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Increase in growth, productivity and nutritional status of wheat (*Triticum aestivum* L. cv. WH-711) and enrichment in soil fertility applied with organic matrix entrapped urea

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Abstract

Field experiments were conducted during two consequent years in semi-arid, subtropical climate of Rohtak district situated in North-West Indian state Haryana to evaluate the effects of eco-friendly organic matrix entrapped urea (OMEU) on wheat (*Triticum aestivum* L. cv. WH-711). The OMEU prepared in granular form contained cow dung, rice bran (grain cover of *Oryza sativa*), neem (*Azadirachta indica*) leaves and clay soil (diameter of particles <0.002mm) in 1:1:1:1 ratios and saresh (plant gum of *Acacia* sp.) as binder entrapping half of the recommended dose of urea. A basal application of organic matrix entrapped urea showed increase in plant growth in terms of fresh and dry weights, root length, root number, leaf number, tillers, plant height, earlet number, earlet length and productivity in terms of grain yield and straw yield over free form of urea (FU) and no fertilizer (NF) application. The OMEU increased total soluble proteins, organic N and free ammonium content in the leaves at 45 and 60 days. The nutritional status of wheat grains in OMEU applied plants was almost similar to that observed for FU applied plants. An increase in organic carbon and available phosphorus (P) was observed in OMEU applied plots on harvest, whereas pH was slightly decreased over FU applied plots. The microbial population and activity in terms of fungal and bacterial colony count and activities soil dehydrogenase and alkaline phosphatase were significantly higher in OMEU applied plots as compared to the FU applied plots. Our data indicate that OMEU which are low cost, biodegradable and non-toxic can be used to replace the expensive chemical fertilizers for wheat cultivation in semi-arid, subtropical climate.

Key words

Cowdung, Organic matrix entrapped urea, Plant growth, Saresh (plant gum of *Acacia* sp.), Yield

Introduction

Wheat and rice are the major cereal crops in India, covering a large area of cultivable land in India and other countries and consume maximum amount of N fertilizers (Sharma *et al.,* 2008). Industrial fixation of nitrogen for the use as fertilizer represent the largest human contribution of new reactive nitrogen to the N-cycle, which is evident from the fertilizer use in India during 1995-2005 (FAI, 2005). From 1960, hybrid rice and wheat varieties developed during green revolution phase in India are highly responsive to fertilizer pesticides and water and though have added very significantly to food grain production in the country, it has caused many environmental concerns e.g. loss of organic matter and micronutrients in the soil, loss of biodiversity, depletion of water table, increase in salinity and contamination of water and air with reactive nitrogen species (FAI, 2005; Singh and Singh, 2008). Due to decrease in organic matter and micronutrients in intensive cultivation areas a decline or stagnation in the productivity of wheat has been documented which persuade farmers for further loading of nitrogenous chemical fertilizers (Quyen *et al.,* 2002; Satyanarayana *et al.,* 2002; Singh *et al.,* 2006; Liew *et al.,* 2010).

It has added serious environmental problems such as increase in green house gases, ammonia volatilization, eutrophication of streams and lakes, destruction of ozone layer, soil acidification and human diseases (Golloway *et al.*, 2008; Gupta *et al.,* 2008; Velmurugan *et al.,* 2008; Weligama *et al.,* 2010). Some studies have shown leaching losses of nitrogen from soil in Indo-Gangetic-Plains whereas ammonia volatilization loss with application of 120.0 kg N ha^{-1} in rice and wheat has also been recorded (Sharma *et al.,* 2008). A large area in Uttar Pradesh, Punjab, Haryana and other part of the country as well as in many other countries has been affected by nitrate pollution of ground water (Rawat and Singh, 2010). Thus it appears that the large increase in nitrogen fertilizers represents a potentially alarming situation from the environmental, economic and resource conservation point of view and indicates an urgent need for improving efficiency of the fertilizer use. The use of slow release and other customized fertilizers especially N fertilizers have been reported for rice (Zheng *et al.,* 2006; Dahiya *et al.,* 2004; Li *et al.*, 2005; Tang *et al.,* 2006; Kabat and Panda, 2009; Kumar *et al.*, 2012), lettuce (Hartrath, 1986), potato (Prugar and Hadacova, 1996), tomato (Montemurro, 2005), bean (El-Gindy *et al.,* 2000), zuccini (Martinetti and Paganini, 2006), soy bean (Kaushal *et al.,* 2006), beans (El-Tohamy *et al.,* 2009), grape, mango, banana and date palm (Hasan *et al,* 2010), peach (Kandil *et al.,* 2010) and wheat (Mubeen *et al.,* 2006; Carlier *et al.,* 2008; Shaharoona *et al.,* 2008). However, most of the formulations are based on expensive chemicals and may be out of reach to the farmers in Indian agricultural economics. It require development of low cost, ecofriendly slow release fertilizers, which can be developed using local biodegradable agro waste easily available for local production by small scale industries or by farmers. We have demonstrated that chemical fertilizers entrapped in organic matrix containing cow dung, clay soil, neem leaf powder, rice bran and *Acacia* gum (non toxic and biodegradable organic materials) as a carrier prepared in the form of super granules enhanced growth, productivity and yield in rice (Dahiya *et al.,* 2004) and Indian mustard (Sharma *et al.*, 2011). This fertilizer has been found eco-friendly and cost effective, therefore this study has been extended for important cereal crop wheat, extensively grown in Indian subcontinent. No such study is available for wheat as per our data base.

