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Full Length Research Paper

The effect of Pellet fertilizer application on Wheat Yield and its Components

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Increased use of fertilizer nitrogen (N) in agricultural production continues to raise concerns, because of the risk of surplus N leaving the plant-soil system and thereby causing environmental contamination. Therefore, decreasing nitrate leaching from crop production fields, such as in wheat fields, is of considerable importance. Against this backdrop, a field experiment was conducted to assess the effect of pellet fertilizer, produced by mixing urea and dry cow dung manure, on wheat yield and its components. The study was carried out, during the 2007-2008 wheat-growing season, at the experimental farm of Zanjan Agricultural Research Center in Iran. The experimental layout was a randomized complete block design replicated four times. The pellet fertilizer was produced by mixing urea (50, 100 and 150kg N/ha) with dry cow dung (100, 200 and 300 kg/ha i.e. twice the rate of urea). The mixture was ground and compressed by closed die method at three levels (167, 223 and 279 mp) of compressive forces, giving a total of ten treatments including; treatments nine of pellet fertilizer plus a control treatment with 150kg N ha^{-1}. The biological yield, grain yield, number of spikes per square meter, number of grains per spike, grain weight, harvest index, and grain protein content was calculated. Treatment T_7 significantly produced better harvest index, higher number of spikes/m^2, highest 1000 grain weight, the maximum biological yield, the maximum grain yield and highest grain protein content per hectare. The use of pellet fertilizer is therefore a better alternative to uncoated urea due to its slow and continuous nutrient release for plant uptake at different stages of its growth.

Key words: biological yield, dry cow dung, urea, grain protein content, Wheat, Grain yield

INTRODUCTION

Wheat (*Triticum aestivium L.*) production in Tehran State is the backbone of the whole agricultural system (Anonymous, 2004; Baghestani et al, 2005). Its growth, development and yield depend mainly on available water and fertilizer (Halitligil et al., 2000). Fertilizer management is an important part of the overall management package target towards realizing higher yield (Bayoumi and El- Demardash, 2008). Application of

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nitrogenous fertilizer improves various crop parameters like 1000–grain weight (Warraich et al., 2002), grain yield (Warraich et al., 2002), number of spikes per unit area, number of grains per spike and biological yield (Al–Abdul Salam, 1997). Nitrogen fertilization strongly influences the quality of protein in wheat flour. Tolbert (2004) found that increasing nitrogen fertilizer increased protein content, flour and the arrival time of dough. Nitrogen fertilization management offers the opportunity for increasing wheat protein content and quality.

Increased use of fertilizer nitrogen (N) in agricultural production has however raised concerns, because the N surplus is at risk of leaving the plant-soil system and thereby causing environmental contamination. This is in addition to increased costs associated with the manufacture and distribution of N fertilizer (Alizadeh and Ghadeai, 2006). Wheat being a shallow-rooted crop with the domain root zone at 20 cm below the soil surface, can lead to considerable nitrate loss by leaching under irrigated or high rainfall conditions (Ren et al., 2003; Yu et al., 2003). Liberal application of nitrogen fertilizer results in nitrate accumulation in ground water, due to nitrate leaching (Prasad and Pawer, 1995; Chaney, 1990) and can thus lead to human and environmental health problems.

The efficiency of the N applied in satisfying the N demand of the crop depends on the type of fertilizer, timing of fertilizer application and seasonal trends (Borghi, 2000; Blankenau et al., 2002). Crop response to N fertilizer is also influenced by soil type, crop sequence and the supply of residual and mineralized N (Lóopez-Bellido et al., 2004). Therefore, numerous strategies such as use of N sources, slow release fertilizer, placement techniques and nitrification inhibitors have been devised to reduce nitrogen losses and improve fertilizer use efficiency (Slanger and Kerkhoff, 1984; Freney et al., 1992).

