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Original Research Article

A study for use of slow release fertilizer as a source on the nutrient use efficiency on wheat crop

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Abstract

Environment change presents many challenges for improvement in nutrient use efficiency by its direct effect on the growth and yield of plants, and hence on nutrient demand, and also by its effect on soil nutrient cycle, nutrient availability, and uptake. However, the after effects of climate change on plant nutrition are difficult to figure out because of the complexity of the soil–plant–atmosphere.It is a challenge in the era of smart fertilizer to maintain Nutrients use efficiency of soil. Addition of fertilizer helps us to get greater yield on one hand but may lead to loss of nutrients from the soil. In order to control this loss use of Slow Release Fertilizer has been emerged as an effective solution. A study was conducted to record the effect of various combination of slow release fertilizer on conventional fertilizer with respect to morphological parameters like leaf area, starch and total soluble sugar in the wheat. Varity of wheat plant at different growth stages Soil physio chemical characters like pH, EC, OC, TOC, NPK were studied in the different treatment combinations with slow release fertilizer. The studies of that nutrient use efficiency viz agronomic efficiency, partial factor productivity, N uptake were significantly enhanced by the application of NPK source as slow release fertilizer.
Key Words: Slow release fertilizers, Nutrients use efficiency, Wheat.

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INTRODUCTION

India is the seventh largest country by area having second largest population in the world. Our cultivated land is limited while our population is growing at enormous rate. After independence the number of persons, supported by each hectare of cultivable land has increased by three times but the Per hectare productivity is more or less constant. Need for enhanced crop productivity for ever increasing population necessitated the breeding of high yielding verities of crops which require high amount for nutrition. Increase in agricultural productivity is required to meet the growing demand of agri-produce. It could be increased by the use of fertilizers and pesticides. However, there is currently great concern about the damage caused to the environment by these compounds. Therefore the development of new strategies for the implementation of effective and safe agricultural chemicals has become more important in recent years. This could be achieved in the form of controlled-release formulation specially based on polysaccharides. These formulations not only release the active compound in a slow manner but also after degradation increase the crop output besides proving the water-holding capacity of the soil. Release systems decrease the amount of active ingredient available for leaching and volatilization. These formulations will control the environment, ecosystem and health hazard caused by the conventional pesticide formulations. Hence, these polysaccharide based formulations could be utilized for the safe management of agrochemicals which will decrease their toxic effects and helpful for their better delivery to the field. Nitrogen losses and the impact of those losses on water contamination may be reduced by improving N fertilizer management and other cultural practices to increase efficient N use by crop plants. Management strategies to reduce soil N loss include improved timing of N fertilizer applications, better use of soil and plant testing procedures to determine N availability, switching to use of variable-rate N fertilizer applications and other more effective N fertilizer application methods, application of nitrification or urease inhibitors, and use of N fertilizer sources that are suitable for local environmental conditions (Dinnes *et al*., 2002).

Slow- or controlled-release fertilizer: A fertilizer containing a plant nutrient in a form which delays its availability for plant uptake and use after application, or which extends its availability to the plant significantly longer than a reference 'rapidly available nutrient fertilizer' such as ammonium nitrate or urea, ammonium phosphate or potassium chloride. Such delay of initial availability or extended time of continued availability may occur by a variety of mechanisms. These include controlled water solubility of the material by semi-permeable coatings, occlusion, protein materials, or other chemical forms, by slow hydrolysis of water-soluble low molecular weight compounds, or by other unknown means. Tandan2010