Materials and Methods

Site of experiments: The experiments were conducted in the agricultural fields situated in a semiarid subtropical climate at Rohtak, Haryana (India), located at 28.54" N latitude, 76.38° E longitudes and an altitude of 222.5 m above sea level. The certified seeds of wheat (*Triticum aestivum* L. cv. WH-711) were obtained from a local dealer at Rohtak. The organic matrix entrapped urea (OMEU) contained half of the recommended dose of chemical fertilizers i.e. 40.0 kg ha^{-1} urea, entrapped in organic matrix consisting of cow dung, rice (*Oryza sativa*) bran, dried powder of neem (*Azadirachta indica*) leaves and clay soil (diameter of particles <0.002 mm) in 1:1:1:1 ratios and saresh (plant gum of *Acacia* sp.). The effects of various fertilizers were studied in experimental plots (was 3x3m^2) in random block design during 2005-2008 (Oct-April). There were three treatments each with three replicates i.e. NF (No fertilizers) = control (no additional fertilizers), FU = Free urea; soluble urea in two split doses of 80 kg ha^{-1} at 0 and 30 days of sowing, OMEU= Organic matrix entrapped urea; half of the recommended dose of urea i.e. 80.0 kg ha^{-1}urea in organic matrix.

Preparation of organic matrix entrapped urea (OMEU): Agro waste like cow dung, rice (*Oryza sativa*) bran, dried powder of neem (*Azadirachta indica*) leaves and clay soil (diameter of particles <0.002 mm) were collected locally. All the collected materials were dried separately in an oven at 60-70^0 C for 3 days and powdered in a grinder and mixer. This supporting matrix was then mixed in 1:1:1:1 ratios. For preparing OMEU, half of the recommended dose of chemical fertilizer i.e. 80.0 kg ha^{-1} urea entrapped in 160.0 kg ha^{-1} matrix (1:2 ratio) and finally immobilized with 25% saresh (about 25.0g for 1.0 kg) was used as binder to the matrix and a total 123.10 kg ha^{-1} MOEU granules was applied as a basal application at the time of sowing.

Estimation of released ammonium from slow release fertilizers (SRFs): Ammonium released from SRFs was measured periodically using method given by Weatherburn (1967).

Physico-chemical characteristics of soil : Soil pH was measured electrometrically using glass electrode pH meter, model N1G 333 (Jackson, 1973). Electrical conductivity (EC) was measured by the method of Richard (1954). Organic carbon in the soil samples was estimated by wet digestion method of Walkley and Black (1934) with slight modification. Available phosphorus in soil was estimated by the method of Olsen *et al.* (1954). Potassium was estimated by flame photometer (Perkin-Elmer model 52, flame photometer with acetylene of propane burner) following the method of Jackson (1973). The soil dehydrogenase activity was measured by the method of Casida *et al.* (1964) and alkaline phosphatase activity was measured by the method of Tabatabai and Brenner (1969). Available nitrogen in soil was estimated using the alkaline potassium permanganate method of Subbaih and Asija (1955). Microbial biomass was measured by plate count method of APHA (1984).

