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Impact of Carbon Coated Urea with Organic Fertilizers on (Soybean - Wheat) Crops Succession

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ABSTRACT

Two field experiments on soybean (*Glycine max* L.; Variety Giza, 111), wheat (*Triticum aestivum* L.; Variety Misr 1), were conducted at Agricultural Experimental Research Station of Tag El-ezz, Agricultural Research Centre, El-Dakhalia Governorate, Egypt during two successive summer - winter seasons of (May to November 2019) and (November 2019 to May 2020). The experiment treatments were included eleven (11) treatments (T_1- Absolute control, T_2- 100% U (recommended dose of urea fertilizer), T_3- 100% CCU (recommended dose of carbon coated urea fertilizer), T_4- 75% U+ 20 m^3 farm yard manure (FYM), T_5- 75% U+10 m^3 FYM, T_6- 50% U+20 m^3 FYM, T_7- 50% U+10 m^3 FYM, T_8- 75% CCU+20 m^3 FYM, T_9- 75% CCU +10 m^3 FYM, T_{10}- 50% CCU +20 m^3 FYM, T_{11}- 50% CCU +10 m^3 FYM). The treatments were layout in complete randomize block plot design with three replicates. The results indicated that the highest mean values of vegetative growth stage (N, P and K % and chlorophyll a, b and Carotene), chemical content of harvest stage (N, P and K % in soybean stover and seeds or wheat grains and straw) and protein %, as well as yield and its components (plant height cm, stover, seeds ton fed^{-1} and 100 seed weight of soybean or straw, grains yield (Ton fed^{-1}) and1000 grain weight (g) of wheat) were recorded with integrated application of inorganic and organic fertilizers. T_8- 75% CCU + 20 m^3 FYM, was considered as most suitable treatment for obtaining the highest yield of soybean – wheat under these experimental conditions.

***Keywords*:** Urea - carbon coated urea and soybean- wheat crops rotation.

INTRODUCTION

Nitrogen is the very important nutrient for increasing crops. It's needed by largest amount. The proper management of N fertilization has been one of the most important management practices to increase crops yield and quality.

Nitrogen (N) is required in larger amount than any other nutrients Babar, *et al.*, (2016). Though, N fertilizer application is an important practice for increasing crop efficiency in agricultural production Behera, *et al.*, (2013) and Wang, *et al.*, (2015) but, low Nitrogen Use Efficiencies (NUEs) was an indication to lower economic returns for farmer's fertilizer investments.

Urea is a primary source of N in solid fertilizers. Urea is the most consumed nitrogen fertilizer in the world. However, its agronomic and economic efficiency is reduced by the volatilization of NH_3, which can reach 78 % of the applied nitrogen.

Lose N volatilization occur as a result of the actuation mechanisms of fertilizer contact with the urease enzyme present in the soil. Thus, various urea-based products had been developed in order to increase the efficiency of its use, promoting technological advances in the field of N input. Among these advances, there was a search for new coated fertilizers as urea granules coated with various materials (resins, waxes, polymers, etc.) may depend on the characteristics of the polymers and increase efficiency through a gradual nutrient release mechanism Civardi, *et al.*, (2011) and Rodrigues, *et al.*, (2014). The coating of urea granules with charcoal oxidation has the potential to reduce the volatilization, due to the acidic character, the high buffering capacity and CEC. Diogo Mendes de Paiva, *et al.*, (2012).

Panday, *et al.*, (2019) suggested that adding coal char at optimal rates may potentially reduce agricultural reactive N to the atmosphere by decreasing NH3 volatilization from fertilized soils.

Jia, *et al.*, (2021) Stated that the application of biochar coated urea (BCU) could minimize nitrogen loss mainly by reducing nitrate leaching loss; which could be attributed to the slow-release performance of BCU, followed by biochar induced adsorption of nitrogen due to the porous nature and surface functional groups of biochar. However, the application of BCU enhanced ammonia volatilization due to the increase of soil NH^{+4}–N concentration and pH value of microenvironment around urea by BCU. The application of BCU increased NUE by about 20% when compared with urea, since BCU reduced losses of nitrogen fertilizer and increased concentration of nitrogen in the soil as well as nitrogen uptake in oilseed rape. Furthermore, the reduction of nitrogen application by 20% when BCU served as a nitrogen source not only reduced nitrogen loss but significantly improved NUE, with no negative effect on the biomass.

In this study carbon coated urea (CCU) is considered as a promising control release nitrogen fertilizer for reducing loss of nitrogen and increasing NUE. However further investigations are required to validate the mechanism and controlling the loss of nitrogen from soil, NUE and effect on crop yield.

It's well known that, soil organic matter was the single most important constituent that influences the soil fertility, soil formation, soil biology, physical and chemical

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properties of soil (Soil health) which in turn reflects in to crop yield. Lakaria, *et al.*, (2011) stated that soil organic matter plays pivotal roles in several processes of the soil ecosystem including nutrient cycling, soil structure formation, carbon sequestration, water retention and energy supply to microorganisms.

Aher, *et al.*, (2015) observed that soil organic carbon, available N, P and soil enzyme activities viz., dehydrogenase (DHA) and alkaline phosphatase were found significantly higher in the plot managed organically. The total biomass and seeds yield of soybean was found highest in organic farming practices followed by integrated and chemical practices.

Rotations avoid yield depressions under monoculture which increase populations of microorganisms and decrease population of antagonistic microorganisms in the crop root rhizosphere. Cook, (1984)

Dogan, and Bilgili (2010) showed that grown cereal crops (wheat or maize) after legume crops produced more grains yield than those grown after non legume crops. In cereal – legume rotation or intercropping systems, the cereal benefits from the nitrogen fixed by the legume and the decomposition of nutrient – vies biomass, root and nodules of legume which help to increase soil organic matter as well as reduced weeds population density and biomass production.

Soybean was a very energy-rich seed legume containing 40% protein and 19 % oil in the seeds, as well as using in many of food industry. Under good growing conditions with adequate N fixation, seeds yield of 3–4 tones/ha can be obtained.

Wheat was the major and essential crop in Egypt. It grows in Egypt on an area of 3.39 million fed with an annual production of about 9.28 million tones and with an average yield of 2.74 tons per fed during 2014-2015 growing season CLAC, (2015).

