Yield Productivity and Energy-Saving Advantages at Applying Slow-Release Nitrogen Fertilizer in Upper Egypt

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Abstract: Two experiments have been conducted in New Valley and Assiut agriculture research stations "*Typic Torripsamments, hyperthermic and Typic Torriorthents*, coarse loamy, hyperthermic" to evaluate the fertilization of two cropping sequences of oil crops (sunflower, safflower and peanut & sesame and canola) with ureaform (UF) as a slow release nitrogen fertilizer (SRNF) comparing with ammonium nitrate (AN) as a conventional one. First sequence: the applied rates of UF-fertilizer have been 45, 67.5, 90, and 112.5 kg N.fed^{-1} added as side banding only at planting the first crop ,Sunflower, followed by safflower planting in the same previous plots and then peanut to determine the residual effect of UF-fertilizer. Ammonium nitrate (AN) has been applied in one rate of 45, 45 and 20 kg N.fed^{-1} (recommended rate) for each crop of the sequence and in the same order. It has been taken as a scale to estimate the performance of UF, in addition to no-fertilized one (Control). Second sequence: UF-fertilizer has been applied in the same rates mentioned in first sequence against the recommended rate of ammonium nitrate (45 kg N.fed^{-1} for each crop) with or without application of clay sediments and control treatment. Yield and its components, Nitrogen & energy consumption ability, net return and investment factor have been recorded. The results show that: (1) Firstly, the UF-fertilizer has almost had strong positive effect on yield and its components for both two cropping sequences. (2) Secondly, calculations of nitrogen-consumption ability have demonstrated that the UF-fertilizer has had much more efficiency at donating its nitrogen than that of AN one where their values at first cropping sequence have been (on average) 70 and 110 kg N. ton^{-1} dry matter (yield) for UF and AN respectively, as well as 92.66 and 158.72 at second cropping sequence. (3) Thirdly, calculations of Energy-consumption ability have illustrated that the saved energy with application of UF-fertilizer to produce one ton dry matter (yield) has been (on average) 36.54% for first cropping sequence and 41.6% for second cropping sequence calculated of those of AN-one. In other words, the saved energy with using UF has been (on average) 83.75 and 105.69, Liter of diesel fuel.ton^{-1} dry matter for first and second cropping sequence respectively which equivalent to 3132.25 and 3952.81 M. Joule or 0.53 and 0.67 barrel of diesel fuel or L.E. 92.13 and L.E.116.26. This would undoubtedly reduce CO_2 emissions, the first accused in global worming case. (4) Fourthly, all treatments have been almost implemented reasonable profitability (IF>3) either at first or second cropping sequences. The economic application of UF has been fulfilled when it hah been applied in high rate and then it is enough to fertilize two crops. It is also observed that added the clay has positively affected net return; however it has not given profitability. In spite of marked superiority of UF-net return value to those of AN, their IF values have been approximated. (5) Fifthly, the cost of consumed energy related to nitrogen fertilization has been reduced to about 1/2 by using UF fertilizer.

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Key words: ureaform; slow release nitrogen fertilizer (SRNF); clay sediments; oil crops; nitrogen-consumption ability; energy-consumption ability

1-Introduction

One of the most important axes of agriculture modernization in Egypt is that related to the application of innovations and new technologies to promote plant productivity and environmental protection. In fertilization field, the use of slow release nitrogen fertilizers (SRNFs) is the most important one of them for environmental reasons representing the reduction of nitrogenous losses from conventional nitrogen fertilizer in forms of seeped nitrate through soil profile into water system, ammonium volatilization and nitrous oxide emission (Horgan et al 2002 and Fernandez et al 2004). Moreover, their application increased the crop yield, Nitrogen use efficiency and net economic return in spite of their higher costs (Abbady et al 2006, Abbady et al 2008 and Abd El-Aal et al 2008) as well as conserved soil fertility (Abbady et al 1999). The response of such fertilizers was more effectively illustrated when they applied on new reclaimed soils where the coarse texture, high infiltration rate, nutrients poverty and its low retention are presented. The used SRNF, here, is the ureaform (UF) which proved its success under Egyptian condition in several works, for example El-Mallah et al,1998, Hegazy et al,1998 and Awaad et al, 2003. Ureaform fertilizers are combinations of various methylene-urea polymers such as methylene-diurea, dimethylene-triurea, trimethylene tetraurea and so on (Abbady, et al, 1992).

The longer the polymer chains, the longer the decomposition period (the slower N-release). Used formula in this paper lasts in soil giving its nitrogen for two consecutive growth seasons.

Energy is nowadays making up serious world problem that the agricultural crops became one of its sources; hence the spent energy in chemical nitrogen fertilizers manufacture must be pointed out. Bhat et al 1994 stated that depending on the type of nitrogen fertilizer produced and the efficiency of process, production of a kilogram of nitrogen requires from 51 to 68 M J of energy (1mega Joule =106Joule).

Goering 1989 demonstrated that a liter of diesel fuel has an energy content of about 37.4 M J. This paper has had the study of cultivating two cropping sequences of oil-crops (sunflower, safflower and peanut & sesame and canola) in new reclaimed soils (New Valley and Assiut) to promote the concept of exploiting such areas to help fill the gab between the domestic production and consumption from edible oil. The main objective of this paper is to determine the suitable rate of UF-fertilizer comparing with AN-one which gives highest productivity and profitability as well as trying to answer the question of: Can energy be saved by using SRNF.

2-Materials and Methods

Two field experiments have dealt with two cropping sequences of oil crops and two forms of nitrogen fertilizer. First experiment has been conducted at agricultural research station of New Valley governorate "*Typic Torripsamments, hyperthermic"**. The cropping sequence has been sunflower (*Helianthus annuus*) Giza, 102 variety, safflower (*Carthamus tinctorius*. L) Giza, 1, and peanut (*Arachis hypogaea L.*) Giza, 6. Second experiment has been conducted at agricultural research station of Assiut "*Typic Torriorthents*, coarse loamy, hyperthermic"*. The cropping sequence has been sesame (*Sesamum indicum*) Shandawel, 3, and canola (*Braaica napus*) Serw, 4. Physical and chemical properties of both two soils have been presented in table 1. The soil analyses have been performed according to Jackson, 1958.The used nitrogen fertilizers have been ureaform (UF) as a slow release nitrogen fertilizer (SRNF) with 40% nitrogen and 60% activity index, prepared by Abbady et al. (1992) and ammonium nitrate (AN, 33%N) as a conventional one which used in official recommended rate representing the standard level to compare the different effects of UF-fertilizer.