Determination of biochemical parameters and nutritional status in wheat grain: Organic nitrogen was estimated by the microkjeldahl method (Lang, 1958). Protein and free ammonium was estimated by the method of Bradford (1976) and Weatherburn (1967) respectively. Nutritional status was estimated by using Nutritional Parameter Estimation Machine. The values have been expressed in dry matter percentage (%).

Determination of growth parameters : The fresh weight of different plant parts was recorded at 60 and 120 days after sowing with single pan electric balance. Dry weight of the same tissue was recorded after drying it in a hot air electric oven 60°C for 48 hrs. The root and shoot length was measured regularly on a meter scale. The growth parameters like number of leaves and primary roots were counted at regular intervals.

Statistical analysis: The data were analyzed by one-way analysis of variance (ANOVA) and $p<0.05$ with Completely Random Block Design according to the experimental plan.

Results and Discussion

Release of ammonium (method) from the OMEU in wet soil and water: The OMEUs released 13 m mol NH_4^+ in wet soils up to 40th day after placing in glass beaker, whereas the soil could retain very low amount of NH_4^+ if added in unbound form (Fig. 1A). Release of NH_4^+ from OMEU however, profoundly faster, when the granules were placed directly in water (Fig. 1B). It indicates that the affectivity of these OMEU granules for retention of the nutrients is limited in non-waterlogged conditions. The N is deficient in the agricultural soil of semi-arid, subtropical Indo-Gangatic plains of Northern Indian States which witnesses a very extensive rice-wheat cropping system (Nayak *et al.,* 2011). The loading of synthetic N fertilizers have been found directly co-related to the productivity of cereals in general and wheat in particular (Abedi *et al.,* 2010; Cerny *et al.,* 2010). The loaded fertilizers, however, are not completely utilized by the plants due to limited efficiency of plants to take-up and assimilate the nutrients which range from 30-50% depending on the plant genetic makeup and soil texture as well as due to losses by leaching, run-off, volatilization and emissions in soil, water and atmosphere (Adesemoye *et al.,* 2009; Xue *et al.,* 2010; Jiang *et al.,* 2010; Rawat and Singh, 2010). The organic fertilizers (Sieling *et al.,* 2006), biofertilizers (Mikhailouskaya and Bogdevitch, 2009; Kumar *et al.,* 2010; Ramanjaneyulu *et al.,* 2010), customized fertilizers (Dahiya *et al.,* 2004; Singh 2006; Singh *et al.,* 2008, 2010; Emilsson *et al.,* 2010; Sharma and Singh, 2011) or integrated nutrient systems (Adani *et al.,* 2007; Sharma *et al.,* 2011; Singh *et al.,* 2011) are seen as possible alternatives. William and Gorden (1999) have stated that, when urea fertilizers are applied to the surface, losses of fertilizer N as NH_3 can exceed 40% and generally greater with increasing temperature, soil pH and surface residue.

Growth parameters: Fresh and dry weights of wheat (*Triticum aestivum* L. cv. WH-711) increased with the application of free urea 80 kg ha^{-1} (two split doses) and entrapped urea 40 kg ha^{-1} bound in organic matrix (OMEU) at 60 days and 120 days after sowing (Fig. 2). The increase in plant biomass by the free or entrapped urea was significantly higher over no fertilizer applied plants.

Tiller number and plant height enhanced significantly with the application of FU as well as OMEU at 60 and 120 days after sowing (Fig. 2). The percentage increase of 40% in tiller number and 4% in plant height was recorded in 60 days old plants by the application of OMEU over free urea.