Use of slow-release N fertilizers to mitigate N losses: Slow-release fertilizers (SRF) are being tested for use with agronomic crops as an alternative to conventional N fertilizers in order to improve NUE and decrease N losses to the environment. There are two main types of slow-release N fertilizers with different modes of action: 1) condensation products of urea and urea-aldehydes (e.g. urea-formaldehyde, urea-crotonaldehyde, and urea-isobutyraldehyde based products) and 2) coated urea fertilizers (e.g. sulfur-coated, polymer-coated, and a mix of sulfur and polymer-coated urea) (Trenkel, 1997). compared the effects of SRF urea and conventional urea under no-tillage on corn yields. Their results showed no significant differences between fertilizers in neither grain N content nor NUE, although SRF urea treatments had higher NUE than treatments with non-coated urea. Barbieri *et al*. (2006). Any approach that increases nutrient use efficiency (NUE) may lead to a reduction in the amount of applied fertilizer per unit area. This in turn should contribute to the reduction of potential pollution problems by decreasing fertilizer production. One reservation regarding the use of SRF/CRFs forreducing environmental problems related to fertilizer production is the extent to which the various materials used for preparing SRF/CRFs (plastics, formaldehydes, sulphur, etc.) contribute to environmental pollution.One possible way to improve nutrient and particularly nitrogen use efficiency while reducing the environmental hazards is by using controlled release or slow release fertilizers (Hauck, 1985; Shaviv and Mikkelsen, 1993; Peoples *et al*., 1995; Bockman and Olfs, 1998; Shaviv, 1999)

Nitrogen use efficiency: Nutrient use efficiency (NUE) can be considered as the amount of nutrients taken up from the soil by plants and crops within a certain period of time compared with the amount of nutrients available from the soil or applied during that same period of time. Improving NUE in agriculture has been a concern for decades (Dobermann, 2005), and numerous new technologies have been developed in recent years to achieve this. The types of fertilizers and their management in agriculture will be at the forefront of measures to improve the global N balance in the short- and long-term. The slow release treatment combinations exhibited significantly different responses to fertilizer N in both yield and biomass but not in harvest index. The results reported here suggest that improvement in yield was more strongly associated with a gain in biomass rather than harvest index (Morgan *et al*, 2009) with the use of slow release fertilizers. The increase in yield with application of biochar and sulphated urea could be attributed to prolong availability of mineral nitrogen over a long period of time. Increase in grain yield of wheat with inhibitors has been reported in literature (Rodgers and Ashworth 1982; Singh and Beauchamp 1988; Bronson *et al*; 1991; Mahapatra *et al*; 1997). Application of modified urea materials were found to be superior in improving the N content in grain and straw. This was probably better synchronization of plant N supply with the demand set by the plants. The result of N uptake was also followed in similar order with highest with pastille application and lowest in control plot. In general, application of fertilizer N improved N content of grain and straw which resulted in better uptake of nutrients in N treated plot in comparison with control. Similar results were obtained for NUE of wheat crop. In past also, use of inhibitors like DCD, neem cake and nitrapyrin has proved beneficial in improving N use efficiency in wheat particularly on percolating soils exhibiting considerable nitrate leaching losses and heavy textured soils amenable to higher denitrification losses (Prasad and Power 1995). Nitrogen use efficiency is of significant importance in crop production system due to its impact on farmer economic outcomes and environmental impact. Nitrogen use efficiency also, may be reduced in crop production due to many factors including losses of soil nitrogen by volatilization, leaching and denitification. (Jokela and Randall 1989) conducted a study of the effects of N application rate on residual NO3-N in non-irrigated corn and concluded that when N rate was increased, soil NO3 -N was also higher. Another study showed no significant differences in soil NO3 -N among several N fertilizer rates, although there was a clear trend of higher soil NO3 -N levels with the highest fertilizer N application which may cause accumulation in the soil profile and leaching into groundwater in the long term (Elmi etal., 2005) Fertilizers constitute an integral part of improved crop production technology (Saifullah *et al.* 2002). Nitrogen (N) is major factor limiting yield of wheat (Andrews *et al.* 2004). Optimum N management to wheat is important for maximum yield, optimum water utilization and minimum contamination to environment (Corbeels *et al.* 1999).There is need to reduce use of N fertilizer application and search for genotypes with greater N use efficiencies, either in a strict physiological or agronomic sense (Andrews *et al.* 2004). The efficiency of wheat cultivars to N use has become increasingly important to allow reduction in N fertilizer use without decreasing yield. Phosphorus is essential for enhancing seed maturity and seed development (Ziadi *et al.* 2008). Both P and K application favored tillering of wheat and reduced lodging in wheat (Liakas *et al.* 2001), improved photosynthetic activity and transport to the ripening grains. This resulted heavier grains (Zhang *et al.* 1999). With adequate application of phosphorus, 20% more grain yield of wheat can be obtained (Ascher *et al.* 1994). N and P uptake could be enhanced with increased P applications (Jiang *et al.* 2006).). Different researchers recommended different P application rates. Chaturvedi (2006) found 28.5 kg P ha-1 as optimum for growth, plant height, tillers, grains spike-1, 1000 grain weight, grain and straw yields. Jiang *et al.* (2006) observed 108 kg P ha-1 for higher leaf area index, tillers, ear bearing tillers and dry matter accumulation. Khalid *et al.* (2004) applied 45 kg P ha-1 in wheat and obtained maximum emergence, productive tillers, grain yield and biological yield. Potassium is a one of special significance because of its active role in bio-chemical functions of plant e.g. activating various enzymes, protein formation, carbohydrates and fat concentration, tolerance to drought and resistance to frost, lodging, pests and disease attack (Marschner, 1995). Thus K deficiency in soil may results in yield losses (Ali *et al.* 2008). Increase in cropping intensity and introduction of high yielding fertilizer responsive cultivars have resulted in a considerable drain of soil K reserves. In the present day, intensive and high yield oriented agriculture, there is a negative K balance and soils are being mined for this essential element (Tan *et al.* 2005). Increased use of N without adding required K in soil has further aggravated K deficiency (NFDC, 2003) because K play important role in improvement of the growth indices. Increasing K amount in wheat grain increased dry matter, 1000-grain weight, tillers, K contents in plant, The demand for plant nutrients is expected to increase continuously with population growth (Kaarstad, 1997; Keeney, 1997), particularly in developing countries. According to Keeney (1997), world population is expected to increase by about 2.3 billion by 2020 and double by the year 2050. If meat and food consumption in developed countries is matched by the rest of the world by the mid-21st century, then grain and nutrient demand is expected to triple (Keeney, 1997; Kawashima *et al.*, 1997). Keeping in mind that the amount of land used for food production changed very slightly over the past few decades (Kaarstad, 1997; FAO, 1999), and may even have decreased in parts of the world due to urbanization (Keeney, 1997), the nutrient load per unit area is steadily increasing. All this implies that food production will have to be much more intensive and efficient than ever before.