Much research has been done on the use of nitrogen fertilizer but less attention is given on sources and method of nitrogen fertilizer application in wheat crop (Wagen et al., 2002). In view of the importance of nitrogenous fertilizer in wheat production vis-à-vis its effects on the environment, strategies that optimize on its benefits while reducing environmental impacts should be sought. Fertilizer pelleting is one such approach. In technological process in agriculture, pelleting is interaction between particles of material and applied forces, through a process of biomass densification, to increase its bulk density and decrease volume. Biomass densification is the use of some form of mechanical pressure to reduce the volume of grind material and conversion of this material to a solid form (pellets), that is easier to handle and store than original material (Erickson and Prior, 1990; Hernandez et al., 2006). Pellet fertilizer is a type of slow-release N fertilizer with long–term effects including reduced leaching losses and enhanced N uptake, as well as positive effects on both health and soil nutrient levels.

The objective of the current study was to determine the effect of pellet fertilizer, produced by mixing urea and dry cow dung manure, under different levels of compressive forces, on wheat yield and its components.

MATERIALS AND METHODS

Study area

The study was carried out, during the 2007-2008 wheat-growing season, at the experimental farm of Zanjan Agricultural Research Center in Iran. The experimental farm is located about 30 km east of the Zanjan province in Iran. The station ($48^0 47^1$, $36^0 31^1$) is at a height of 1770 meters above sea level. The average annual rainfall and temperature is 284.5 mm and 9.5 ^{O}C respectively.

The measured soil parameters prior to the commencement of the experiment were; pH 7.8; EC 0.72 dsm^{-1}; Saturation Percent 41; Organic C 0.49 per cent; total N 0.048 per cent; Olsen P 12.4 ppm; K 398 ppm; Nitrate N: 5.4 ppm; clay content 32 per cent; silt content 32 per cent and sand content 36 per cent and textural class: clay loam.

Treatments and Experimental design

Production of Pellet fertilizers

Single pelleter setup

In this research, a single pelleter setup was designed for pellet production (Figure.1, 2 and Table 1). This device had a fixed and movable jaw and a control section. This set-up allows for adjusting applied load, speed of loading and time of loading. The samples for pelleting were compressed by a hydraulic cylinder (Figure.1) at different pressures and die size.

Before pelleting, dry cow dung manure and urea fertilizer were mixed (in a ratio of one part of urea to two parts manure) and ground using a hammer mill.. In later stage, the ground samples were compressed by closed die method at three levels of compressive forces (167, 223 and 279 mp).

Pellet fertilizer production and treatments

The pellet fertilizer was produced by mixing urea (50, 100 and 150kg N/ha) with dry cow dung manure; 100, 200 and 300 kg/ha). The mixture was ground and compressed by closed die method at three levels (167, 223 and 279 mp) of compressive forces, giving a total of ten treatments including control treatment ; T1 (50:100), T2 (100:200), T3 (150:300) compressed at 167mp; T4 (50:100), T5 (100:200), T6 (150:300) compressed at 223mp and T7 (50:100), T8 (100:200), T9 (150:200) compressed at 279mp plus a control treatment with 150kg N ha^{-1}.

Order to production of pellet fertilizer not immediately disintegrate and yet not too hard to process that before the end of all the wheat growing season urea to gradually make free from three levels of pressure force were used to study what level of pressure that this type of fertilizer for us to produce.

Experimental design

The experimental layout was a randomized complete block design with four replications and plot sizes of 6 x 6m.

Table 1: Summary of the experimental treatments.

Treatment	Components Urea	Cow dung	Compressive force (mp)
T1	50	100	167
T2	100	200	167
T3	150	300	167
T4	50	100	223
T5	100	200	223
T6	150	300	223
T7	50	100	279
T8	100	200	279
T9	150	300	279
Control	150	0	0