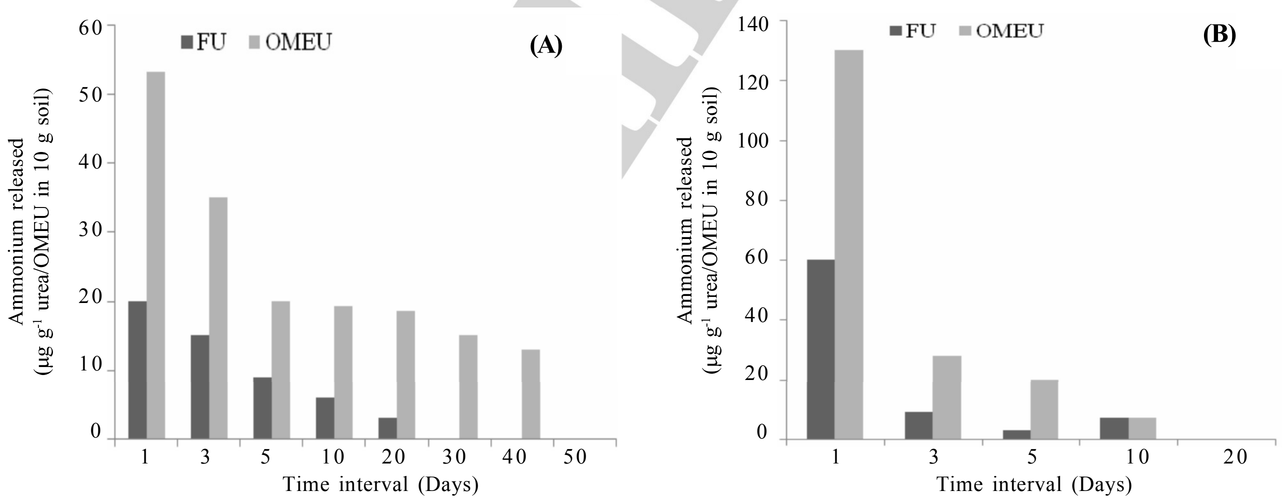

Fig. 1 : Ammonium released from organic matrix entrapped urea (OMEU) containing 25% saresh (binder) at different days interval in (A) wet soil and (B) water. Values are mean of six replicates ± SE. Data was analyzed by one-way ANOVA at $p< 0.05$

On 120 days tiller number and plant height were increased by 49 and 5% by the application of OMEU over the FU. There was significant increase in tiller number and plant height in free and entrapped urea applied plants over no fertilizer plants. Root length and root number also increased by 19 and 32% respectively on 60 days and 22 and 11% respectively on 120 days over free urea (Fig. 2). The significant percentage increase of 8% in leaf number was recorded in 60 days old plants by the application of OMEU over un-entrapped urea. A similar trend of increase in leaf number was observed when plants were grown for 120 days in the same experimental plots where OMEU showed 30% increase in leaves over no fertilizer and 20% over the free form of urea.

The performance of newly developed fertilizers on wheat was studied for two subsequent years in the experimental fields. The growth and biomass increase was primarily because of increase in fresh and dry weight of different plant parts. Tillers and roots were increased very significantly. It appears that an ideal fertilizer management can be achieved in which nutrients are supplied to plants continuously in the form and quantity that are required at each stage of growth and productivity of plants (Kandil *et al.,* 2010). Similarly, other crops showed enhanced plant growth and yield with the application of slow release fertilizers including tender green mustard (Ombodi *et al.*, 2000; Ali *et al.,* 2005; Mubeen *et al.,* 2006; Carlier *et al.,* 2008; Shaharoona *et al.,* 2008; El-Tohamy *et al.,* 2009; Hasan *et al.,* 2010; Kandil *et al.,* 2010). The rapid conversion of synthesized carbohydrate in to protein and consequent to increase in the number and size of growing cells, resulting increase in number of tillers is depend on the nitrogen use efficiency of the plant (Singh and Agarwal, 2001; Singh *et al.,* 2011).

Yield attributes: Application of OMEU increased grains and straw yield by more than four fold over no fertilizers (Table 1). The application of conventional urea also increased the grains and straw yield but was lower than OMEU. The data revealed that entrapment of commercially available conventional urea in the better carrier (organic matrix in our case) can significantly increase the efficacy of urea for wheat production. El-Kramany (2001) and Eyvazi (2010) found that slow-release nitrogen fertilizer gave the highest yield ha^{-1} of wheat when compared with other fertilizers. Further, Amal *et al.,* (2007) reported that slow-release nitrogen fertilizer significantly increased yield/plant of grain sorghum as compared with other nitrogenous fertilizers; ammonium nitrate, ammonium sulphate and urea. The higher productivity in wheat crop was also reflected by increased total soluble protein, total organic nitrogen and free ammonium with the application of OMEU at 45 and 60 days after sowing (Figure 2 a, b and c). Some customized fertilizers have been reported to improve the productivity in wheat (Mubeen *et al.,* 2006; Carlier *et al.,* 2008; Shaharoona *et al.,* 2008).