MATERIALS AND METHODS

A field experiment was conducted in a farmer's field in Bhopal district of India on a sandy clay loam soil with wheat as test crop. The row spacing of the crop was 22.5 cm and the individual plot area was 9 m^2. The crop was raised with standard management practices with following fertilizer treatments.

Fertilizer treatments

Treatments Details
T1 Absolute control (No fertilizer)
T2 Urea- N @ 120 kg N ha^{-1}
T3 Urea Pestilles - N @ 120 kg N ha^{-1}
T4 FYM sorbed urea- N @ 120 kg N ha^{-1}
T5 Urea+ Biochar (castor coated)- N @ 120 kg N ha^{-1}
T6 Urea+ Biochar (Wax coated)- N @ 120 kg N ha^{-1}
T7 Urea zeolite coated- N @ 120 kg N ha^{-1}
T9 Nano urea- N @ 120 kg N ha^{-1}

Representative sample of surface soil collected from the experimental field before the start of the experiment was analysed. The pH of the soil was 8.20 and electrical conductivity was 0.3416 (soil water suspension 1:2.5 ratio). Organic carbon content was 0.576%, Total organic carbon was 0.98%. Nitrogen was 199 kg $ha^{-1,}$ Olsen P was12.25 kg ha^{-1} and Potassium was 119.014 kg $ha^{-1.}$ Morpho-physiological and biochemical parameters were recorded at various growth stages as mentioned below.