The objective of this study, is to investigate coated urea with carbon as available materials. - Evaluate the influence of interaction effects of slow release fertilizers (carbon coated urea) with organic fertilizers on soybean and its residual effects on wheat.

- Investigate the treatments on soil fertility and crops production.
- Also, increasing efficiency in the use of nitrogen fertilizers level and decreasing of pollution hazard.

MATERIALS AND METHODS

The present work was postulated to study the effects of slow release fertilizers as well as nitrogen fertilization rates on yield, yield components and chemical characteristics of soybean-wheat cropping plants and soil properties. Two field experiments were conducted at Tag El-Ezz Agricultural Research Station, Agricultural Research Centre (ARC), Dakahlia Governorate, Egypt, on clayey soil during two consecutive summer-winter growing seasons of 2019 and 2020 using soybean (*Glycine max* L.; Variety Giza, 111), wheat (*Triticum aestivum* L.; Variety Misr 1) The experimental area was located at 30º 95' 6128" N latitude and 31º 61' 0597' E longitude. The experiments were included eleven (11) treatments (T_1- Absolute control, T_2- 100 % U (recommended dose of urea fertilizer), T_3- 100 % CCU (recommended dose of carbon coated urea fertilizer), T_4- 75 % U+ 20 m^3 FYM, T_5- 75 % U+10 m^3 FYM, T_6- 50 % U+ 20 m^3 FYM, T_7- 50 % U+ 10 m^3 FYM, T_8- 75 % CCU+ 20 m^3 FYM, T_9- 75 % CCU+ 10 m^3 FYM, T_{10}- 50 % CCU+ 20 m^3 FYM, T_{11}- 50 % CCU+ 10 m^3 FYM). The treatments were layout in complete randomize block plot design with three replicates, where the treatments were located randomly. The physical and chemical characteristics of the studied soil before soybean and wheat planting are shown in (Table 1).

Manufacturing of carbon coated urea (CCU):

Urea granules (46% N) were used and treated with formaldehyde as an adhesive materials and then fumigated with carbon finally and leave many days for complete drying. Manufacturing of carbon coated urea was done at Laboratory of Delta Company for Fertilizers and Chemical Industries in Talkha as fig. (1and2).

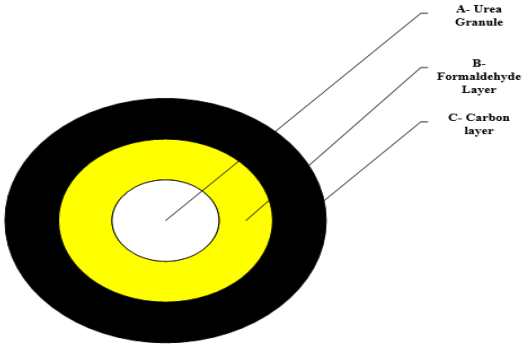

Fig. 1. The cross section schematic of carbon coated urea.

Fig.2. Photo of carbon coated urea.

Table 1. Some physical and chemical properties of the experimental soil before soybean cultivation and after soybean harvest:

properties	Particle size distribution, (%)			Textural Class	*EC dSm^{-1}	**pH	$CaCO_3$ (%)	O.M (%)		
	Sand	Silt	Clay							
Before	14	20	66	Clayey	0.15	8.45	1.00	1.17		
After	14	19	67	Clayey	0.12	8.25	1.00	1.84		
properties	Soluble cations (meq l^{-1})					Soluble anions (meq l^{-1})			Available macroelement mg kg^{-1}		
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	N	P	K
Before	0.27	0.21	0.18	0.09	00	0.25	0.38	0.12	42.5	10.5	340
After	0.22	0.18	0.12	0.10	00	0.23	0.29	0.10	85.90	16.77	390

*** Soil Electrical Conductivity (EC) and soluble ions were determined in soil solution (1: 5).**

**** Soil pH was determined in soil water suspension (1: 2.5).**

Table 2. Some physical and chemical properties of experimental FYM:

Properties	Ph (1:10)	EC(1:10) dsm^{-1}	O.M	O.C	Total N%	C/N ratio	Total P%	Total K%
Values	6.53	3.78	33.02	18.08	1.3◦	13.7	0.41	0.72

Field Experiments:

Cultivation method and layout of Experiment:

Recommended rates of soybean seeds (30 Kg fed^{-1}) were sown on ridges with plant spacing of 25 cm in plots (3.5 m length m x 3 width m) at May 2019 then, Recommended rates of wheat grains (60 Kg fed^{-1}) were sown in plots (3.5 m length m x 3 width m) at November 2019. The normal cultural practices for soybean / wheat production were followed according to the instruction laid down by the Ministry of Agriculture land Reclamation (MALR).

Organic and Mineral Fertilizers Application Rates:

Organic fertilizer farm yard manure (FYM) was incorporated with soil surface at the rate of 20 m^3 fed^{-1} and 10 m^3 fed^{-1} (20.36 and 10.18 kg $plot^{-1}$) before cultivation.

The P fertilizer rate as calcium super phosphate (6.76 % P) in a rate of (150 kg fed^{-1}) (375 g $plot^{-1}$) applied as recommended rate during land preparation, before soybean cultivation. K fertilizer was applied as potassium sulphate (40 % K) in a rate of 50 Kg Fed^{-1} (125 g $plot^{-1}$) with the second irrigation. N fertilizer was applied as urea (46 % N) in a rate of 15 unit (32.6) Kg fed^{-1} (81.5, 61.12 and 40.75 g $plot^{-1}$) as active dose with planting then 40 unit (86.95) kg fed^{-1} was added later (217.37, 163.03 and108.68 g $plot^{-1}$) for soybean. Before wheat cultivation, the P fertilizer rate as calcium super phosphate (6.76 % P) in a rate of (100 kg fed^{-1}) (250 g $plot^{-1}$) applied as recommended rate during land preparation. K fertilizer was applied as potassium sulphate (40 % K) in a rate of 48 Kg fed^{-1} (120 g $plot^{-1}$) with the second irrigation. N fertilizer was applied as urea (46 % N) for wheat according to residual nitrogen in soil after soybean. The harvest time on October 2019 and May 2020 for soybean and wheat, respectively.