Nutritional status: Application of OMEU maintained the grain protein, moisture, starch, wet gluten and zeleny as estimated for free urea (FU) (Table 2). Data in Table 3 indicate that OMEU caused a minor change in level of N, P and K in grains and straw. It was observed that wheat plants supplied with OMEU contain 27.03, 8.12 and 10.41 kg ha^{-1} NPK respectively in grains and 31.80, 5.02 and 25.01 kg ha^{-1} NPK respectively in straw (Table 3). The FU treated plant

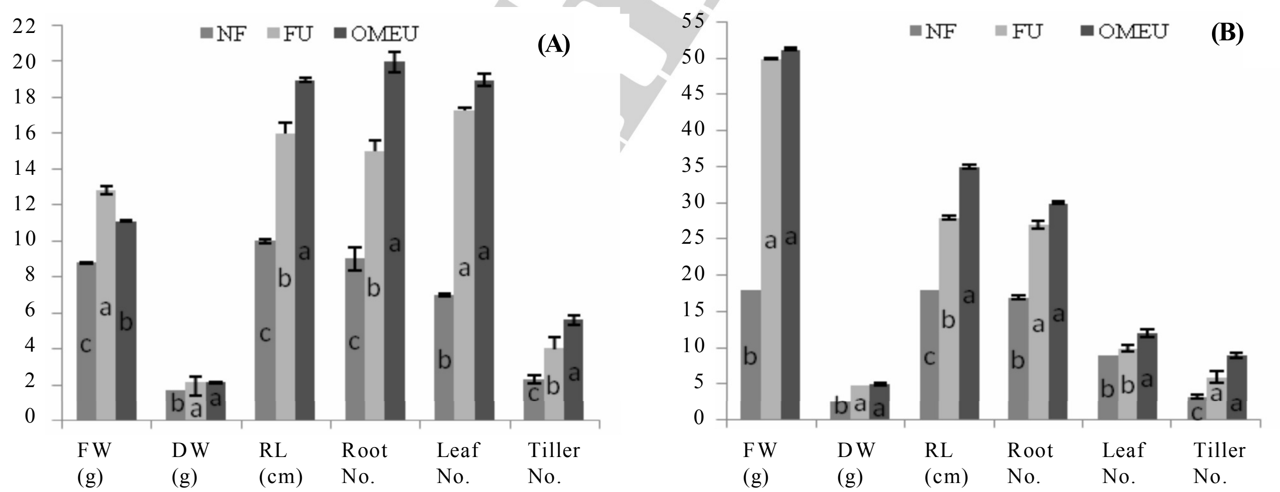

Fig. 2 : Effect of free urea (FU) and organic matrix entrapped ureas (OMEU); on physical growth and productivity in (A) 60 and (B) 120 day old field grown wheat (*Triticum aestivum* L. cv. WH-711) plants. Values are mean of significant $\pm$ SE. Differences are statistically significant and shown by different alphabets using Newman-Keuls test. Data analyzed by one way ANOVA at $p<0.05$

Table 1. Effect of free urea (FU) and organic matrix entrapped urea (OMEU) on yield after harvesting of wheat (*Triticum aestivum* L. cv. WH-711) crop

Treatments	Grains yield (q ha^{-1})	Straw yield (q ha^{-1})
NF	$10.0^{c}\pm0.033$(100)	$15.0^{c}\pm0.033$(100)
FU	$38.0^{b}\pm0.033$(380)	$60.0^{b}\pm0.058$(400)
OMEU	$40.0^{a}\pm0.033$. (400)	$63.0^{a}\pm0.033$(420)

Values are mean of six replicates $\pm$ SE. Differences are statistically significant and shown by different alphabets using Newman-Keuls test. Data analyzed by one way ANOVA at $p<0.05$

contained NPK as 28.0, 8.0 and 10.40 kg ha^{-1} in grains and 30.0, 5.0 and 24.0 kg ha^{-1} respectively in straw, whereas no added fertilizer applied plants had a level of NPK as 17.82, 6.43 and 7.78 kg ha^{-1} in grains and 25.41, 2.99 and 20.44 kg ha^{-1} respectively in straw. Nutritional status of wheat grain which include protein, moisture, starch, wet gluten, zeleny and nutrients uptake of N, P and K kg ha^{-1} in seed and straw was recorded almost similar with application of OMEU, however, increased significantly over no fertilizer application plants.