Table 1:

Sr. No.	DAS	Stages
1	40	Tillering
2	70	Max. Tillering
3	85	Flowering
4	100	Post flowering
5	115	Harvesting

There are 8 slow release NPK sources viz., which were tested for their material are given in table 1. These 8 slow release NPK sources were tested in comparison with conventional or standared NPK fertilizer viz., urea single super phosphate and muriate of potash. These six fertilizer sources were applied at three NPK levels of recommended dose (100:60:40 kg N, P and K respectively). Thus, there were totally eight treatments which were replicated three times in a Randomized Block Design. Findings with reference to different parameters are discussed in the following part. Morpho-physiological Parameters-. Environmental physiology is a study in plant ecology and plant morphology. physiologist examine plant response to various physical factors and parameters in different growth stages like leaf area, chlorophyll a, chlorophyll b, total chlorophyll and SPAD Leaf area – Leaf area was collected from leaf area meter(LICOR) Chlorophyll- Chlorophyll content (SPAD value) was recorded from randomly sected plants with the help of SPAD meter at 30, 60 and 90 DAS. The average of top, middle and base value were expressed as SPAD (Soil Plant Analysis Development) values. Biochemical parameters- Methods of Biochemical Analysis provides a timely review of the latest developments in the field. By this analysis we study how to maintain health wellness and the effects of nutritional deficiencies. In agriculture, biochemists investigates soil and fertilizers and try to discover ways to improve crop cultivation, crop storage and pest control. Total soluble sugar and Starch was estimated by Anthron method calorimetrically.

RESULT AND DISSCUSION

Table 1: Leaf areas and chlorophyll content of wheat variety at flowering stage under different fertilizers treatments

Treatments	*Leaf area*	chl a	chl b	Total chl	SPAD
T1	*119.913*	0.167	0.059	0.231	49.4
T2	*136.94*	0.15	0.091	0.241	51.266
T3	*117.003*	0.178	0.106	0.283	52.933
T4	*107.266*	0.149	0.09	0.249	45.666
T5	*78.32*	0.196	0.148	0.345	51.933
T6	*200.563*	0.173	0.096	0.281	51.8
T7	*238.185*	0.177	0.119	0.286	52.466
T8	*183.043*	0.171	0.065	0.245	53.4
CD p (0.05)	*NS*	0.033	0.045	0.077	4.221

Morpho-physiological Parameters- Leaf area- There was no significant difference in leaf area of the plants among various treatments although highest leaf area was recorded in Urea+ Biochar (Wax coated)- N @ 120 kg N $ha^{-1}$and Urea zeolite coated- N @ 120 kg N $ha^{-1}$and lowest was recorded in Urea+ Biochar (castor coated)- N @ 120 kg N ha^{-1}an Absolute control at flowering stage. **Chlorophyll-** There was significant difference among the various treatments for total chlorophyll content in leaf (Table 3). The highest chlorophyll a, chlorophyll b and total chlorophyll were recorded in Urea biochar (castor coated) – N @ 120 kg N ha^{-1}, treated plot followed by urea zeolite coated – N @ 120 kg N ha^{-1} and Urea Pestilles– N @ 120 kg N ha^{-1} followed by absolute control. **SPAD reading-** The SPAD reading recorded in the treatment also exhibited similar trend to that of chlorophyll content (Table 1).

Table 2: TSS content in wheat shoot under different fertilizers treatments (mg/kg)

Treatments	Tillering	Max. Tillering	Flowering	Post Flowering
T1	53.244	156.654	136.008	98.028
T2	136.476	129.924	159.804	147.132
T3	117.288	131.814	130.464	159.012
T4	187.614	158.166	145.44	168.084
T5	121.986	169.452	199.116	168.036
T6	156.762	177.012	156.528	202.103
T7	172.944	130.14	227.7	174.483
T8	143.424	168.696	156.06	199.936
CD p (0.05)	39.07	19.628	11.865	49.5

