggested that the increase in tomato yield in response to fertilizer application can be explained by the increase in fruit number per plant rather than the increase in fruit weight (Table 6). Satti and Abdalla (1984) stated that nitrogen fertilization did not influence the number of flowers formed in the first three trusses and suggested that the role of fertilizers could be manifested in later trusses. A better understanding of the physiological basis of assimilates partitioning for the reproductive and vegetative growth activities and the role of the macro and micronutrients in flower formation and fruit development should provide a clear insight into the production practices that might play a dominant role in tomato yield determination.

Fruit quality of tomato, taste and flavour, is mainly a blend of organic acids and sugars (Stevens, et al., 1979). Light intensity and potassium content during the growing period were reported to have profound effects on tomato sugars and acids (Grierson and Kader, 1986). Except for those of ASN, the tested fertilization recipes showed no effect on total sugars under Gezira conditions (Table 7). Slight (0.3 – 0.5%) but significant decline in sugars percentage was detected for the two ASN recipes. This drop in sugars percentage may be explained by the relatively high and efficient N and K uptake observed for the ASN recipes (Table 5) and that may be due to the heavier fruiting load associated with the high yield obtained by this recipes.

Heavy N application was reported to depress the sugars content in tomatoes (Grierson and Kader, 1986).

Economic analysis indicated that application of ASN + ADB gave the highest net returns followed by AS + ADB. The use of these two recipes is highly profitable as shown by the high value/cost ratios of 17:1 and 15:1 for the two recipes respectively. This means that the costs of the two recipes amounted only to seventeenth and fifteenth of the values of their respective increments in tomato marketable yields. Urea at the high nitrogen level presented fairly low cost and the third highest value/cost ratio (10:1) and acceptable net returns. Hence, it may provide a suitable alternative for some farmers.

Recommendations

On the basis of the statistical analysis and the economic evaluation of the experiment's combined results as discussed before, the following recommendations are proposed as other fertilization options for the tomato growers in the Gezira:

First option: ASN at 43 kg N/ha + 3 L ADB foliar fertilizer**.**

This recipe increased tomato yield by 78% compared to the control and showed the highest increment in net returns and the highest value/cost ratio. ASN should be applied three weeks after planting and ADB at concentration of 325 ml/100 litres of water as four sprayings at two weeks intervals starting from the fifth week after planting**.**

Second option: AS at 43 kg N/ha + 3 L ADB foliar fertilizer.

This recipe increased tomato yield by 66% compared to the control and showed the second highest increment in net returns and the second highest value/cost ratio. AS and ADB should be applied in a similar way as ASN and ADB in the previous recipe.

Third option: Urea at 86 kg N/ha.

This recipe increased tomato yield by 40% compared to the control and showed the fifth highest increment in net returns and the third highest value/cost ratio. Urea should be applied in two equal doses, three and seven weeks after planting.

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Table 1. Soil chemical and physical properties of the Gezira benchmark El-Remeitab soil series*

Chemical Properties:			Physical Properties:	
% $CaCO_3$		3.7	% clay	54
ECe (dS/m):	0-30 cm	0.7	Air Dry Bulk Density (gm/cm^3)	1.71
	30-90 cm	3.7	Coefficient of linear extensibility (COLE)	0.14
ESP:	0-30 cm	6	Hydraulic Conductivity (cm/hr)	0.24
	30-90 cm	12	Wetting Front (cm)	25
pH –Paste		8.1	Avail. Water Cap. (cm):	
% O.C.		0.360	0-30 cm	6.24
% N		0.039	30-120 cm	19.84
Available P (mg P/kg soil)		2		
Ext. K [cmol (+)/kg soil]		0.89		
CEC [cmol (+)/kg soil]		54		
Soluble Anions (meq/L)				
SO_4^{-2}		0.8 – 74.2		
NO_3^{-1}		2.1 – 11.5		

* (Fine, smectitic, isohyperthermic Chromic Haplusterts).
Source: El Tom (1972); El Sharif, (1992); and SMSS-USDA/SSA, (1982).

Table 2. Metrological Data for Gezira in the period 2003 to 2005 winter seasons

Season/ Month		Temperature (°C)			RH (%)
		Mean Max.	Mean Min.	Mean	
2003-04					
	Nov	38.1	20.2	29.2	45
	Dec	35.3	15.9	25.6	45
	Jan	33.9	15.6	24.8	39
	Feb	34.9	16.6	25.8	36
	Mar	39.2	19.3	29.3	28
2004-05					
	Nov	38.1	20.1	29.1	40
	Dec	33.8	16.6	25.2	45
	Jan	32.3	13.9	23.1	37
	Feb	38.8	20.7	29.8	40
	Mar	39.5	19.9	29.7	29

Source: Gezira Met. Station.

Table 3. Analysis of variance for tomato total yield (t/ha) combined over years 2003 - 2005 at the Gezira Research Station.