Protein content of wheat grain and other nutritional parameters also increased due to higher availability of nitrogen in soil as reported by Pearson and Jacobs (1987) in corn Dahiya *et al.* (2004) in rice, Thurley and Ching (1986) in barley and Sharma and Singh (2011) in mustard. This shows that increase in grain protein could be due to an increase in activities of N-assimilating enzymes (Dahiya *et al.*, 2004). The availability of nitrogen in the grain filling stage of wheat with OMEU application led to increased grain protein content.

The organic matrix entrapped urea (OMEU) increased total soluble proteins, organic N and free ammonium content in the leaves at 45 and 60 days (Fig. 3). Total soluble protein increased by 15 and 7% respectively in 45 and 60 days old plants with the application of OMEU over that in free urea (recommended dose applied in two split doses), whereas it decreased significantly in no fertilizer plants (Fig. 3 A). On the other hand, total organic nitrogen (TON) increased marginally with the application of OMEU over free urea at 45 and 60 days after sowing (Fig. 3B). The total organic nitrogen (TON) was, however, significantly higher in the fertilizer applied plants over no fertilizers plants. The application of free urea and OMEU increased ammonium content in wheat leaves by 4-5 folds over no fertilizer plants (Fig. 3 C). The customized fertilizers (coated urea) reduced its solubility, releasing in to the soil and consequently higher availability of nutrients e.g. nitrogen and carbon for the growing crops (Aziz and El-Ashry, 2002, 2009; Kaushal *et al.,* 2006).

Table 2 : Effect of free urea (FU) and organic matrix entrapped urea (OMEU) on nutritional status of wheat (*Triticum aestivum* L. cv. WH-711) grains

Treatments	Protein dry matter (DM)%	Moisture %	Starch dry matter (DM)%	Wet Gluten dry matter(DM)%	Zeleny %
NF	$8.4^{b}\pm0.033$(100)	$7.1^{b}\pm0.033$(100)	$64.2^{b}\pm0.00$(100)	$20.1^{c}\pm0.033$(100)	$25.9^{c}\pm1.376$(100)
FU	$9.6^{a}\pm0.058$(114)	$7.2^{b}\pm0.00$(101)	$65.6^{a}\pm0.033$(102)	$24.7^{a}\pm0.033$(123)	$29.8^{b}\pm0.067$(115)
OMEU	$9.9^{a}\pm0.00$(118)	$7.8^{a}\pm0.067$(110)	$66.7^{a}\pm0.067$(104)	$25.6^{a}\pm0.033$(127)	$30.9^{a}\pm1.00$(119)

Values are mean of six replicates $\pm$SE. Differences are statistically significant and shown by different alphabets using Newman-Keuls test. Data analyzed by one way ANOVA at $p<0.05$

Table 3. Effect of free urea (FU) and organic matrix entrapped urea (OMEU) on physico-chemical characteristics of soil in experimental field of wheat (Triticum aestivum L. cv. WH-711) crop before sowing and after harvesting

	pH (1:2)	EC (1:2) (dS m^{-1})	OC (%)	Total N (kg ha^{-1})	Aval. N (kg ha^{-1})	Aval. P (kg ha^{-1})	Aval. K (kg ha^{-1})
Before sowing of wheat crop							
	9.0	0.24	0.33	330.0	105.0	20.0	220.0
After harvesting of wheat crop							
NF	$8.9^{a}\pm1.00$ (100)	$0.20^{a}\pm0.001$ (100)	$0.34^{a}\pm0.003$ (100)	$337.0^{a}\pm0.667$ (100)	$108.0^{b}\pm0.003$ (100)	$22.0^{b}\pm0.333$ (100)	$223.0^{b}\pm0.333$ (100)
FU	$8.6^{a}\pm0.067$ (97)	$0.21^{a}\pm0.333$ (105)	$0.31^{b}\pm0.003$ (91)	$350.0^{b}\pm0.667$ (104)	$120.0^{a}\pm0.00$ (111)	$21.0^{b}\pm0.00$ (95)	$220.0^{b}\pm0.577$ (97)
OMEU	$8.2^{b}\pm0.033$ (92)	$0.22^{a}\pm0.003$ (110)	$0.35^{a}\pm0.003$ (103)	$355.0^{b}\pm0.333$ (105)	$121.0^{a}\pm0.333$ (112)	$25.0^{a}\pm0.333$(114) (132)	$295.0^{a}\pm0.333$