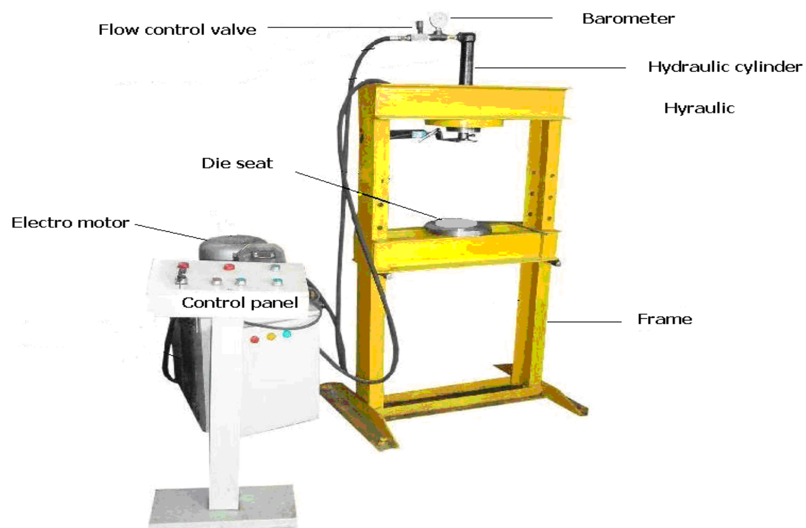


Figure 1: Hydraulic press setup.

Agronomic Practices

Wheat cultivar Shahriar was planted on 22/7/2007 at the rate of 120 kg/ha. Each plot was supplied with P fertilizer before sowing at a rate of 100 kg p ha^{-1}.

First and second irrigation were given after 15 and 30 days of sowing respectively and subsequent irrigations were applied on the tiller, stem extension, heading, seeding, milky seed, pasty seed, and solidity seed stages. The plots were kept free of weeds by hand weeding, throughout the growing period of the crop. Pellet fertilizers were applied in between two rows in a line at stem elongation stage on 25 weeks after planting.

Plant sampling and analysis

The crop was harvested at maturity, on 39 weeks after planting and samples obtained, from a 2.7 m^2 portion at the center of the plot for yield and yield components determination.

The number of productive spikes was counted in one meter long row at three different points in each plot and average number of spikes per square meter was calculated. The number of grains per spike was calculated by counting the number of grains of ten randomly selected spikes from each plot. The total number of grains from selected spikes was divided by 10, to get average number of grains per spike. Grain weight was recorded by weighing 1000

Figure 2**:** Produced pellets manures from single pelleter setup.

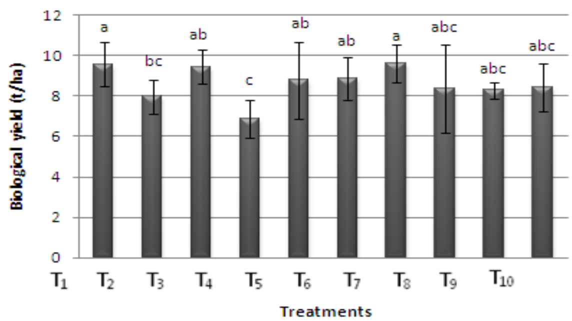


Figure. 3: The effect of different rates of pellet fertilizer on biological yield

grains from each treatment. The Harvest index (HI) was calculated as seed weight divided by un-thrashed plant weight x 100 (Wilcox, 1974).

Statistical Analysis

The data collected was analyzed using MSTAT-C and the mean comparisons were made by LSD at 5% probability level.

RESULTS AND DISCUSSIONS

Biological yield

There were significant ($p<0.05$) differences in biological yield between the different treatments with T_7 and T_1 having significantly higher biological yields than the rest of the treatments (Figure. 3). The minimum biological yield was obtained in T_4. There were however no significant differences in biological yield between treatments T4, T8 and control (Figure. 3). These results are attributable to the pellet fertilizer, which released nitrogen slowly and was available to the wheat plant throughout its growth duration. Nonetheless, in the control treatment coupled with irrigation, a lot of urea got leached with only a fraction of the total amount applied being available to the wheat plant. William and Gorden (1999) stated that, when urea fertilizers are applied to the surface without incorporation, losses of fertilizer N as NH3 can exceed 40% and generally greater with increasing temperature, soil pH and surface residue. El-Kramany (2001) had found that, slow-release nitrogen fertilizer gave the highest biological yield/ha of wheat. Further, Amal et al., (2007) reported that, slow-release nitrogen fertilizer significantly increased biological yield/plant of grain sorghum compared with other nitrogenous fertilizers in the order; ammonium nitrate, ammonium sulphate and urea.