In first experiment, UF-fertilizer has been applied in 4 rates; 45, 67.5, 90 and 112.5 kg N.fed^{-1} and added just only before planting first crop (sunflower) in one dose. AN-rate has been applied in one rate split into two doses for each crop; 45, 45 and 20 kg N.fed^{-1} for sunflower, safflower and peanut at the same order, Moreover non-fertilized treatment (control). The experiment has been carried out on a complete randomized design with four replications consisting of 6 treatments.

In second experiment, a spilt plot design has been used. The main plots (a) have been for clay sediments (Table 2) achieved in two treatments 0.0 and 3 ton fed^{-1}. Subplot treatment (b) have come as 45, 67.5, 90 and 112.5 kg N.fed^{-1} of UF-fertilizer used as mentioned in first experiment in addition to AN-one in rate of 45 kg N.fed^{-1} split into two doses for each crop (sesame and canola). Control treatment has been also included. Four replicates for every treatment have been achieved. Then the experiment has consisted of 12 treatments.

For more confirmation, both experiments have been started with first crop followed by second then third which have been planted in the same plots of preceding crop. Recommended rates of calcium super phosphate and potassium sulphate have been applied. Statistical analysis has been carried out according to the procedures outlined by Snedecor and Cochran 1980.

The yield and some yield components of each crop have been recorded. Nitrogen & energy consumption ability calculations and economical analysis have been performed to evaluate the application of UF-fertilizer as a model for SRNFs against conventional one; they have been calculated using the models: 1, 2, 3, and 4 respectively.

- Nitrogen-consumption ability = N-kg.fed^{-1} / yield ton.fed^{-1}……………………………… (1)
- Energy-consumption ability = Liter of diesel fuel.fed^{-1} / yield, ton.fed^{-1} ……………. (2)
- Liter of diesel fuel.fed^{-1} = Quantity of diesel fuel (Liter) required to manufacture 1 kg nitrogen for fertilizer multiplied by N-rate.fed^{-1}

One liter of diesel fuel as an energy = 37.4 M Joule
M Joule =10^6 Joule

- Net return = gross return - total cost…….. (3)
- Investment factor = gross return / total cost (4)

where: Gross return = yield x sale price.

Table 1. Some physical and chemical properties of representative soil samples for the experimental sites

Soil properties	Experiment sites	
	Assiut Exp. Station	New Valley Exp. Station
Sand (%)	66.3	81.5
Silt (%)	28.0	4.00
Clay (%)	5.7	9.84
Texture class.	Sandy loam	Loamy sand
pH (1:1 soil-water suspension).	8.46	7.6
Ec dS/m (1:1 soil-water extract)	0.66	0.58
Soluble cations me 100 g^{-1} soil		
Ca^{+2}	0.31	0.25
Mg^{+2}	0.26	0.22
Na^{+1}	0.09	0.07
K^{+1}	0.01	0.04
Soluble anions me100 g^{-1} soil		
CO_3+ HCO_3	0.31	0.2 2
Cl	0.30	0.30
SO_4	0.07	0.06
Total $CaCO_3$ (%)	17.63	3.3
Total N%	0.041	0.079
$NaHCO_3$ extractable P (mg/kg)	4.35	7.90
NH_4OAC extractable K (mg/kg)	120.9	218.8
DTPA extractable micronutrients (mg/kg)		
Fe.	2.15	4.33
Mn.	1.02	2.00
Zn.	0.34	0.51

Table 2. Some chemical properties of the used clay amendments

Property	pH (1:2.5)	EC (1:2.5) dSm^{-1}	Total Macronutrient %			Available Macronutrient $Mg.Kg^{-1}$			CEC Mme $.100g^{-1}$
			N	P	K	N	P	K	
Value	7.89	7.13	0.02	0.03	0.12	53	12	45	20.50

3-Results and Discussion

Yield, yield components, nitrogen consumption ability (N-CA), energy consumption ability (E-CA) as well as net economic return (NE) and investment factor (IF) of two cropping sequences; sunflower- safflower- peanut and sesame-canola have been studied to determine their affection by application of ureaform (UF) as a slow-release nitrogen fertilizer comparing with conventional one; ammonium nitrate (AN).

3-1- Agronomic appraisal

3-1-1-First cropping sequence

Data listed in Table 3 show that there have generally been significant differences among the yield and its components values affected by different N–treatments. At first crop (sunflower), plant yield, seed index and yield of UF-treatments (on average) have surpassed those of AN-treatment. It is also observed that the yield and its components have gradually increased with increasing UF-N rates. However, the yield of AN-treatment (45 kg $N.fed^{-1}$) has not significantly differed from its corresponding of UF-treatment. At second crop, the results of this crop have not more varied than those of previous crop, however the yield of AN-treatment has approximated with that of UF_2–treatment which has proven that the residual part from UF-fertilizer has certainly managed to nourish another crop. At the third crop, the picture has entirely differed where the yield and its components of UF treatments have been inferior to that of AN-treatment except at UF_4 (its N-rate = 2.5 times of AN-rate). This result has emphasized upon existence of the UF-fertilizer in soil continuously releasing its nitrogen to meet the plant demands and no nitrogen loss has occurred whatever its rate was.

Table 3 Yield, some yield components of first cropping sequence (sunflower, safflower and peanut) and % relative increase calculated of AN-treatment yield as affected by different treatments.