Biochemical parameters- Total Soluble Sugar (TSS)*:* TSS in wheat was found to be significantly different at all the growth stages with various treatments. (Table 2) The highest TSS content was observed in tillering stage under the FYM sorbed urea- N @ 120 kg N ha^{-1} treatment followed by Urea zeolite coated- N @ 120 kg N ha^{-1},Urea+ Biochar (Wax coated)- N @ 120 kg N ha^{-}, Nano urea- N @ 120 kg N $ha^{-1}$and Urea- N @ 120 kg N ha^{-1} when compared to remaining treatments. However lowest TSS content was recorded in absolute control at tillering stage. In maximum tillering stage highest TSS content was observed in Urea+ Biochar (Wax coated)- N @ 120 kg N ha^{-1}. The highest TSS content was found in zeolite coated urea treatment at flowering stage. The highest TSS content was recorded in in Urea+ Biochar (Wax coated)- N @ 120 kg N ha^{-1}at post flowering stage followed by Urea zeolite coated- N @ 120 kg N ha^{-1}, Nano urea- N @ 120 kg N ha^{-1},, Urea+ Biochar (Wax coated)- N @ 120 kg N ha^{-1} FYM sorbed urea- N @ 120 kg N $ha^{-1}$and Urea+ Biochar (castor coated)- N @ 120 kg N ha^{-1} and Lowest TSS content was observed in absolute control.

Table 3: Starch contents in wheat shoot under different fertilizer treatments (mg/kg)

Treatments	Tillering	Flowering	Post Flowering
T1	62.64	150.516	179.17
T2	49.733	165.888	166.17
T3	42.986	168.372	267.73
T4	71.496	161.352	189.46
T5	79.273	156.42	203.86
T6	72.63	154.728	279.36
T7	60.41	150.984	219.56
T8	56.376	189.576	231.12
CD p (0.05)	2.942	13.889	32.076

Starch-Starch content in wheat shoot was found to vary significantly at all the growth stages with various treatments (Table 3). The results indicated that with the increase in the days after sowing, starch contents have increased. The maximum starch content in wheat was recorded under the in Urea biochar (Wax coated) – N @ 120 kg N ha^{-1}followed by Urea zeolite coated N @ 120 kg N ha^{-1} Urea biochar (castor coated) – N @ 120 kg N ha^{-1}, and treatment at tillering stage. In tillering stage the minimum starch content was observed Urea N @ 120 kg N ha^{-1} and control treatment. The maximum starch content was recorded in in Urea zeolite coated N @ 120 kg N ha^{-1}, Urea pastilles coated N @ 120 kg N ha^{-1} and Nano Urea – N @ 120 kg N ha^{-1} respectively at flowering, post flowering stages. We also observed N content, yield, N uptake, total N uptake and Nutrient Use Efficiency under the different slow release fertilizer treatments (Table 4). The highest N content was found to be Nano urea – N @ 120 kg N ha^{-1} followed by Urea biochar (Wax coated) – N @ 120 kg N ha^{-1}in grain. Lowest was found in absolute control. The highest N content was observed in straw under the Nano urea – N @ 120 kg N ha^{-1} treated plots and the lowest was observed in absolute control. The highest grain yield was found in urea pestilles – N @ 120 kg N ha^{-1} and FYM sorbed urea – N @ 120 kg N ha^{-1} treated plots. Lowest grain yield was found in absolute control. The highest straw yield was observed in urea pestilles – N @ 120 kg ha^{-1} and lowest in absolute control.

Table 4: Nitrogen Uptake of wheat grain and straw under different fertilizer treatments

Treatments	N Content (%)		YIELD (q/ha)		N Uptake (kg N/ha)		Total N uptake (kg N/ha)	NUE (%)
	Grain	Straw	grain	straw	grain	Straw		
T1	1.70	0.144	23.9	35.2	40.5	5.1	45.6	
T2	1.80	0.176	41.3	55.1	74.3	9.7	83.9	32
T3	2.00	0.185	59.8	72.8	119.6	13.5	127.0	46
T4	2.00	0.204	51.1	56.0	102.2	11.4	105.6	48
T5	1.90	0.251	43.5	55.2	82.7	13.9	96.5	42
T6	2.00	0.288	32.6	45.7	61.8	11.8	73.6	57
T7	1.90	0.273	40.2	55.6	80.4	15.2	133.3	42
T9	2.17	0.360	41.0	54.7	88.9	19.7	108.5	52