Plant Growth Parameters Data:

Vegetative growth stage:

During vegetative growth stage up to 60 days after planting, plants were taken randomly to determine: pigments (chlorophyll a, b and carotenoid) contents in soybean – wheat leaves were determined according to Sumanta, *et al.,* (2014). Pigments were determined in fresh weight samples. The samples of leaves were dried at 70° c to determined N % according to the methods described by Jones, *et al.,* (1991) and both P and K % according to Peters, *et al.,* (2003).

Soybean-Wheat yield, its Components and Chemical constituents:

Soybean-Wheat yield and its components:

After harvesting, soybean plants were taken randomly and separated in seeds and stover, wheat plants were separated in grains and straw to determine: plant height (PH, cm), soybean seeds/ wheat grains weight (g $plant^{-1}$) and soybean stover / wheat straw yield (Ton fed^{-1}) and soybean 100 seeds / wheat 1000 grains weight determined (g) and biological yield (Ton fed^{-1}).

Chemical composition of soybean and wheat at harvest:

Seeds and stover of soybean or grains and straw of wheat samples were collected then oven-dried at 70 °C and finely ground and wet digested using concentrated sulfuric acid and perchloric acid according to Cottenie, *et al.,* (1982).

Concentration of macronutrients (N, P and K) in soybean-wheat seeds/ grains and stover /straw samples were determined as formerly mentioned in leaves. Crude protein content was calculated by multiplying the total N by the factor 6.25 for soybean /5.70 for wheat as described by A.O.A.C., (2007).

Agronomical N -use efficiencies (NUE).

It was calculated as the following equation according to Naeem, *et al.,* (2017).

$$\text{NUE (kg yield/kg applied)} = \frac{\text{seed yield of treated (kg fed}^{-1}\text{)} - \text{seed yield of control (kg fed}^{-1}\text{)}}{\text{N applied (kg fed}^{-1}\text{)}}$$

Soil analysis: Soil texture, physical and chemical analyses were determined using the methods described by Piper, (1950), Hesse, (1971) and Hillel, (1972). After harvest, soil samples from each experimental plot were taken to determine available N, P, and K according to Reeuwijk, (2002). Organic matter was determined according to Walkley and Black chromic acid wet oxidation method according to Hesse, (1971).

Feasibility:

It was done through an account of total cost, gross return, net return and B: C ratio was calculated as below. Benefit cost Ratio (BcR) = Gross return/ Total Cost of Cultivation.

Statistical analysis: Appropriate analysis of variance was performed using COSTATE Computer Software. The significant differences among the mean of various treatments were established by the Least Significant Differences method (LSD) and Duncan's Multiple Comparisons Test. according to Gomez and Gomez, (1984).

RESULTS AND DISSCUSSION

Soybean plants and its components at vegetative stage:

The obtained data (Table 3) show that, there were significant differences between most treatments under study with soybean nutrients and pigments (chlorophyll a, b and Carotene) at vegetative stage which increased by the application of urea, integration of carbon coated urea and organic fertilizers at the rate of 75% urea or 75% carbon coated urea with organic fertilizer (FYM) with the superpass to carbon coated urea. The obtained data revealed that T8 **(**75% CCU + 20 m^3 FYM), gave the highest values for all parameters under investigations compared with control, urea (100%) and carbon coated urea (100%) or between them. While, T_7 **(**50% U+10 m^3 FYM) gave the lowest values.

It's clear that carbon coated urea with FYM was superior compared with other treatments. These findings demonstrated that the improved efficiency of carbon coated urea with organic fertilizer to the soil increased the availability of nutrients considerably resulting in a positive effect on growth parameters. These results match with those by Mello, *et al.,* (2017).

Table 3. Effect of urea, carbon coated urea with farm yard manure and their interaction on nutrients % and pigments (mg g FW^{-1}) of soybean plants at vegetative stage 2019/2020 seasons.

Treatments	Soybean					
	Nutrients % at vegetative stage			Chlorophyll a (mg g FW^{-1})	Chlorophyll b (mg g FW^{-1})	Carotene (mg g FW^{-1})
	N%	P%	K%			
Absolute Control	2.36k	0.25h	2.58g	0.330j	0.107j	0.110j
100 % U	3.40f	0.35cde	3.21de	0.427e	0.151f	0.154e
100 % CCU	3.51e	0.37bcd	3.28cde	0.435d	0.161e	0.158d
75 % U+20 FYM	3.80c	0.38abc	3.51b	0.442c	0.172d	0.164c
75 % U+10 FYM	3.68d	0.39abc	3.39bcd	0.448b	0.180c	0.170b
50 % U+20 FYM	2.83i	0.30gh	2.70g	0.390h	0.128i	0.135h
50 % U+10 FYM	2.70j	0.27fg	2.68g	0.357i	0.125i	0.130i
75 % CCU +20 FYM	4.10a	0.42a	3.75a	0.461a	0.201a	0.179a
75 % CCU +10 FYM	3.95b	0.40ab	3.44bc	0.457a	0.192d	0.176a
50 % CCU +20 FYM	3.20g	0.31efg	3.10ef	0.419f	0.140g	0.147f
50 % CCU +10 FYM	3.02h	0.33def	2.98f	0.413g	0.130h	0.141g
LSD $_{at\ 5\%}$	0.04	0.04	0.20	0.004	0.004	0.004

Soybean yield and its components at harvest stage:

The results presented in (Table 4) revealed that, appreciable significant increasing in most soybean plant parameters under study such as plant height, (pods, stover, seeds and 100-seeds) weight (g) and also, (stover, seeds and biological) yield Ton fed^{-1} as influenced by integrated application of the treatments under study .The treatments of T_8 (75% RDCUF+ 20 m^3 FYM), gave the highest values for pods weight (g), seeds weight (g), 100 seeds weight (g), and seeds Ton fed^{-1}, which their values are 46.89, 32.25, 25.71 and 2.13, respectively. While T_7 (50% U + 10 m^3 FYM) gave the lowest values for all parameters under investigation. These results are coinciding with the work of Abou-zaied, *et al.*, (2014) who reported that when sulpher coated urea (SCU) was applied at 20 kg N fed^{-1} to soybean plants could effectively produce equal or better seeds yield than the plants were fertilized with 40 kg N fed^{-1}. Therefore, such results indicate the potentiality of reducing application rates for soybean by 20 kg N fed^{-1} Units if the coated forms of urea were adopted than the uncoated urea.