Treatments	Sunflower (first crop)					Safflower (second crop)					Peanut (third crop)				
	N rate Kg.fed^{-1}	Plant yield (g)	Seed Index* (g)	Yield ton.fed^{-1}	Relative Increase %	N rate Kg.fed^{-1}	Plant Yield (g)	Seed Index* (g)	Yield ton.fed^{-1}	Relative Increase %	N rate Kg.fed^{-1}	Seed Index* (g)	Shelling**	Yield Ton. Fed^{-1}	Relative Increase %
Control	0.0	12.0	2.10	0.284	-54.78	0.00	27.7	3.15	0.841	-25.90	00.0	49.2	30.8	0.878	-46.08
AN	45.0	26.6	5.10	0.628	-	45.0	53.3	5.73	1.135	-	20.0	96.1	60.3	1.628	-
UF1	45.0	31.3	6.07	0.580	-07.29	0.00	33.6	5.58	1.081	-4.77	00.0	76.4	53.5	1.253	-23.04
UF2	67.5	36.3	6.45	0.670	06.69	0.00	39.5	7.63	1.128	-0.62	00.0	88.0	52.1	1.305	-19.84
UF3	90.0	47.2	6.80	0.950	51.27	0.00	48.8	8.09	1.346	18.59	00.0	91.2	58.4	1.433	-11.98
UF4	112.5	58.2	7.23	1.026	63.38	0.00	91.0	9.40	1.710	50.66	00.0	91.2	59.7	1.568	-03.69
Means of UF treat		43.25	6.64	0.807	28.51	00.0	53.23	7.68	1.315.8	15.97	00.0	86.7	55.93	1.389	-14.64
L.S.D 0.05		3.8	0.51	0.105			5.0	0.89	0. 20			11.1	3.2	0.56	

* Seed index = weight of 100-seed (g) for each crop

**Shelling % = Seed weight (g) / Pod weight (g)

Table 4 Sum of 1st & 2nd crop yield (summation $_1$) and 1st, 2nd and 3rd crop yield (summation $_2$) (ton.fed^{-1}), % yield relative increase of UF-treatments calculated of AN-treatment yield, yield increased (ton.fed^{-1}), NCA (kg N. ton^{-1} yield), total consumed energy (diesel fuel L. fed$^{-1)}$, ECA (L. ton^{-1} yield).

Treatments	Summation of first and second crop yield data (summation 1)							Summation of first, second and third crop yield data (summation 2)						
	N rate Kg.fed^{-1}	Yield ton.fed^{-1}	Relative increase %	Yield increased ton.fed^{-1}	N-CA kg N. ton^{-1} yield	Consumed Energy diesel fuel L. fed^{-1}	ECA L. fuel. ton^{-1} yield	N rate Kg.fed^{-1}	Yield ton.fed^{-1}	Relative Increase %	Yield increase ton.fed^{-1}	N-CA kgN ton^{-1} yield	Consumed Energy diesel fuel L. fed^{-1}	E-CA L. fuel. ton^{-1} yield
Control	00.0	1.125	-36.19	-	-	-	-	00.00	2.003	-40.93	-	-		
AN	90.0	1.763	-	0.638	141	144	226	110.0	3.391	-	1.387	79	176	127
UF1	45.0	1.661	-05.79	0.536	84	72	134	45.00	2.914	-14.07	0.911	49	72	79
UF2	67.5	1.798	01.98	0.673	100	108	160	67.50	3.103	-8.49	1.100	61	108	98
UF3	90.0	2.296	30.25	1.171	77	144	123	90.00	3.729	9.97	1.726	52	144	83
UF4	112.5	2.736	55.23	1.611	70	180	112	112.5	4.304	26.92	2.301	49	180	78
Means of UF treat.		2.123	20.40	0.998	83	126	132		3.512	3.59	1.510	53	126	85

N-CA = N Kgm.fed^{-1}/ yield, ton.fed^{-1}

E-CA = Consumed diesel fuel liter.fed^{-1} / yield, ton.fed^{-1}

Consumed energy, diesel fuel liter.fed^{-1} = nitrogen rate. Kg.fed^{-1} x 1.6

where 1.6 is the international average of consumed diesel fuel quantity (Liter) to produce one kg nitrogen for fertilizer.

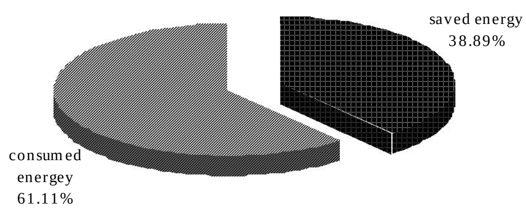


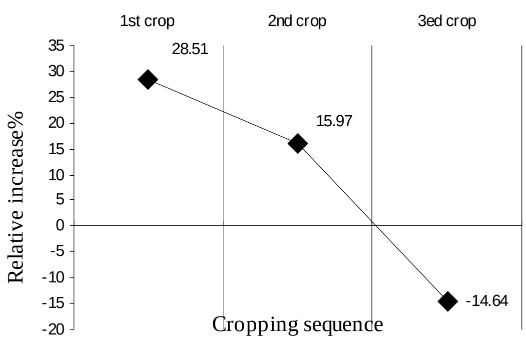
Figure 1 pattern of % relative increase of UF-treatments yield (on average) calculated of AN-treatment yield for first cropping sequence

Relative increase values of UF- treatments yield calculated as percentage of AN- treatment yield (Table 3 and Figure 1) have been amounted (on average) 28.42 for first crop, 15.97 for second and -14.64 for third. Such tendency would have illustrated that no need to plant third crop unless the applied UF was in high rate.

Data given in Table 4 represent comprehensive view for obtained results of first & second crop yield $(\text{summation})_1$ and the same results in addition to third crop results $(\text{summation})_2$. Examination of such two summations has shown that:

Firstly, in spite of magnitude of both yield and yield increased of UF-treatments (on average) at summation_2 comparing to their corresponding at summation_1, their relative increase value (on average) has been very low (3.59%) which has again confirmed that no need to cultivate third crop at application of UF-fertilizer because its residual quantity at this interval (third season), seemingly is not enough to give recompensed yield. These results have been in agreement with those of Abbady et al 2006.