Grain yield

The mean grain yield differed significantly ($p<0.01$) with the application of different rates of pellet fertilizers (Figure. 4). The highest increase in grain yield (4.200 kg ha^{-1}) was achieved in T_7 and the lowest increase in grain yield (2.550 kg ha^{-1}) in T_4 (Figure.4). While the control treatment produced 3.375 kg ha^{-1} (Figure. 4). These results could be attributed to the beneficial effect of coating urea which thus regulated nutrient release and enhanced nitrogen use efficiency by the wheat plant. This is in addition to the reduction of N losses through leaching and hence a constant supply of nutrients to the root. Besides, the manure component of the pellet

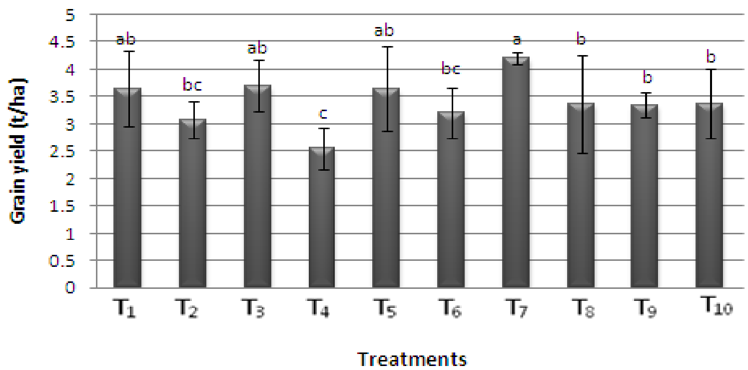
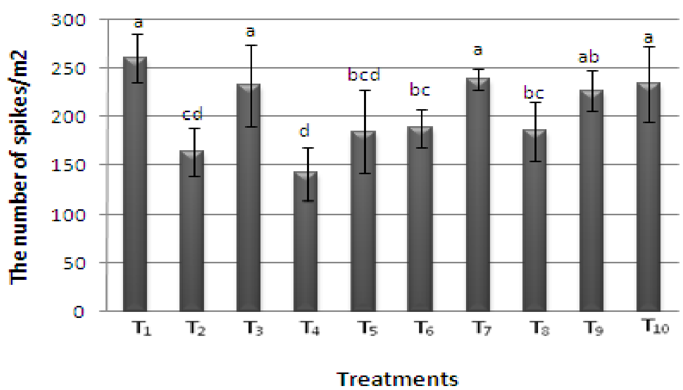


Figure. 4: The effect of different rates of pellet fertilizer on grain yield.



.5: The effect of different rates of pellet fertilizer on number of spikes/m^2

fertilizer too released N and P slowly as well as contributing to the soil organic matter.

Tejada et al. (2006) reported that manure is a good fertilizer on soil that requires P and N to produce high yields. This is attributed to manure's slow release of plant nutrients and contents of N and P (Onwonga et al. 2010).These results are similar to those of Bagheri et al. (2009) who reported that a pellet fertilizer containing 92 kg N/ha and 600 kg/ha cow manure gave higher grain yields in corn.

Yield component of Wheat

Number of spikes/m^2

The different levels of pellet fertilizer application had a significant ($p < 0.01$) effect on the number of spikes/m^2 of wheat (Figure. 5). Treatments; T_1 (261.0), T_7 (239.0), T_{10} (234.5), T_3 (233.3) and T_9 (227.3) had significantly higher number of spikes/m^2 than T4 (142.3), T2 (164.8) and T5 (185.5). The slow release of N by the pellet fertilizer