Table 4. Effect of urea, carbon coated urea with farm yard manure and their interaction on soybean plant height cm, (pods, stover, seeds and 100-seeds) weight (g), stover, seeds and biological yield (Ton fed^{-1}) at harvest stage at 2019/2020 seasons.

Treatments	Soybean							
	Plant height (cm)	Pods weight (g plant^{-1})	Stover weight (g plant^{-1})	Seeds weight (g plant^{-1})	100-seeds weight (g)	Yield (Ton fed^{-1})		
						Stover	Seeds	Biological
Absolute Control	61.00g	19.04k	26.06g	17.05k	15.95i	1.72g	1.12k	2.84h
100 % U	80.33c	31.92f	36.51d	22.85f	19.43f	2.41d	1.51f	3.92e
100 % CCU	81.66c	33.47e	38.18d	24.79e	20.58e	2.52d	1.64e	4.16d
75 % U+20 FYM	85.33b	37.14c	47.42b	28.83c	22.72c	3.13b	1.90c	5.03b
75 % U+10 FYM	82.00c	35.22d	45.15c	26.59d	21.43d	2.98c	1.75d	4.73c
50 % U+20 FYM	71.00ef	24.84i	29.84f	19.71i	17.00h	1.97f	1.30i	3.27f
50 % U+10 FYM	68.00f	22.42j	28.48f	19.04j	16.50hi	1.88f	1.26j	3.14g
75 % CCU +20 FYM	89.28a	46.89a	49.84a	32.25a	25.71a	3.29ab	2.13a	5.42ab
75 % CCU +10 FYM	87.00ab	40.47b	49.24ab	30.53b	23.38b	3.25a	2.01b	5.26a
50 % CCU +20 FYM	76.00d	28.50g	32.57e	22.40g	18.00g	2.15e	1.48g	3.63f
50 % CCU +10 FYM	73.00de	26.50h	28.93f	21.11h	17.66g	1.91f	1.39h	3.03g
LSD $_{at\ 5\%}$	3.11	0.24	2.05	0.14	0.60	0.135	0.009	0.139

The increment rates of the highest values for seeds yield over control, 100 % urea, and 100 % carbon coated urea were 90.17, 41.05 and 29.87 %, respectively. Such increase might be due to the physiological effect of nitrogen nutrition on plant development. And also, organic fertilizer (FYM) which enhanced soil physic-chemical properties and accordingly increasing the growth as mentioned by Aher, *et al*., (2015). Soil organic matter plays pivotal roles in several processes of the soil ecosystem including nutrient cycling, soil structure formation, carbon sequestration, water retention and energy supply to microorganisms as mentioned by Lakaria, *et al*., (2011).

The finding in (Table 5 and 6) points to that N, P and K % and uptake kg fed^{-1} at harvest stage of soybean stover and seeds increased significantly by integrated application of T_8- 75% CCU+ 20 m^3 FYM, than the rest of other treatments. The increase in soybean stover N%, P%, K%, N (kg fed^{-1}), P (kg fed^{-1}) and K (kg fed^{-1}) uptake was (13.86, 44.44, 8.57, 55.44, 97.38 and 48.20%), respectively compare to 100% urea.

While, the soybean seeds N%, P%, K%, N (kg fed^{-1}), P (kg fed^{-1}) and K (kg fed^{-1}) uptake values were (8.38, 58.06, 27.77, 52.89, 122.86 and 80.24%), respectively compare to 100% urea.

Such increase in nutrients attributed to improved efficiency of carbon coated urea to the soil increased the availability of nitrogen. Also, FYM increase available N, P and K might be due to the organic acids, which were released during microbial decomposition of organic matter, which helped in the solubility of native nutrients.

Table 5. Effect of urea, carbon coated urea and farm yard manure and their interaction treatments on soybean stover nutrients content % and uptake (kg fed^{-1}) at 2019/2020 seasons.

Treatments	Soybean					
	Stover			Uptake		
	N%	P%	K%	N (kg fed^{-1})	P (kg fed^{-1})	K (kg fed^{-1})
Absolute Control	0.67j	0.15h	2.50h	11.52e	2.58e	43.00f
100 % U	2.02e	0.27de	2.80e	48.68c	6.50c	67.48d
100 % CCU	2.09d	0.30cd	2.84d	52.66c	7.56c	71.56d
75 % U+20 FYM	2.20b	0.35ab	2.90c	68.86ab	10.95a	90.77b
75 % U+10 FYM	2.16c	0.33bc	2.87cd	64.36b	9.83b	85.52c
50 % U+20 FYM	1.71h	0.19fgh	2.69f	33.68d	3.74d	52.99e
50 % U+10 FYM	1.59i	0.17gh	2.64g	29.89d	3.19de	49.63e
75 % CCU +20 FYM	2.30a	0.39a	3.04a	75.67ab	12.83a	100.01a
75 % CCU +10 FYM	2.27a	0.37ab	2.96b	73.77a	12.02a	96.20ab
50 % CCU +20 FYM	1.90f	0.23ef	2.77e	40.85c	4.94c	59.55d
50 % CCU +10 FYM	1.85g	0.21fg	2.72f	35.33d	4.01d	51.95e
LSD $_{at\ 5\%}$	0.03	0.041	0.04	11.38	1.64	6.86

Table 6. Effect of urea, carbon coated urea with farm yard manure and their interaction on soybean seeds nutrients content % and uptake (kg fed^{-1}) at 2019/2020 seasons.