Secondly, the fertilizing role of N-fertilizer could be evaluated by application of nitrogen- consumption ability (N-CA) supposal. It is calculated as in model (1). N-CA (kg $N.ton^{-1}$) = N-rate $kg.fed^{-1}$/yield $ton.fed^{-1}$(1)



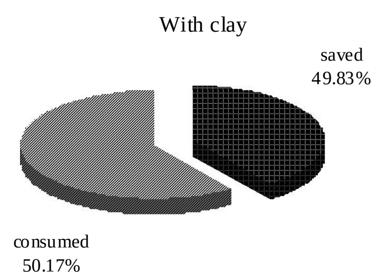


Figure 2 Energetic position at using UF-fertilizer for first cropping sequence

It represents the nitrogen quantity consumed from fertilizer nitrogen to produce one ton of yield. The data in Table 4 also illustrated that N-CA from UF-fertilizer has been less than that from AN-one in both two summations, i.e. the UF-fertilizer has had more efficiency at donating its nitrogen. It is also observed that N-CA values at summation_2 have been less than that at summation_1, due to severe depletion of UF- nitrogen performed by the three crops.

Thirdly, this part has been concerned the energy consumption; according to the reports of Bhat et al 1994 and Goering 1989 as pointed out in the introduction , it can be inclusively concluded that manufacturing one kilogram of nitrogen for fertilizer requires the energy equivalent to from 1.36 to 1.82 liter of diesel fuel. Taking the average value 1.6 to calculate consumed energy ($Liter.fed^{-1}$) as recorded in materials & methods, energy consumption ability (E-CA) could be imitatively calculated to N-CA using the model (2). E-CA ($L.ton,^{-1}$ yield) = consumed energy, Liter of diesel $fuel.fed^{-1}$/ ton $yield.fed.^{-1}$………..… (2)

It is noticed that E-CA (Liter of diesel fuel. ton^{-1}) at using UF-fertilizer (on average) has been much less than that at using AN-one, also their values have been gradually decreased with increasing the N-rate of UF either at summation_1 or at summation_2, this due to increasing obtained yield quantity at those rates. Moreover, E-CA at summation_2 for UF-fertilizer (on average) has been much less than it is (itself) at summation_1.Considering the E-CA of AN-fertilizer (on average) equals 100, then this of UF-one equals 61.11, i.e. the saved energy by using UF has been 38.89% as shown in Fig. 2. In other analysis; the saved-energy by using UF-fertilizer (on average) has been amounted 90.0 and 50.0 L. diesel $fuel.ton^{-1}$ dry matter (sunflower, safflower, peanut) representing 3366 and 1870 M Joule* at summation_1 and summation_2 respectively and those have represented the energy content of 0.57 and 0.32 barrel** or L.E. 99.00 and L.E.55.0

* One Joule is the work done, or energy expended, by a force of one Newton moving one Meter along the direction of the force. ** American barrel = 158.984 Liters

3.1.2. Second cropping sequence

Data presented in Table 5 show that regardless of type and rate of nitrogen fertilizer at first crop, the clay addition has had insignificant effect on seed index and significant one on both plant yield and crop yield. The added clay has increased the $yield.fed^{-1}$ with 25.9%. At second crop, the clay addition has given significant effect on each of plant yield, seed index and $yield.fed^{-1}$; the yield increase has been 10.37%. This is expected because the added clay would improve soil physical and chemical properties specially water holding capacity and cation exchange capacity in addition to its nutrients content. These results are in a harmony with those obtained by Al-Omran et al. 2002 and Suganya and Sivasamy 2006.

Examination of summed up data of the two crops has demonstrated that the added clay has increased the yield by 11.81%, however it has not had effect on averages of yield increased and nitrogen & energy consumption.

About the effect of different treatments, the data show almost significant differences between AN-treatment and UF-ones as well as amongst UF-treatments themselves; at first crop in case of no adding clay, the plant yield, seed index and crop yield values of AN-treatment have nearly equaled to those of UF_1&UF_2 and been inferior to UF_3&UF_4 while in case of adding clay, such estimates of AN-treatment have been inferior to those of UF-treatments. Also, % yield relative increases of UF-treatments calculated of AN-treatment yield (as a standard level) have ranged from -8.79 to 30.78 at no-adding clay and from 14.93 to 32.46 at adding clay. At second crop, the strong superiority for UF-treatments effect (residual part) to AN-treatment (current fertilization) has been evidently shown; the values of plant yield , seed index and crop yield for former have been greater than those of latter. Such effect has dominated either in case of adding clay or not. % yield relative increases have ranged from 5.81 to 22.09 at no- adding clay and from 8.82 to 38.6 at adding clay. As it is appeared, the UF- fertilizer has been more donations for its nitrogen at second crop than that at first one although the second crop has been nourished on the residual part of UF previous-added at first crop planting, this action has emphasized on two facts: 1-The residual part in soil from UF has been sufficient to grow another crop, this result was much obtained before, El-mallah et al., 1998; Awaad et al.2003 and Abbady et al. 2006.

It seems that the adaptations between UF fertilizer and soil microorganisms that are responsible about its breaking-down during first crop growing period have a bit lagged especially, that the applied soil is obviously not enough fertile (Table 1.)

Speculation of the summed up effects of UF and AN-treatments (Table 5) has illustrated that UF treatments have fulfilled high preponderancy in the matter of the studied-estimates comparing with those of AN-treatment; their total yield and its % relative increases have been gradually increased with the N-rate increase. It is worthy to clarify that 90 kg N in form of conventional nitrogen fertilizer (AN) have given yield as much as 45 or 67.5 kg N in form of slow release nitrogen fertilizer (UF).

In regard to N-CA, it is noticed that the values belonging to UF-treatments have been got much lower than that of AN-treatment. Also, using UF has been reduced the consumed - nitrogen (on average) with 31.28% in case of no-adding clay and 49.83% in case of adding clay. This may be due to its improving effect on soil characteristics which would reflect upon plant productivity. Here, it must be pointed out that saving 40.63% (on average) of used nitrogen may promote the application of SRNFs.

The trend of E-CA values of UF-treatments has taken the same as the N-CA trend ; they have been increased with increasing N-rate, however, they have been never exceeded that of AN-treatment, yet the discountable quantity as a percent of that of AN-treatment reached 31.44% in case of no-adding clay and 49.83% in case of adding clay. This has been logically expected because saving nitrogen means saving energy (Figure 3a). For more illustration, to obtain 1 ton of plant product (sesame and canola), the consumed is 254 liter of diesel fuel (on average) at applying conventional fertilizer and 148.27 liter when the SRNF has been applied. The difference is 105.73 liter; this represents 41.63% saved energy (figure 3b) if UF-fertilizer has been in use and equivalent to 3952.81 M Joule or energy content of 0.67 barrel diesel fuel or L.E.113.30.