The highest N uptake was observed in Urea biochar (Wax coated) – N @ 120 kg N ha^{-1} followed by Nano urea – N @ 120 kg N $ha^{-1}$and FYM sorbed urea – N @ 120 kg N ha^{-1} in grain. The Lowest N uptake was recorded in absolute control. Lowest was recorded in absolute control. The highest Nutrient use efficiency was observed in Urea biochar (Wax coated) – N @ 120 kg N ha^{-1} followed by urea pestilles – N @ 120 kg N ha^{-1}, FYM sorbed urea – N @ 120 kg N ha^{-1} treated plots. Lowest was observed in plots treated with urea N @ 120 kg N ha^{-1} (Table 4). Nitrogen is one of the most important nutrient elements of plant. The soil reserve of nitrogen is not good enough to meet the plant nitrogen requirement. Therefore, supplementation of plant N requirement through chemical fertilizer is indispensable for getting a sustainable and economic yield of crops. However, the fate of nitrogenous fertilizer in soil is subject to several kinds of losses. The tricky situation with N fertilizers is that if we control one kind of loss it triggers another kind of loss with higher magnitude. Due to these circumstances, the apparent recovery of nitrogenous fertilizer is low and ranged from 30-50%. Nitrogen is an indispensable element for plant growth and is most limiting in the field conditions owing to its low availability combined with leaching and other immobilization or volatilization losses. Mineralization makes nitrogen available to crops from crop residues and older organic matter. These processes are dynamic and so the availability of nitrogen is continually changing and, in addition, is highly spatially variable. Under practical conditions, nutrient use efficiency (NUE) can be considered as the amount of nutrients taken up from the soil by plants and crops within a certain period of time compared with the amount of nutrients available from the soil or applied during that same period of time. Improving NUE in agriculture has been a concern for decades (Dobermann, 2005), and numerous new technologies have been developed in recent years to achieve this. The types of fertilizers and their management in agriculture will be at the forefront of measures to improve the global N balance in the short- and long-term. The most important task for the future is to further improve NUE or, more precisely, N-use efficiency (Grant, 2005), because a significant share of the added fertilizer N is lost during the year of application. Genetic gain in yield was smaller without added fertilizer N. This was observed in the present experiment wherein absolute control treatment, produced least grain yield and biomass. Since we have ensured uniform dose of 120 kg/ha N in each of the slow release fertilizer treatments, there was no significant variation in parameters like plant height and tiller number with external effluence. However there was significant variation in shoot dry weight and reproductive traits like spike weight, grain weight and biomass yield with the application of various combinations of slow release fertilizers. The increase in shoot dry weight due to adequate N nutrition is explainable in terms of possible increase in nutrient mining capacity of plant as a result of better root development and increased translocation of carbohydrates from source to growing points in well-fertilized plots. These results were in conformity with earlier findings already reported in rice (Chaturvedi 2005)

CONCLUSION

Slow release nitrogen fertilizers can be applied as a preplant application. It reduces production costs, eliminates the need for multiple applications of soluble nitrogen fertilizers. Also slow release nitrogen fertilizers were able to increase nitrogen use efficiency by reduce nitrogen leashate and volatilization from soils. It is well known that nitrogen nutrition influences the content of photosynthetic pigments, the synthesis of the enzymes taking part in the carbon reduction, the formation of the membrane system of chloroplasts, etc. Thus the increase in growth and yield owing to the application of N-fertilizers may be attributed to the fact that these nutrients being important constituents of nucleotides, proteins, chlorophyll and enzymes, involve in various metabolic processes which have direct impact on vegetative and reproductive phases of plants. In the present study also chlorophyll content was found to be higher with slow release fertilizer treatments. Chlorophyll content was found to be higher with Slow release fertilizer treatments

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