Treatments	Soybean					
	Seeds			Uptake		
	N%	P%	K%	N (kg fed^{-1})	P (kg fed^{-1})	K (kg fed^{-1})
Absolute Control	3.96k	0.18i	1.25j	44.35k	2.01j	14.00k
100 % U	7.51f	0.31ef	1.80f	113.40f	4.68f	27.18f
100 % CCU	7.60e	0.35de	1.86e	124.64e	5.74e	30.50e
75 % U+20 FYM	7.87c	0.40c	2.05c	149.53c	7.60c	38.95c
75 % U+10 FYM	7.74d	0.37cd	1.98d	135.45d	6.47d	34.65d
50 % U+20 FYM	6.21i	0.24h	1.52i	80.73i	3.12hi	19.76i
50 % U+10 FYM	6.09j	0.22hi	1.49i	76.73j	2.77i	18.77j
75 % CCU +20 FYM	8.14a	0.49a	2.30a	173.38a	10.43a	48.99a
75 % CCU +10 FYM	8.00b	0.44b	2.21b	160.80b	8.84b	44.42b
50 % CCU +20 FYM	6.59g	0.29fg	1.70g	97.53g	4.29fg	25.16g
50 % CCU +10 FYM	6.47h	0.26gh	1.63h	89.93h	3.61gh	22.65h
LSD $_{at\ 5\%}$	0.03	0.04	0.04	0.71	0.73	0.75

It was evident from the results (Table 7) that carbon coated urea influence significantly on protein content the highest increase was by application of T_8 (75% CCU+20 m^3 FYM) over the control, 100% urea and %100 carbon coated urea were 82.85, 6.53 and 4.8% respectively. Also, agronomic use efficiency % were the highest values at the same treatment. The benefit effect of integration of inorganic and organic fertilizers manifest in net return and B: C ratio. The net return of L.E and B: C ratio was significantly higher in T_8 treatment followed by T9 as it could be able to increase the yield of soybean in addition to increase the cost of production. Thus, the application of T_8 (75% CCU +20 m^3 FYM) was economically feasible and recommended for soybean production.

Table 7. Effect of urea, carbon coated urea with farm yard manure and their interaction on soybean protein %, Agronomic use efficiency and economics at 2019/2020 seasons.

Treatments	% protein	Agronomic use efficiency	Total cost, L.E	Gross return, L.E	Net return L.E	B:C ratio
Absolute Control	24.75k	0.00	9610	24609.4	14999.4	1.56
100 % U	46.93f	7.09	9550	32562.4	23012.4	2.41
100 % CCU	47.50e	9.45	10800	34844	24044	2.23
75 % U+20 FYM	49.18c	18.91	11934	40801	28867	2.42
75 % U+10 FYM	48.37d	15.27	10674	38104.2	27430.2	2.57
50 % U+20 FYM	38.81i	6.55	11796	28059	16263	1.38
50 % U+10 FYM	38.06j	5.09	10536	27111	16575	1.57
75 % CCU +20 FYM	50.87a	24.48	12870	44575	31705	2.46
75 % CCU +10 FYM	50.00b	21.58	11610	42993	31383	2.70
50 % CCU +20 FYM	41.18g	13.09	12420	31043.6	18623.6	1.50
50 % CCU +10 FYM	40.43h	9.82	11160	29167	18007	1.61
LSD $_{at\ 5\%}$	0.15					

Soil Properties as affected by treatments:

As showed in fig. 1:4 that the soil fertility status after harvesting of soyabean plants affected by all the treatments. It can noticed that soil fertility status after soyabean has a relatively amount of N, P, K mg kg^{-1} more than the soil before soybean cultivation. This indicate that carbon coated urea minimize ammonia volatilization and reduce nitrate leaching and consequently increase nitrogen, NUE and sustainable soil fertility. These results were coinciding with those of Jia, *et al.,* (2021) Who stated that the application of biochar coated urea (BCU) could minimize nitrogen loss mainly by reducing nitrate leaching loss; which could be attributed to the slow-release performance of BCU induced adsorption of nitrogen due to the porous nature and surface functional groups of biochar. However, the application of BCU enhanced ammonia volatilization due to the increase of soil NH^{+4}–N concentration and pH value of microenvironment around urea by BCU. The application of BCU increased NUE since BCU reduced losses of nitrogen fertilizer and increased concentration of nitrogen in the soil as well as nitrogen uptake in oilseed rape.

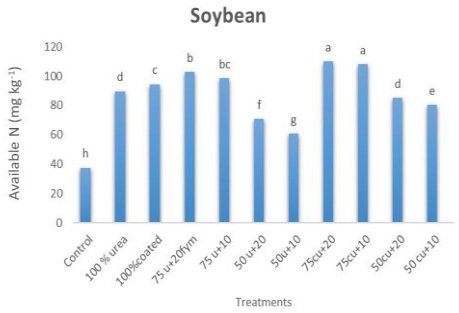

Fig.1. Avavilable N (mg kg^{-1}) in soil after soybean harvest.

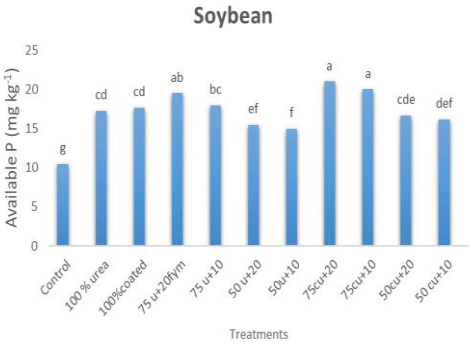

Fig.2. Avavilable p (mg kg^{-1}) in soil after soybean harvest.

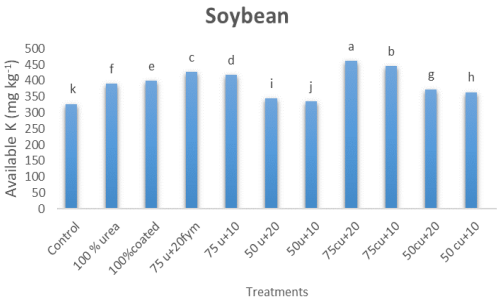

Fig.3. Avavilable K (mg kg^{-1}) in soil after soybean harvest.

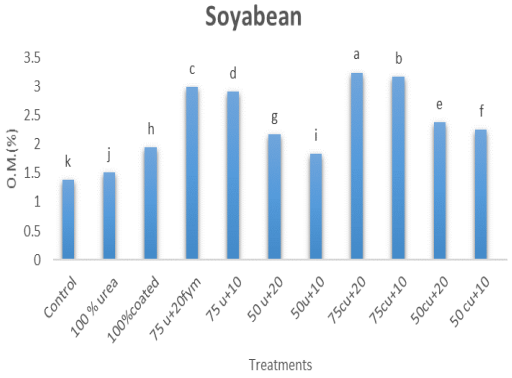

Fig.4. O.M % in soil after soybean harvest.