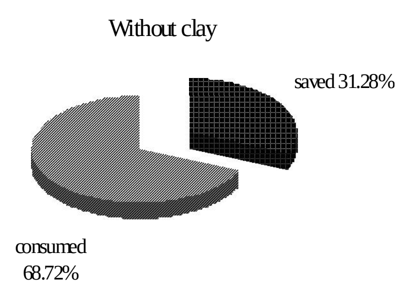


Figure 3a Energetic position at using UF fertilizer as affected by added clay for second cropping sequence

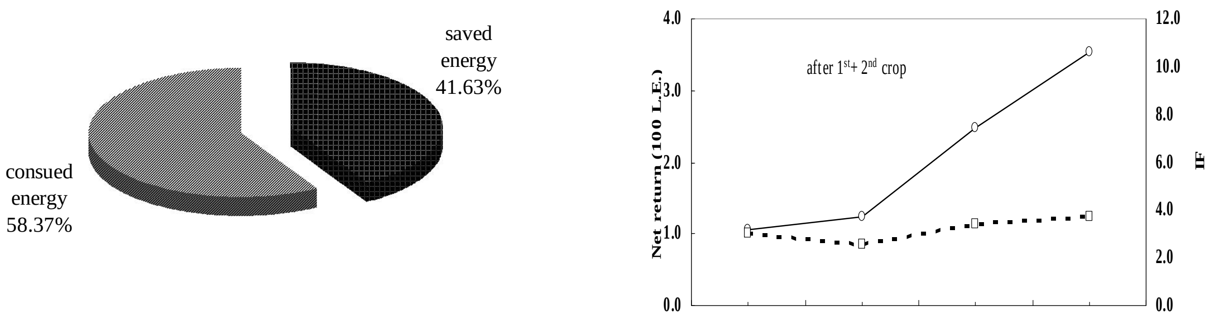


Fig.3b. General energetic position at using UF-fertilizer for second cropping sequence

Table 5 Yield, some yield components of second cropping sequence (Sesame and Canola), their summation, % relative increase calculated of AN-treatment yield, N-CA and E-CA as affected by different treatments.

Treatments		Sesame					Canola					Summation					
Clay (A)	Ureaform (B)	N rate $Kg.fed^{-1}$	Plant yield g	Seed index g	Yield ton. fed^{-1}	Relative Increase %	N rate Kg. Fed-	Plant yield g	Seed index g	Yield ton. Fed^{-1}	Relative increase %	Yield ton. fed^{-1}	Relative increase %	Yield increase ton. fed^{-1}	N-CA kg N. ton^{-1}	Consumed energy L. fed^{-1}	E-CA L.fuel ton^{-1}
Without Clay	Control	0.00	8.15	1.51	0.154	-66.15	0.00	6.55	1.33	0.521	-39.42	0.675	37.0	-	-	-	-
	AN	45.0	16.9	2.33	0.455	-	45.0	10.38	1.79	0.860	-	1.315		0.640	140.63	144	225.0
	UF1	45.0	18.5	1.90	0.415	-8.79	00.0	10.79	1.85	0.910	5.81	1.325	0.76	0.650	69.23	72.0	110.77
	UF2	67.5	16.5	3.20	0.420	-7.69	00.0	11.03	1.89	0.940	9.30	1.360	3.42	0.685	97.83	108.0	156.52
	UF3	90.0	23.6	2.60	0.560	23.08	00.0	11.40	1.94	0.985	14.54	1.545	17.44	0.870	103.45	144.0	165.52
	UF4	112.5	25.1	2.90	0.595	30.78	00.0	11.93	2.02	1.050	22.09	1.645	25.10	0.970	115.98	180.0	185.57
	Means of treatments		18.13	2.41	0.433	-7.19		10.35	1.8	0.878	3.08	1.311	18.7	0.763	105.42	129.6	168.68
	Means of UF treatments		20.93	2.65	0.498	9.35		11.29	1.93	0.971	12.94	1.469	11.69	0.794	96.62	126.0	154.60
With Clay	Control	0.00	11.05	1.81	0.241	-102.91	00.0	7.84	1.65	0.621	-29.90	0.862	-37.37	-	-	-	-
	AN	45.0	17.3	3.10	0.489	-	45.0	10.48	1.80	0.873	-	1.362	-	0.509	176.82	144	282.91
	UF1	45.0	24.3	2.50	0.562	14.93	00.0	11.11	1.90	0.950	8.82	1.512	11.01	0.659	68.29	72.0	109.27
	UF2	67.5	26.3	2.50	0.612	25.15	00.0	11.70	1.99	1.021	16.95	1.633	19.90	0.780	86.54	108.0	138.46
	UF3	90.0	27.3	2.50	0.641	25.56	00.0	12.75	2.15	1.150	31.73	1.791	31.50	0.938	95.95	144.0	153.52
	UF4	112.5	29.1	2.70	0.724	32.46	00.0	13.25	2.22	1.210	38.60	1.934	30.83	1.081	104.07	180.0	166.51
Means of treatments			22.56	2.52	0.545	4.81		11.19	1.95	0.971		1.516	18.1	0.784	106.33	129.6	170.13
Means of UF treatments			26.75	2.55	0.635	24.53		12.2	2.07	1.083	24.03	1.718	23.31	0.856	88.72	126.0	141.94
LSD A	0.05		n.s	n.s	n.s			0.54	0.08	0.066							
LSD B	0.05		2.2	n.s	0.003			0.45	0.07	0.054							
LSD AB	0.05		3.1	n.s	0.005			0.63	0.10	0.077							

*Seed index = weight of 1000-seed (g)

3.2. Economic appraisal:

The choice to use either UF-fertilizer or AN-one should not be based on nitrogenous content, because it's both the same nitrogen. UF-fertilizer has the benefit of being less likely to leach into ground or surface water (environmentalist's viewpoint). The farmer's viewpoint, however, is entirely different, the loss or gain is his concern. Here, the economic appraisal for UF-fertilizer against AN-one through their use to fertilize the two cropping sequences (sunflower-safflower-peanut & sesame-canola) has been achieved. Perhaps, if the results have satisfactorily come, there should be little resistance to adopting the SRNFs application.