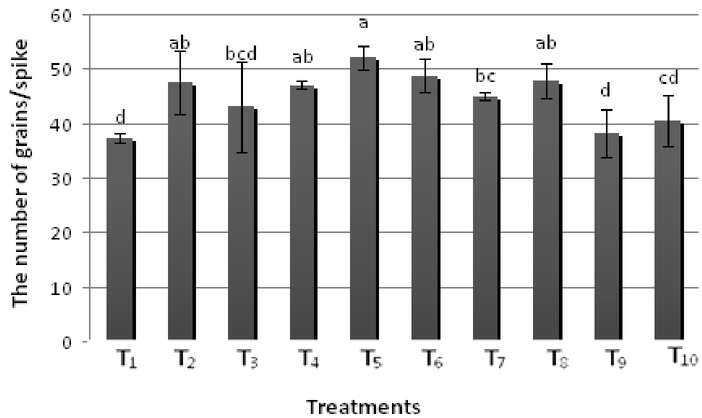


Figure. 6: The effect of different rates of pellet fertilizer application on number grains/spike

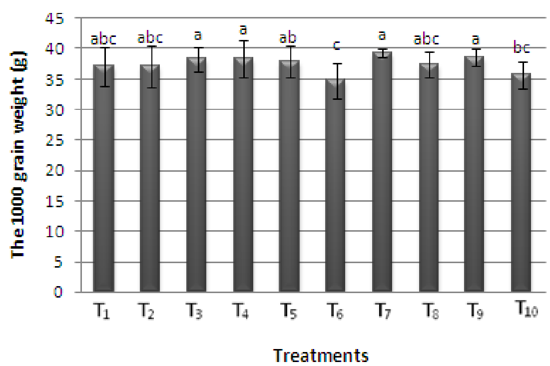


Figure. 7: The effect of different rates of pellet fertilizer on 1000 grain weight

ensured availability of N throughout the duration of the wheat growth with resultant production of more tillers and consequently more number of spikes. Sonbol et al., (2000) reported that, wheat grown in soil amended with slow-release N fertilizer gave significantly more number of spikes/m^2 than wheat grown in soil amended with ammonium-nitrate or ammonium sulphate.

Number of grains per Spike

Different rates of pellet fertilizers influenced significantly ($p< 0.01$) the number of grains per spike (Figure.6). The results of the current study revealed that treatment T_5 significantly ($p< 0.01$) produced more grains per spike (52) compared to control (40), and treatments T_1 (37) and T_9 (37) (Figure. 6). It was noted that treatments that produced the lowest number of spikes/m^2 (Figure. 5) had more number of grains/spike. This is attributable to the fact that plants spend more energy to produce more grain and hence treatments with more spikes produce less number of grains/spike. Amany et al., (2006) and Bagheri et al. (2009) had also found that, slow-release nitrogen fertilizer gave the highest grains number in maize.

1000 grain weight

There were significant ($p < 0.01$) difference in 1000 grain weight with the application of the different rates of pellet fertilizer (Figure 7). The highest 1000 grain weight was recorded in T_7 (39.36 g), T_9 (38.65 g), T_4 (38.38 g) and T_3 (38.33 g) compared to T_6 (34.86 g) and (35.72 g) (Figure.7). Because the pellet fertilizer released nitrogen slowly and for prolonged periods meant that N was available for plant uptake in seed stage and with resultant

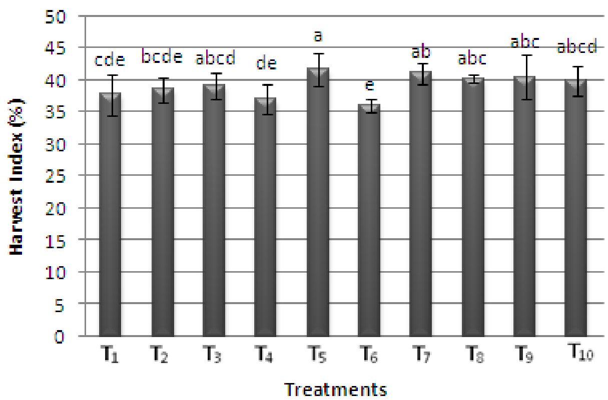


Figure. 8: The effect of different rates of pellet fertilizer on Harvest Index

higher a 1000 grain weight in the respective treatments. In the control, due to the high leaching of urea, the N was not readily available to the plant at seed stage and consequently low 1000 grain weight.. El-Kramany (2001) and Amany et al., (2006) had also found that, slow-release nitrogen fertilizer gave the highest 1000 grain weight of wheat and maize, respectively. An observation also shared by Bagheri et al. (2009) who reported higher grain weight in corn with application of pellet fertilizer comprising of .92 kg N/ha and 600 kg/ha cow manure.