In addition to soyabean as legumes plant plays an important role for increasing soil fertility by fixing atmospheric nitrogen. Also, the role of organic fertilizer FYM.

These results with in match with those of by Dogan and Bilgili, (2010), who stated that soil organic matter increased by legume crops which fixed nitrogen and the decomposition of organic matter– vies biomass, root and nodules. And Liang, *et al.*, (2003), who stated that the composted bio-solids, once applied to the soil, can accelerate plant growth, improve soil moisture retention, increase organic matter in the soil, and control erosion of the topsoil.

Wheat plants and its components at vegetative stage:

The obtained data in (Table 8) show that, there were significant differences between most treatments under study with wheat N, P and K% and pigments (chlorophyll a, b and carotene) at vegetative stage which increased by the application of integration of carbon coated urea and organic fertilizers FYM. The obtained data revealed that T8 **(**75% CCU+ 20 m^3 FYM), gave the highest values for all parameters under investigations compared with control, urea (100%) and carbon coated urea (100%) or between them.

Table 8. Effect of urea, carbon coated urea with farm yard manure and their interaction on nutrients % and pigments (mg g FW^{-1}) of wheat plants at vegetative stage at 2019/2020 seasons.

	Wheat					
Treatments	**Nutrients % at vegetative stage**			**Chlorophyll a (mg g FW^{-1})**	**Chlorophyll b (mg g FW^{-1})**	**Carotene (mg g FW^{-1})**
	N%	**P%**	**K%**			
Absolute Control	1.66k	0.25g	1.61k	0.350e	0.069e	0.145h
100 % U	2.41f	0.50bc	3.15f	0.386a-d	0.087de	0.172d
100 % CCU	2.50e	0.49bc	3.20e	0.392abc	0.091de	0.176d
75 % U+20 FYM	2.79c	0.52ab	3.37c	0.403ab	0.098d	0.186b
75 % U+10 FYM	2.66d	0.51ab	3.31d	0.398ab	0.103c	0.181c
50 % U+20 FYM	2.03i	0.42ef	2.75i	0.365cde	0.110de	0.157fg
50 % U+10 FYM	1.94j	0.40f	2.70j	0.361de	0.077de	0.154g
75 % CCU +20 FYM	3.08a	0.54a	3.60a	0.415a	0.150a	0.193a
75 % CCU +10 FYM	2.91b	0.52ab	3.55b	0.409a	0.130b	0.190ab
50 % CCU +20 FYM	2.22g	0.47cd	3.05g	0.413a	0.076de	0.164e
50 % CCU +10 FYM	2.10h	0.45de	2.97h	0.374b-e	0.073de	0.161ef
LSD $_{at\ 5\%}$	0.06	0.038	0.04	0.030	0.027	0.005

Wheat yield and its components at harvest stage:

Data in (Table 9) illustrate that at wheat harvest stage there was a noticeable significant increases with application of T8 (75% CCU + 20 m^3 FYM) treatment, where gave the highest values for all parameters under investigation which were 238.73(g), 45.10 (g), 3.31 (Ton fed^{-1}) 4.01 (Ton fed^{-1}) and 7.32 (Ton fed^{-1}), for grain weight, 1000- grain weight, straw, grains and biological yield, respectively. Whereas T_7 (50% U +10 m^3 FYM), gave the lowest values for all parameters under study.

From the same table the percentage differences between grains yield (Ton fed^{-1}) compared with control, 100% urea and 100% carbon coated urea were 90.95, 13.28 and 10.77 %, respectively. These results agree with those of Hassanein, *et al.,* (2013) who adding 90 kg N fed^{-1} slow release N fed^{-1} (Enciabien) which resulted in a significant increment in plant height, grain yield (g m^{-2}), grain yield (ton fed^{-1}) and harvest index, while addition of slow release N fertilizers at the rate of 120 kg N/fed surpassed the other treatments in other characters of wheat plants.

Table 9. Effect of urea, carbon coated urea with farm yard manure and their interaction on plant height (cm),(straw, grains and 1000- grain) weight (g) and (straw, grains and biological) yield (Ton fed^{-1}) of wheat plant at harvest stage at 2019/2020 seasons.

Treatments	Wheat						
	Plant height (cm)	Straw weight (g)	Grains weight (g)	1000-grain weight (g)	Yield (Ton fed^{-1})		
					Straw	Grains	Biological
Absolute Control	81.50k	131.00j	125.00k	35.60k	2.20j	2.10k	4.30k
100 % U	91.70f	175.00e	210.51f	40.50f	2.94e	3.54f	6.48f
100 % CCU	93.20e	181.00d	215.37e	41.50e	3.04d	3.62e	6.66e
75 % U+20 FYM	96.10c	190.00b	225.52c	43.40c	3.19b	3.79c	6.98c
75 % U+10 FYM	94.70d	185.00c	220.76d	42.80d	3.11c	3.71d	6.82d
50 % U+20 FYM	87.00i	158.00h	192.27i	37.60i	2.65h	3.23i	5.88i
50 % U+10 FYM	85.90j	153.00i	187.41j	36.80j	2.57i	3.15j	5.72j
75 % CCU +20 FYM	98.90a	197.00a	238.73a	45.10a	3.31a	4.01a	7.32a
75 % CCU +10 FYM	97.30b	194.00a	232.06b	44.10b	3.26a	3.89b	7.15b
50 % CCU +20 FYM	90.20g	169.00f	201.23g	39.20g	2.84f	3.38g	6.22g
50 % CCU +10 FYM	88.50h	162.67g	198.19h	38.50h	2.73g	3.33h	6.06h
LSD $_{at\ 5\%}$	0.83	3.96	2.35	0.51	0.067	0.039	0.083

Data in (Table 10) mentioned that N, P and K % and uptake (kg fed^{-1}) in wheat straw at harvest stages increased by integrated application of T$_8$ **(** 75% CCU+ 20 m^3 FYM),where , gave the highest values for nutrients uptake which were 40.38, 8.61 and 124.79 (kg fed^{-1}) for N, P and K, respectively. But the T$_7$ (50% U + 10 m^3 FYM) gave the lowest values.