Expenses of inputs have represented only in the purchase and application of nitrogen fertilizers, because the cost of all other agricultural processes have not been included. It would be pointed out that the UF-fertilizer has not had credible price and its cost has been the costs of the chemicals used in preparing it (in laboratory).Then the inputs have been as follow:

1-L.E.4500 to prepare one ton of UF (L.E.3000 for formalin and L.E.1500 for urea)

2- L.E.1300 for one ton ammonium nitrate.

3- L.E. 35 for one ton clay sediments.

4- L.E.25.00 for laborer per day.
5- L.E. 1.10 for liter of diesel fuel.

The outputs have represented selling price of different oil crops under study and which have come as follow:
1- L.E. 3000 for one ton sunflower.
2- L.E. 3000 for one ton safflower.
3- L.E. 5300 for one ton peanut.
4- L.E. 7000 for one ton sesame.
5- L.E. 1400 for one ton canola.

3.2.1. First cropping sequence:

Data recorded in table 6 and table 7 demonstrates that: Firstly, regardless of kind or rate of applied nitrogen fertilizer, all treatments at $position_1$ (sum of $1^{st}+2^{nd}$ crop economical data) and $position_2$ (sum of $1^{st}+2^{nd}+3^{rd}$ crop ones) have generally been profitable because of their IFs (IF_1+IF_2) have been more than 3 (FAO, 2000). Secondly, rational approximation for the net return (NR) values of UF-treatments to those of AN-treatment has been occurred. They have been proportionally amounted 0.82, 1.4 and 0.9 of those of AN-treatment after each of first, second (sum of $1^{st}+2^{nd}$) and third crop (sum $1^{st}+2^{nd}+3^{rd}$) in the same order. This has been expected due to the high cost of UF. Thirdly, economic application of UF has been seemingly prospered when it had been applied in high rates (table 7) where their IF_2 and IF_3 values have been approached to those of AN-fertilizer (as a standard treatment). This could be explained on the basis of severe nitrogen depletion of applied UF at planting first crop and consumed at all 3 crops growing period long. To discuss the only UF data (table7 and figure 4), it would be illustrated that NR_1 &IF_1 calculated for first crop data, NR_2 & IF_2 calculated for sum of first and second crop data and NR_3 & IF_3 calculated for sum of first, second and third crop data.

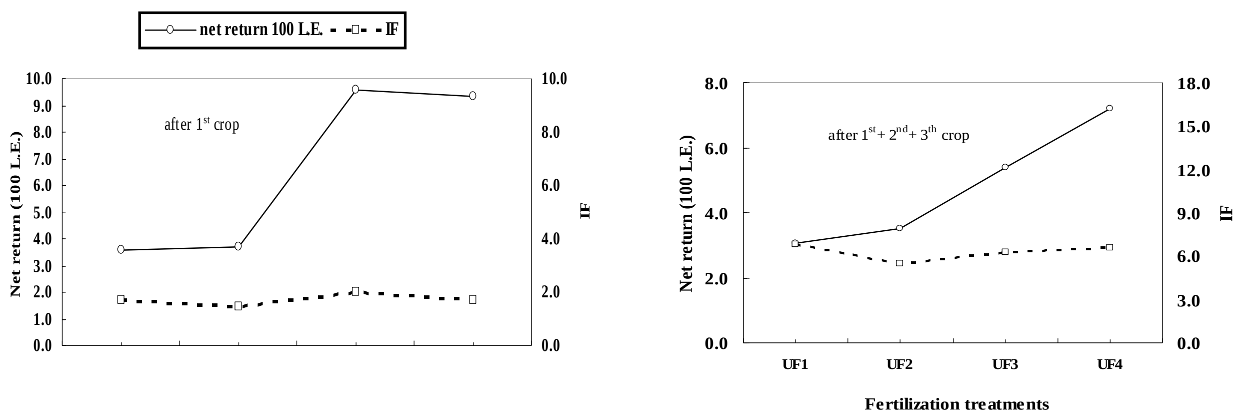


Figure 4 UF treatments in relation to net return and investment factor of first cropping sequence

Table 6 Total cost, gross and net return produced from N-fertilization for first cropping sequence.

Treatments	Sunflower (first crop)								Safflower (second crop)							Peanut (third crop)						
	App. fert. Kg. fed^{-1}	Cost fert. L.E. fed^{-1}	Lab-or L.E. fed^{-1}	Total Cost L.E. fed^{-1}	Yield increase ton. fed^{-1}	Gross return L.E. fed^{-1}	Net return 1 L.E. fed^{-1}	IF_1	App. fert. Kg. fed^{-1}	Cost fert. L.E. fed^{-1}	Lab-or L.E. fed^{-1}	Total Cost L.E. fed^{-1}	Yield increase ton. fed^{-1}	Gross return L.E. fed^{-1}	Net return L.E. fed^{-1}	Appl. fert. Kg. fed^{-1}	Cost fert. L.E. fed^{-1}	Lab-or L.E. fed^{-1}	Total Cost L.E. fed^{-1}	Yield increase ton. fed^{-1}	Gross return L.E. fed^{-1}	Net return L.E. fed^{-1}
AN	143.3	186.3	50	236.3	0.344	1031.1	794.8	3.36	143.3	186.3	50	236.3	0.293	879.9	643.6	60	78	50	128	0.750	3975.0	3847.0
UF1	112.5	506.3	25	531.3	0.296	887.1	355.3	1.67	0.0	0.0	0.0	0.0	0.239	717.6	717.6	0.0	0.0	0.0	0.0	0.375	1987.5	1987.5
UF2	168.8	759.4	25	784.4	0.386	1157.1	372.7	1.48	0.0	0.0	0.0	0.0	0.286	858.6	858.6	0.0	0.0	0.0	0.0	0.428	2268.4	2268.4
UF3	225.0	1012.5	25	1037.5	0.666	1997.1	959.6	1.92	0.0	0.0	0.0	0.0	0.504	1513.2	1513.2	0.0	0.0	0.0	0.0	0.555	2941.5	2941.5
UF4	281.3	1265.6	25	1290.6	0.742	2225.1	934.5	1.72	0.0	0.0	0.0	0.0	0.869	2605.5	2605.5	0.0	0.0	0.0	0.0	0.690	3657.0	3657.0
UF treatments means				866.0	0.523	1566.6	655.61	1.9					0.473	1423.7	1423.75					0.512	2713.6	2713.6

Table 7 Economic position of N-fertilization for 1st and 2nd crop yield (position) $_1$ and for 1st, 2nd and 3rd crop yield (position)$_2$ in first cropping sequence.