Harvest index

The HI differed significantly ($p \leq 0.01$) across the different levels of pellet fertilizer applications (Figure. 8). The highest HI was observed in T_5 (41.66%) and lowest HI in T_6 (36.04%). This observation is due to the fact that N was available in all stages of wheat growth due to its slow release by the pellet fertilizer and this resulted in high grain yield in these treatments. Consequently the proportion of grain yield to biological yield was more in these treatments. For the control treatment, urea was available for plant uptake in the early and mid stages of plant growth hence its higher biological yield than grain yields. Moreover, the biological yield of the control was not significantly different from treatments in which the pellet fertilizer was applied. Lóopez-Bellido et al., (2005) found that HI to be less sensitive to N fertilizer timing and splitting.

Grain protein content

There were significant ($p<0.05$) differences between different treatment in grain protein content (Figure. 9). Maximum grain protein content was observed in T_9 (13.44) and T_7 (12.98) with minimum grain protein content in T_7 (11.92) (Figure.9). The availability of nitrogen in the grain filling stage of wheat with pellet fertilizer application led to increased grain protein content. Lóopez-Bellido et al., (2005) found that the timing and splitting of N fertilizer application also influenced grain protein content, which was always highest when half or one third of the 150 kg N ha^{-1} rate was applied at stem elongation, and in some cases when N was applied only at tillering. Wuerst and Cassman (1992) reported an increase in grain protein content of about 0.75% with application of slow-release nitrogen fertilizer compared with urea.

CONCLUSION

Application of pellet fertilizer - a slow-release nitrogen fertilizer - improved the quantity and quality of wheat yield and its components compared to urea. Application of the slow-release nitrogen fertilizer to wheat plants caused an increase in harvest index, number of spikes/m^2, 1000 grain weight, the biological yield, the grain yield and grain protein content per hectare. The use of pellet fertilizer is thus a suitable alternative to uncoated urea for wheat

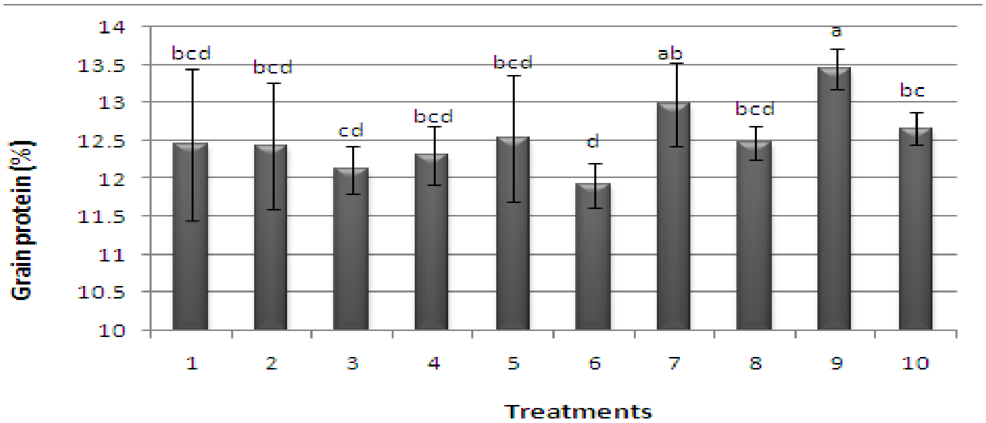


Figure 9: The effect of different rates of pellet fertilizer on grain protein content.

production and in ensuring a safe and health environment. Additionally, the production of the pellet fertilizer by combining dry cow dung manure and urea also contributes to the improvement of soil organic matter that is key for sustained agricultural productions.

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