Source of Variation	df	ss	ms	Prob.
Season (S)	1	628.5	628.5	0.017
Residual	6	355.7	59.3	
Fertilization Recipes (FR)	11	872.5	79.3	<.001
Some vs Nothing	1	226.1	226.1	<.001
Soil vs Foliar	1	214.7	214.7	<.001
Soil (only) vs soil + Foliar	1	3.0	3.0	0.482
(Soil + Foliar)				
AS + ASN vs Others	1	197.5	197.5	<.001
AS vs ASN	1	8.1	8.1	0.247
S x FR	11	47.0	4.3	0.714
Residual	66	390.9	5.9	
Total	95	2294.6		

Table 4. Total yield (t/ha) of the tomato cultivar "Super Strain B" as affected by some fertilization recipes at the Gezira Research Station, seasons 2003–05

Fertilization Recipes	Seasons		Combined	% increase over Check
	2003-04	2004-05		
86 kg N/ha				
AS	13.1	18.7	15.9	31
ASN	17.9	23.2	20.5	69
NPK	19.0	24.5	21.7	79
Urea	13.7	20.2	17.0	40
43 kg N/ha + 3 L ADB				
AS	16.8	23.5	20.1	66
ASN	18.8	24.3	21.5	78
NPK	14.5	17.0	15.8	31
Urea	14.2	17.8	16.0	32
ADB				
1.2 L/ha	11.5	16.5	14.0	16
7.7 L/ha	13.2	20.4	16.8	39
14.3 L/ha	13.0	15.9	14.4	17
Control	9.4	14.7	12.1	-
Mean	14.6	19.7	17.2	
Significance	***	***	***	
CV%	14.4	15.1	14.2	
SE (±)	1.05	1.49	0.86	

*** Significance at P = 0.001.

Table 5. Dry mater accumulation and N, P (P_2O_5) and K uptake 0f the tomatoes cultivar "Super Strain B" as affected by some fertilization recipes at the Gezira Research Station, season 2004-05

Fertilization Recipes	**Dry matter (t/ha)**	**Uptake (kg/ha)**		
		N	**(P_2O_5)**	**K**
86 kg N/ha				
AS	5.55	131	32	186
ASN	5.59	134	30	191
NPK	5.91	146	40	186
Urea	5.11	124	29	185
43 kg N/ha + 3 L ADB				
AS	5.34	122	28	147
ASN	6.01	135	31	176
NPK	4.97	104	42	135
Urea	4.99	109	31	136
ADB				
1.2 L/ha	3.92	79	28	86
7.7 L/ha	4.10	81	30	113
14.3 L/ha	5.20	124	41	126
Control	2.79	56	20	79
Mean	4.95	112	32	145
Significance	***	***	***	***
CV%	13.6	11.3	12.7	17.1
SE (±)	0.389	7.3	2.3	14.4

*** Significance at P = 0.001.

Table 6. Yield components of tomatoes cultivar "Super Strain B" as affected by some fertilization recipes at the Gezira Research Station, season 2004-05

Fertilization Recipes	Marketable Yield (t/ha)	Fruits/ plant (No.)	Fruit wt. (g)
86 kg N/ha			
AS	14.7	10.0	76
ASN	18.6	10.6	77
NPK	19.6	11.0	73
Urea	16.0	10.4	72
43 kg N/ha + 3 L ADB			
AS	18.4	12.6	64
ASN	19.4	13.1	78
NPK	13.5	8.4	67
Urea	14.0	9.9	62
ADB			
1.2 L/ha	12.9	7.7	70
7.7 L/ha	16.0	10.0	67
14.3 L/ha	12.5	7.8	73
Control	11.6	7.4	67
Mean	15.6	9.9	71
Significance	***	***	Ns
CV%	15.4	19.6	14.2
SE (±)	1.20	1.37	5.0

*** Significance at P = 0.001; Ns = not significant at P = 0.05.

Table 7. Growth and quality parameters of tomatoes cultivar "Super Strain B" as affected by some fertilization recipes at the Gezira Research Station, season 2004-05

Fertilization Recipes		Growth index	leaflets/ plant (No.)	Branches/plant	Sugar (%)
86 kg N/ha					
	AS	33.0	168	6	5.1
	ASN	33.2	161	7	4.6
	NPK	38.7	195	7	5.2
	Urea	31.1	177	7	5.3
43 kg N/ha + 3 L ADB					
	AS	38.8	203	7	5.4
	ASN	33.3	179	7	4.8
	NPK	36.1	176	6	5.4
	Urea	30.0	171	7	5.4
ADB					
	1.2 L/ha	36.2	174	7	4.6
	7.7 L/ha	36.2	163	7	5.5
	14.3 L/ha	34.1	166	8	5.3
Control		32.8	156	6	5.1
Mean		34.4	174	7	5.1
Significance		Ns	Ns	Ns	**
CV%		11.8	16.2	22	7.7
SE (±)		2.03	19.9	1.1	0.20

** Significance at P= 0.01. Ns = not significant.

Table 8. Value/cost ratio analysis for the promising fertilization recipes at the Gezira,season 2004-05

Fertilization Recipes	Marketable Yield (t/ha)	Yield Increment			Recipe Cost (SD/ha)	Net Returns* (SD/ha)	Value/ cost Ratio
		(t/ha)	%	Value (SD/ha)			
86 kg N/ha							
AS	14.7	3.1	27	155,000	37,600	117,400	4
ASN	18.6	7.0	60	350,000	37,050	312,950	9
NPK	19.6	8.0	69	400,000	85,560	314,440	5
Urea	16.0	4.4	38	220,000	21,830	198,170	10
43 kg N/ha + 3 L ADB							
AS	18.4	6.8	59	340,000	22,870	317,130	15
ASN	19.4	7.8	67	390,000	22,410	367,590	17
NPK	13.5	1.9	16	95,000	47,576	47,424	2
Urea	14.0	2.4	21	120,000	14,102	105,898	9

*Net return = Increment in total returns due to the application of the recipe concerned only.