Treatments	Economic position for 1st and 2nd crop (position)$_1$				Economic position for 1st, 2nd and 3rd crop (position)$_2$			
	Total cost L.E. fed^{-1}	Gross Return L.E. fed^{-1}	Net return $_2$ L.E. fed^{-1}	IF_2	Total cost L.E. fed^{-1}	Gross return L.E. fed^{-1}	Net return $_3$ L.E. fed^{-1}	IF_3
AN	472.6	1911.0	1438.4	4.04	600.6	5886.0	5285.4	9.80
UF1	531.3	1604.7	1073.4	3.02	531.3	3592.2	3060.9	6.76
UF2	784.4	2015.7	1231.3	2.57	784.4	4284.1	3499.7	5.46
UF3	1037.5	3510.3	2472.8	3.38	1037.5	6451.8	5414.3	6.22
UF4	1290.6	4830.6	3540.0	3.74	1290.6	8487.6	7197.0	6.58
UF treatments means	910.9	2990.3	2079.3	3.18	910.9	5703.9	4792.9	6.25

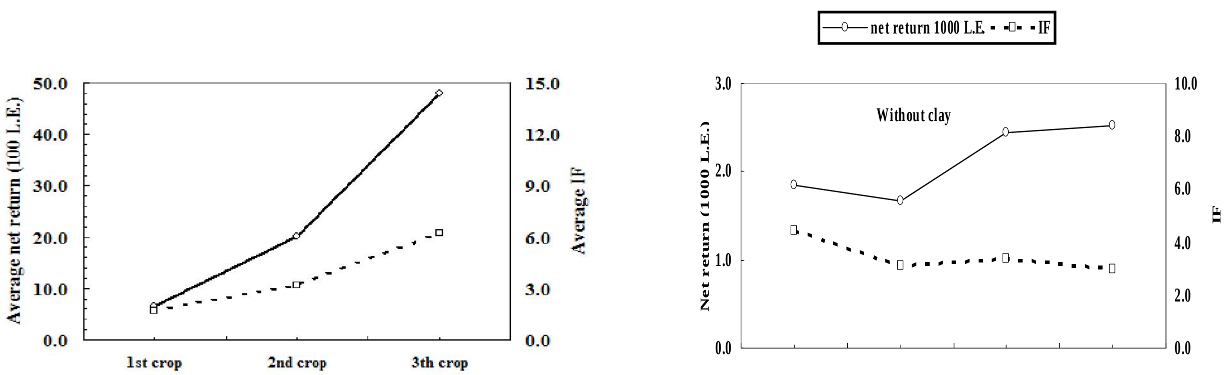


Figure 5 Accumulation of the economic data for first cropping sequence

It is, thereon, observed that NR_1, NR_2 and NR_3 have been increased with increasing applied UF-rate, while IF_1 have been somewhat lowered and nearly not changed (varied from 1.48 to 1.92), IF_2 values have been increased with increasing N-rate of UF, whoever, they still relatively low and IF_3 has given values bit greater than that of IF_2. From table 7 and figure 5, it is noticed accelerated increasing for net return values and delayed one for IF values (on average) from beginning first crop to third one (position$_2$) passing by second one (position$_1$) have been occurred . Hence, it may be decided that the economic rate of UF is UF_3 (90 kg N.fed^{-1}) and planting only two crops under the condition similar to that of this experiment is quite sufficient.

3.2.2. Second cropping sequence:

Generally, it seems that the poverty of soil fertility (Table 1) has negatively affected the plant productivity which would essentially reflect upon the NR and IF values for both two crops which have been somewhat reduced. It is however found according to data given in table 8 that all treatments either slow or conventional nitrogen fertilizer have been implemented some profitability where their IF-values have frequently been more than 3. About clay application, it is observed that the adding clay has given NR greater than no adding clay. Whoever, its added costs has obscured the appearance of profitability where IF (on average) of the former has nearly equated to that of latter.

Evidently, NR produced from UF - application (on average), at second crop has been superior to those produced from AN-one, either with adding or no-adding clay which may due as mentioned before to the UF - decomposition in second season of experiment has been more activating , subsequently more efficient nitrogen release. As for the case of amongst UF-treatments themselves, data in table 8 and figure 6 illustrate that summed up impact (1st crop +2nd crop) of UF-treatments on NR and IF values have been affected by adding clay. Markedly, adding clay has given NR higher than that of no-adding. At the same time IF values have not been changed and approximated in both two cases.

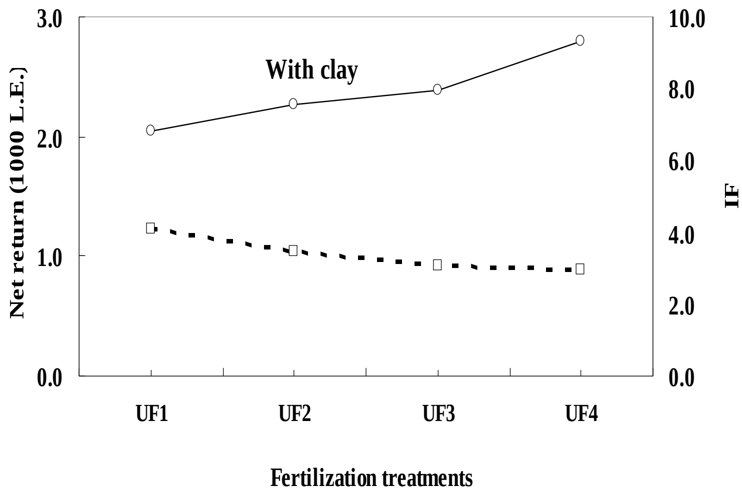


Figure 6 UF-treatments in relation to NR and IF of second cropping sequence

Table 8 Economic position of N-fertilization for 1st and 2nd crop in second cropping sequence