Values are mean of six replicates $\pm$ SE. Differences are statistically significant and shown by different alphabets using Newman-Keuls test. Data analyzed by one way ANOVA at $p<0.05$

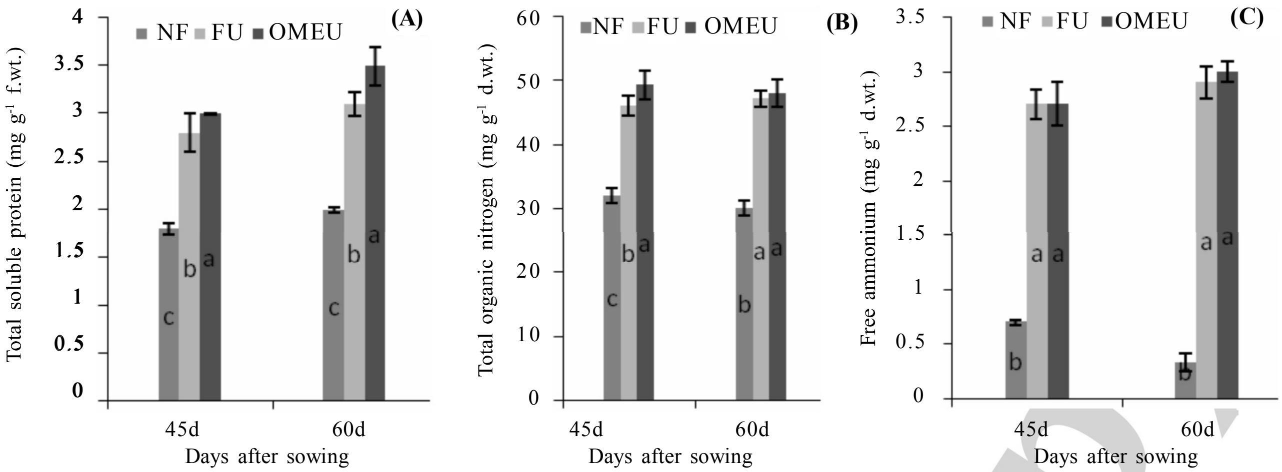

Fig. 3 : Effect of free urea (NF) and organic matrix entrapped urea (OMEU) on (A) total soluble protein, (B) total organic nitrogen and (C) free ammonium on 45 and 60 days old field grown wheat (*Triticum aestivum* L. cv. WH-711) plants. Values are mean of six replications ± SE. Differences are statistically significant and shown by different alphabets using Newman-Keuls test. Data analyzed by one way ANOVA at $p<0.05$

Table 4 : Effect of free urea (FU) and organic matrix entrapped urea (OMEU) on microbial properties of soil in experimental field of wheat (*Triticum aestivum* L. cv. WH-711) crop before sowing and after harvesting

	log No. of fungal colonies g^{-1} of soil	log No. of bacterial colonies g^{-1} of soil
Experimental field before sowing of wheat crop	1.1	2.1
Experimental field after harvesting of wheat crop		
NF	1.2^c±0.033 (100)	3.0^c±0.033 (100)
FU	1.3^b±0.167 (108)	3.2^b±0.058 (107)
OMEU	1.5^a±0.033 (125)	3.8^a±0.067 (127)

Values are mean of six replicates ± SE. Differences are statistically significant and shown by different alphabets using Newman-Keuls test. Data analyzed by one way ANOVA at $p<0.05$

Table 5 : Effect of free urea (FU) and organic matrix entrapped urea (OMEU) on enzymatic activities of soil in experimental field of wheat (*Triticum aestivum* L. cv. WH-711) crop before sowing and after harvesting

	Dehydrogenase activity (µg TPF/g soil/24 h)	Alkaline phosphatase activity (µg PNP/g soil/h)
Experimental field before sowing of wheat crop	13.0	11.0
Experimental field after harvesting of wheat crop		
NF	13.0^c±0.058 (100)	10.0^c±0.058 (100)
UF	14.0^b±0.058 (108)	12.0^b±0.050 (120)
OMEU	17.0^a±0.000 (131)	14.0^a±0.067 (140)

Values are mean of data (n=6) ± SE. Differences are statistically significant and shown by different alphabets using Newman-Keuls test. Data analyzed by one way ANOVA at $p<0.05$

Table 6 : Effect of free urea (FU) and organic matrix entrapped urea (OMEU) on nutrients level kg ha^{-1} of wheat (*Triticum aestivum* L. cv. WH-711) crop after harvesting