Table 10. Effect of urea, carbon coated urea with farm yard manure and their interaction on straw wheat nutrients content % and uptake (kg fed^{-1}) at 2019/2020 seasons.

Treatments	Wheat					
	Straw			Uptake		
	N%	P%	K%	N(kg fed^{-1})	P(kg fed^{-1})	K(kg fed^{-1})
Absolute Control	0.75g	0.18i	2.105j	16.51k	3.96k	51.72k
100 % U	0.93d	0.21e	3.50e	27.36f	6.20f	102.90j
100 % CCU	0.96d	0.22d	3.55d	29.19e	6.57e	107.95i
75 % U+20 FYM	1.06c	0.24c	3.61c	33.84c	7.63c	115.23h
75 % U+10 FYM	1.03c	0.22d	3.58cd	32.02d	6.84d	111.27g
50 % U+20 FYM	0.80f	0.19gh	2.96h	21.24i	5.12i	78.57f
50 % U+10 FYM	0.76g	0.19h	2.90i	19.46j	4.86j	74.54e
75 % CCU +20 FYM	1.22a	0.26a	3.77a	40.38a	8.47a	124.78d
75 % CCU +10 FYM	1.16b	0.25b	3.69b	37.81b	8.05b	120.27b
50 % CCU +20 FYM	0.89e	0.20f	3.30f	25.27g	5.68g	93.69c
50 % CCU +10 FYM	0.86e	0.19fg	3.18g	23.50h	5.38h	86.90a
LSD$_{at5\%}$	0.04	0.005	0.03	1.73	0.23	3.84

As reported above the same trend was in (Table 11) where N, P and K % and uptake (kg fed^{-1}) in wheat grains at harvest stages increased by integrated application of T$_8$ **(**75% CCU + 20 m^3 FYM), where gave the highest values for N, P and K nutrients uptake which were 67.85, 281.29 and170.6 (kg fed^{-1}) for N, P and K, respectively. But the T$_7$ (50% U + 10 m^3 FYM) gave the lowest values.

Data in (Table 12) revealed that integration of inorganic and organic fertilizers had a remarkable influence on wheat protein%, Agronomic use efficiency and economics. The highest values was at T$_8$ (75% CCU+ 20 m^3 FYM).

These results were in harmony with those of Abou-Keriasha and Eissa (2014) who revealed that growing wheat and maize in crop sequence with inclusion of legume intercrops) and fertilizing with mineral N fertilizer combined with compost produced the highest values of intensification index and net return.

It apparent from Fig. 5:8 that residual nutrients after harvest of wheat plants. The integrated application of T$_8$- 75% CCU + 20 m^3 FYM, gave the highest values of N, P, K and OM % than the rest of other treatments.

These results with in match with those found by Liang, *et al*., (2003).

Table 11. Effect of urea, carbon coated urea with farm yard manure and their interaction on grains wheat nutrients content % and uptake (kg fed^{-1}) at 2019/2020 seasons.

Treatments	Wheat					
	Grains			Uptake		
	N%	P%	K%	N (kg fed^{-1})	P (kg fed^{-1})	K (kg fed^{-1})
Absolute Control	1.52k	0.30i	0.60g	31.92k	6.31h	14.31i
100 % U	2.79f	0.45e	0.95d	98.77f	15.91d	27.95e
100 % CCU	2.88e	0.48de	1.03c	104.26e	17.37cd	31.32d
75 % U+20 FYM	3.37c	0.54bc	1.10b	127.72c	20.46b	35.11bc
75 % U+10 FYM	3.26d	0.50cd	1.07bc	120.95d	18.54c	33.26cd
50 % U+20 FYM	1.94i	0.35gh	0.74f	62.66i	11.31fg	19.65h
50 % U+10 FYM	1.75j	0.32hi	0.71fg	55.12j	10.07g	18.00h
75 % CCU +20 FYM	3.83a	0.60a	1.17a	153.58a	24.06a	38.73a
75 % CCU +10 FYM	3.64b	0.58ab	1.10b	141.59b	22.61a	35.86b
50 % CCU +20 FYM	2.31g	0.40f	0.85e	78.08g	13.52e	24.14f
50 % CCU +10 FYM	2.10h	0.37fg	0.80e	69.93h	12.32ef	21.86g
LSD $_{at\ 5\%}$	0.05	0.043	0.05	2.13	1.53	2.11

Table 12. Effect of urea, carbon coated urea with farm yard manure and their interaction on wheat protein%, Agronomic use efficiency and economics at 2019/2020 seasons.

Treatments	% Protein	Agronomic use efficiency	Total cost, L.E	Gross return, L.E	Net return L.E	B:C ratio
Absolute Control	8.66f	0.00	9000.0	14552.0	5552.0	1.62
100 % U	15.90a	24.01	9599.8	22975.5	13375.7	2.39
100 % CCU	16.42a	26.22	10890.0	23569.0	12679.0	2.16
75 % U+20 FYM	19.21bc	40.75	9414.7	24697.5	15282.8	2.62
75 % U+10 FYM	18.58c	38.82	9414.7	24142.8	14728.13	2.56
50 % U+20 FYM	11.06de	38.31	9295.04	20919.7	11624.63	2.25
50 % U+10 FYM	9.97e	35.59	9295.04	20355.3	11060.29	2.19
75 % CCU +20 FYM	21.83a	47.69	10305.0	26006.5	15701.5	2.52
75 % CCU +10 FYM	20.75ab	44.69	10305.0	25363.2	15058.17	2.46
50 % CCU +20 FYM	13.17c	45.04	9930.0	22019.5	12089.5	2.22
50 % CCU +10 FYM	11.97cd	43.28	9930.0	21561.0	11631.0	2.17
LSD at 5%	1.73					

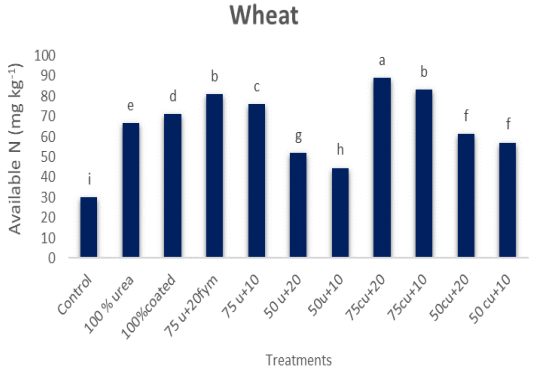

Fig.5. Avavilable N (mg kg^{-1}) in soil after wheat harvest.