Treatments		Sesame (first)										Canola (second)									First economic position for 1st and 2nd crop			
		App. fert. Kg. fed-1	Cost fert L.E. fed-1	Fert. lab. L.E. fed-1	App. clay ton. fed-1	Cost of Clay App. and trans. LE. fed-1	Total Cost L.E. fed-1	Yield income ton. fed-1	Gross return L.E. fed-1	Net return. fed-1	IF	App. fert. Kg. fed-1	Cost fert L.E. fed-1	Fert. lab. L.E. fed-1	App. clay L.E. fed-1	Cost of Clay App. fed-1	Total cost L.E. fed-1	Yield income ton. fed-1	Gross return L.E. fed-1	Net return. fed-1	Cost L.E. fed-1	Gross Return L.E. fed-1	Net Return L.E. fed-1	IF
Without clay	AN	143.3	186.3	50	0	0	236.3	0.301	2107.0	1870.7	8.92	143.3	186.3	50	0	0	236.3	0.339	474.6	238.3	472.6	2581.6	2109.0	5.46
	UF1	112.5	506.3	25	0	0	531.3	0.261	1827.0	1295.8	3.44	0.0	0.0	0	0	0	0.0	0.389	544.6	544.6	531.3	2371.6	1840.4	4.46
	UF2	168.8	759.4	25	0	0	784.4	0.266	1869.0	1077.6	2.38	0.0	0.0	0	0	0	0.0	0.419	586.6	586.6	784.4	2455.6	1664.2	3.13
	UF3	225.0	1012.5	25	0	0	1037.5	0.406	2842.0	1804.5	2.74	0.0	0.0	0	0	0	0.0	0.464	644.6	649.6	1037.5	3486.6	2454.1	3.36
	UF4	281.3	1265.6	25	0	0	1290.6	0.410	3087.0	1290.6	2.39	0.0	0.0	0	0	0	0.0	0.529	740.6	740.6	1290.6	3827.6	2031.2	2.97
UF treatments means							910.9	0.336	2406.3	1367.1	2.74							0.450	629.1	630.4	911.0	3035.4	1997.5	3.48
With clay	AN	143.3	186.3	50.0	3.0	130.0	366.3	0.248	1736.0	1369.7	4.74	143.3	186.3	50.0	0.0	0.0	236.3	0.261	365.4	129.1	602.6	2101.4	1498.8	3.49
	UF1	112.5	506.3	25.0	3.0	130.0	661.3	0.321	2247.0	1585.8	3.40	0.0	0.0	0.0	0.0	0.0	0.0	0.330	462.0	462.0	661.3	2709.0	2047.8	4.10
	UF2	168.8	769.4	25.0	3.0	130.0	924.4	0.371	2597.0	1682.6	2.81	0.0	0.0	0.0	0.0	0.0	0.0	0.409	572.6	572.6	924.4	3169.6	2255.2	3.43
	UF3	225.0	1012.5	25.0	3.0	130.0	1167.5	0.400	2800.0	1632.5	2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.538	753.2	753.2	1167.5	3553.2	2385.7	3.04
	UF4	281.3	1265.6	25.0	3.0	130.0	1420.6	0.483	3381.0	1960.4	2.38	0.0	0.0	0.0	0.0	0.0	0.0	0.598	837.2	837.2	1420.6	4218.2	2797.6	2.97
UF treatments means							1043.4	0.394	2756.3	1715.3	2.75							0.469	656.3	656.3	1043.5	3412.5	2371.6	3.38

3.3. Energetic economical situation:

Again, it must be mentioned that the discussed energy is the energy which has been spent at nitrogen fertilizer manufacturing. Data given in Table 9 show general picture about the cost of consumed energy to produce one ton of yield of first or second cropping sequences: Firstly, the cost at first copping sequence has been less than that at second one. This due to that the obtained yield of first has been more than that of second. Secondly, the cost in case of adding clay has been less than that in case of no adding it.

Thirdly, at using UF fertilizer, the cost (on average) has been much less than that of AN treatment; the reduction has amounted 61%and 62% of that of AN treatment for $summation_1$ and $summation_2$ respectively, for first cropping sequence while at second one, it has amounted 69% and 50% for case of no adding clay and adding it respectively due to high nitrogen use efficiency of UF fertilizer.

In conclusion, in spite of the superior performance of UF-fertilizer in the matter of yield production to that of AN-one, their both profitabilities have come proximate. To produce 1 ton of oil crops using UF-fertilizer, it has been consumed (on average) about 78.45 kg N produced with 4725.49 M Joule or 126.35 liter of diesel fuel while at using ammonium nitrate, the consumables have been about 132.00 kg N produced with 7941.14 M Joule or 212.33 liter of diesel fuel. The application of UF has saved (on average) about 53.55 kg N .ton^{-1}(yield) and 3215.65 M Joule.ton^{-1} or 85.98 liter of diesel fuel.ton.$^{-1}$ which produce at its combustion 229.57 kg of CO_2 emissions. Thus, the application of SRNFs has not only contributed to maintaining the environment (air, water and soil) but it has also helped to enhancing the efficiency of energy application which is the main concern of environmental policies targeting to reduce the CO_2 emissions causing the global worming.

Carbon coefficient of a diesel fuel liter = 2.67Kg CO_2 (U.S. Environmental Protection Agency, 2005).

Table 9.Cost of consumed energy to obtain a ton of dry matter (Yield) of first and second cropping sequences as affected by different treatments.

Treatments	*Cost of energy L.E. ton^{-1}			
	First cropping sequence		Second cropping sequence	
	$(Summation)_1$	$(Summation)_2$	Without adding clay	With adding clay
AN	253	143	247.50	311.20
UF_1	154	88	121.85	120.20
UF_2	176	99	172.17	152.31
UF_3	132	88	182.07	168.87
UF_4	121	88	204.13	183.16
Means of UF - treatments	154	88	170.06	156.13

*Cost of energy, L.E. ton^{-1} = E-CA, L. Diesel fuel .ton^{-1} X L.E. 1.10 (current price)

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