Treatments	Nitrogen		Phosphorus		Potessium	
	Grains	Straw	Grains	Straw	Grains	Straw
NF	17.82^c±0.003(100)	25.41^b±0.003(100)	6.43^b±0.003(100)	3.99^c±0.003(100)	7.88^b±0.003(100)	20.44^c±0.003(100)
FU	25.00^b±0.000(140)	30.00^a±0.058(118)	8.00^a±0.033(124)	5.00^b±0.003(125)	10.40^a±0.033(132)	24.00^b±0.033(117)
OMEU	28.03^a±0.010(157)	31.80^a±0.267(125)	8.72^a±0.040(136)	5.92^a±0.007(148)	10.81^a±0.00(137)	25.61^a±0.003(125)

Values are mean of data (n=6) ± SE. Differences are statistically significant and shown by different alphabets using Newman-Keuls test. Data analyzed by one way ANOVA at $p<0.05$

Table 7 : Approximate cost benefit analysis of organic matrix entrapped urea (OMEU) with free urea (FU) and no fertilizers based cultivation of wheat

***Input**

	Cultivation cost ha^{-1} (Rs.)	Seed used kg ha^{-1} (Rs.)	Fertilizer cost ha (Rs.)	Other (matrix+binder cost) (Rs.)	Total input cost (Rs.)
NF	7000	50.0 (1500)	00.00	-	8,500
FU	8,000	50.0 (1500)	927.0	-	10,427
OMEUs	9,000	50.0 (1500)	463.0	960	10,963

Out put

***Direct out put**				****Indirect out put**
Grains yield ($q\ ha^{-1}$)	**Approximate rate kg^{-1} (Rs.)**	**Cost of produce (Rs.)**	**Net loss (-) and gain(+) (Rs.)**	**Soil Enrichment**
10.0	15	15,000	6,500(+)	very
38.0	15	57,000	46,573 (+)	low
40.0	15	60,000	49,037 (+)	high

*Net gain/loss/hectare is approximate and subject to market fluctuations as well as ** it excludes benefits/cost of environmental concerns which could not be quantified

Soil physico-chemical properties were significantly influenced with the application of OMEU. The soil pH and EC decreased from 8.6 and 0.21 dSm^{-1} in FU applied experimental plots to 8.2 and 0.20 dSm^{-1} in OMEU at the time of crop harvest (Table 4). Our data indicate that there was an increase in percent organic carbon in soil applied with OMEU over FU applied plots. The OMEU application increased % organic carbon (OC) and available P in experimental plots over FU applied plots. At the same time OMEU improved the soil physico-chemical properties and biological properties over soluble form of urea and no fertilizers. Matrix is very helpful in increasing organic carbon content in soil. Customized fertilizers enhance the availability of nutrient in the soil because these fertilizers reduce the losses of nutrients (Kondo *et al*., 2005; Tang *et al*., 2007) polyoleûn-coated urea may reduce N loss via runoff and leaching.

Application of organic matrix entrapped urea affect the soil biological properties significantly (Table 5 and 6). More pronounced increase in fungal and bacterial count, dehydrogenase activity and alkaline phosphatase activity was recorded in the soil samples taken after harvest in OMEU treated experimental plots. The percentage increase of 9, 27, 28 and 16% was found in fungal and bacterial count, dehydrogenase and alkaline phosphatase activity over free urea applied plots.

The approximate net gain/loss of wheat cultivation with different fertilizers applications was calculated by analysis of input cost and income obtained which was based on the sum of common and variable costs of treatments (Table 7). The actual cost of cultivation and cost of product is; however, depend on prevailing market rates during the crop year. The entrapped urea, OMEU having half of the recommended dose of chemical fertilizer resulted in maximum net returns as compared to the application of recommended dose free urea and no fertilizer. In addition it has enriched soil fertility, which will be another benefit in terms of better soil health for the next generation cultivation in this field.

Our results indicate that OMEU, which is entrapped form of urea, is very effective in enhancing productivity and yield of wheat and the fertility of soil in terms of nutritive and biological properties. It appears that the efficacy of chemical urea can be improved by entrapping it in the organic matrix. It can be seen as a successful attempt towards developing alternatives of synthetic N fertilizers, which results too many economical, environmental and health related problems.

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