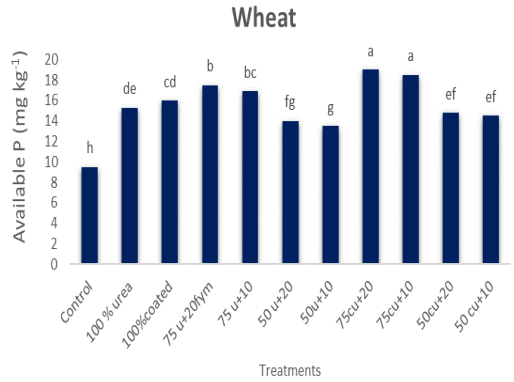

Fig.6. Avavilable p (mg kg^{-1}) in soil after soybean harvest.

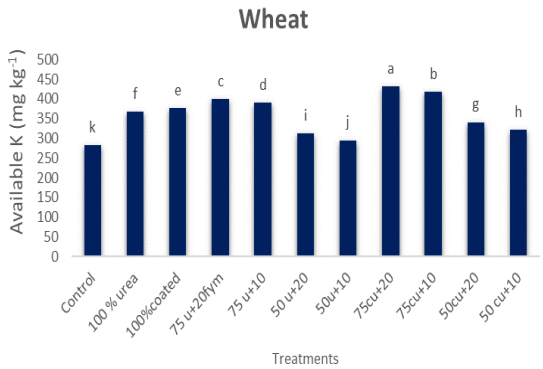

Fig.7. Avavilable K (mg kg^{-1}) in soil after wheat harvest.

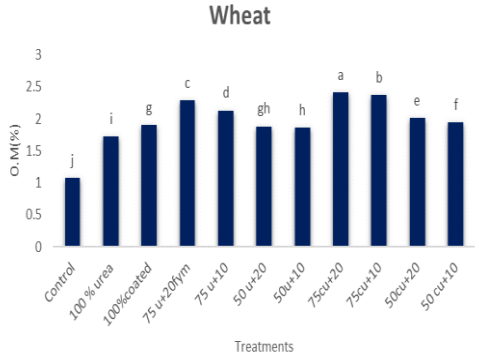

Fig.8. O.M % in soil after wheat harvest.

CONCLUSION

From this study it can be concluded that the maximum technical yield to the soybean crop following wheat in a carbon coated urea system was achieved with integration of inorganic fertilizers (carbon coated urea CUF) with organic fertilizer (FYM) by the application of 75% CCU + 20 m^3 FYM. In top dressing to soybean following wheat provides the maximum economic yield to obtain grains yield.

- The optimization of the N fertilizer applied improving the N recovery and minimizing its possible losses.
- To optimize the N recovery a major portion of N fertilizer should be applied at 75% CCU + 20 m^3 FYM.
- Carbon coated urea are an efficient and economically source for application in top dressing soybean following wheat.

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تأثير اليوريا المغلفة بالكربون مع الأسمدة العضوية على التعاقب المحصولى (فول صويا – قمح)

إيمان محمود رشوان ، رشا السيد المهدى و محمد رضا عبد الهادى محمد

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تم إجراء تجربتان حقليتان على فول الصويا (جيزة صنف١١١) ، قمح (صنف مصر١) ، بمحطة بحوث التجارب الزراعية بتاج العز ، مركز البحوث الزراعية ، محافظة الدقهلية ، مصر خلال موسمين تعاقبيين صيفي شتوى متتاليين (مايو إلى نوفمبر ٢٠١٩) ثم (نوفمبر٢٠١٩إلى مايو ٢٠٢٠). اشتملت التجربة على أحد عشر (١١) معاملة وهى كالتالى (م١- كنترول ، م٢-١٠٠ % يوريا (المعدل الموصي به من سماد اليوريا)، م٣-١٠٠٪ يوريا مغلفة بالكربون (المعدل الموصى به من سماد اليوريا المغلفة بالكربون)، م٤-٧٥٪ يوريا +٢٠م٣سماد بلدى ، م٥- ٧٥ % يوريا +١٠ م٣سماد بلدى ،م٦- ٥٠٪ يوريا + ٢٠ م٣سماد بلدى ، م٧-٥٠٪ يوريا + ١٠ م٣ سماد بلدى ،م٨- ٧٥% يوريا مغلفة بالكربون+٢٠ م٣سماد بلدى ، م٩-٧٥% يوريا مغلفة بالكربون +١٠ م٣سماد بلدى ،م١٠- ٥٠٪ يوريا مغلفة بالكربون + ٢٠ م٣سماد بلدى ،م١١- ٥٠٪ يوريا مغلفة بالكربون + ١٠ م٣ سماد بلدى). صممت التجربة في تصميم قطاعات كاملة العشوائية بثلاث مكررات . أشارت النتائج إلى أن أعلى القيم في مرحلة النمو الخضري (النيتروجين ، الفوسفور و البوتاسيوم٪ والكلوروفيل أ ، ب ، كاروتين) ، المحتوى الكيميائي فى مرحلة الحصاد (النيتروجين ، الفوسفور و البوتاسيوم٪ في عرش وبذور فول الصويا أو قش و حبوب القمح) والبروتين٪ والمحصول و مكوناته (طول النبات سم ، وزن العرش، البذور طن فدان -١ و وزن ١٠٠بذرة جم من فول الصويا أو وزن القش والحبوب طن فدان -١ ووزن ال ١٠٠٠ حبة جم من القمح تم تسجيلها مع معاملة الأسمدة العضوية وغير العضوية معا" . تعتبر معاملة م٨- ٧٥ % يوريا مغلفة بالكربون+٢٠ م٣سماد بلدى هى الأكثر ملاءمة للحصول على أعلى إنتاجية من فول الصويا - القمح تحت ظروف هذه التجربة.