International Scholars Journals

Advances in Agriculture and Agricultural Sciences ISSN 2756-326X Vol. 6 (10), pp. 001-008, October, 2020. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

The effect of pellet fertilizer application on corn yield and its components

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Accepted 22 March, 2020

Increased use of chemical nitrogen fertilizers (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 corn fields, is of considerable importance. Against this backdrop, a field experiment was conducted to assess the effect of pelleted fertilizer, produced by mixing urea and dry cow dung manure, on corn yield and its components. The study was carried out, during the 2009 corn-growing season, at the experimental farm of College of Abouraihan, University of Tehran in Iran. The factorial design of the study comprised of randomized complete block with three replications. Factors this experiment involved: first factor was two levels of fertilizer application method which include pellet and mixed with soil, and second factor was four levels of nitrogen fertilizer pulse dry cow dung (46+600, 92+600, 138+600 and 184+600 kg/ha). The biological yield, grain yield, number of grains per ear, grain weight, harvest index, and grain protein content was calculated. Treatment T8 (184+600 kg/ha pelleted fertilizer) significantly produced better harvest index, highest 1000 grain weight, the maximum biological yield, the maximum grain yield and highest grain protein content per hectare. The use of pelleted fertilizer is therefore a better alternative to uncoated nitrogen fertilizer 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, corn, grain yield.

INTRODUCTION

Corn *(Zea mays L.)* is the most important grain forage crop in Iran. It is not only a source of food, fodder and feed but also many by-products likes glucose, starch, corn oil, etc. Fertilizer management is an important part of the overall management strategies target towards realizing higher yield (Bayoumi and El- Demardash, 2008). Nitrogen fertilizer is universally accepted as a key component to high corn grain yield and optimum economic return. In the Midwest, the primary philosophical approach to developing a N fertilizer recommendation for corn is to consider, as independent variables, yield goal, economic return, management level, and some measure of the inherent differences in soil productivity (Oberle and Keeney, 1990).

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). Liberal application of nitrogen fertilizer

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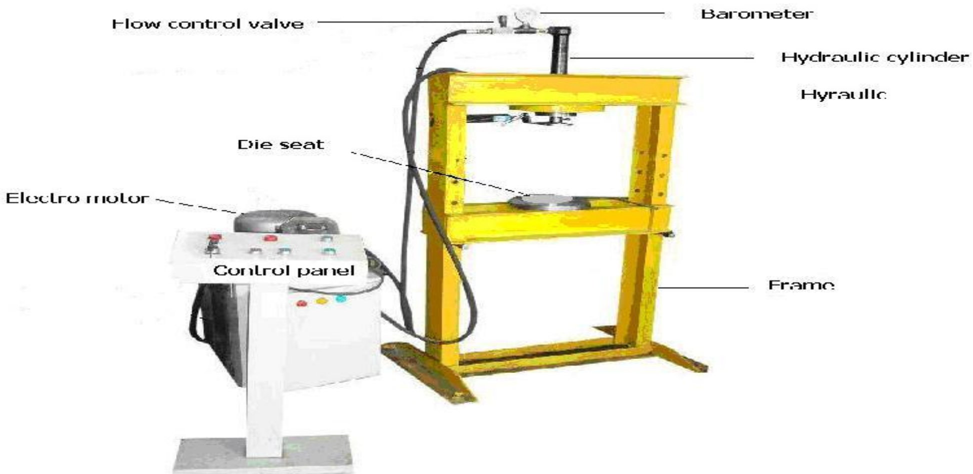

Figure 1. Hydraulic press setup.

Figure 2. Produced pellets manures from single pelleter setup.

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 applied N to satisfy 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 (Lό opez-Bellido et al., 2004). Therefore, numerous strategies such as use of N sources, consumption of 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 crops (Wagen et al., 2002). In view of the importance of nitrogenous fertilizer in corn 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 of such approach. In agricultural technology, 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), which is easier to handle and store than original material (Erickson and Prior, 1990; Hernandez et al., 2006). Pelleted 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 is to determine the effect of pelleted fertilizer, produced by mixing urea and dry cow dung manure, on corn yield and its components.

MATERIALS AND METHODS

Study area

The study was carried out, during the 2009 Corn-growing season, under field conditions in experimental farm College of Abouraihan, University of Tehran in Iran. The experimental farm is located about 30 km east of the Tehran province in Iran. The station (35°28'N, 42.51°17'E) with the elevation of 1024 m above sea level. The average annual rainfall and temperature is 250 mm and 13^{O}C, respectively.

The measured soil parameters prior to the commencement of the experiment were; pH 6.9; EC 0.64 dsm-1; Saturation Percent 41; Organic C 0.55%; total N 0.061%; Olsen P 13.2 ppm; available K 398 ppm; nitrate-N: 5.7 ppm; clay content 29%; silt content 30% and sand content 35% and textural class: clay loam.

Treatments and experimental design

Production of Pelleted fertilizers

Single pelleter setup: In this research, a single pelleter setup was designed for pellet production (Figures 1, 2 and Table 1). This

Table 1. Summary of the experimental treatments.

Treatment	Components		
	Urea	Cow dung	
T1	46	600	mixed with soil
T2	92	600	mixed with soil
T3	138	600	mixed with soil
T4 (control)	184	600	mixed with soil
T5	46	600	pellet
T6	92	600	pellet
T7	138	600	pellet
T8	184	600	pellet

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).

Before pelleting, dry cow dung manure and urea fertilizer were mixed and ground using a hammer mill. In later stage, the ground samples were compressed by closed die method at one level of compressive forces (279 mp).

Pellet fertilizer production and treatments: The pellet fertilizer was produced by mixing urea (46, 92, 138 and 184 kg N/ha) with dry cow dung manure; (600 kg/ha). The two methods of fertilizer application include soil and pellet mixture, in which all pellets were provided by same compressed force (279mp). Total of eight treatments including; T1 (46:600), T2 (92:600), T3 (138:600), T4 (184:600) as a control treatment, in form of mixed with soil; and the other four treatments (T5 (46:600), T6 (92:600), T7 (138:600), T8 (184:600) were applied in form pellet.

Agronomic practices: Corn cultivar single cross 704 was planted on 22/4/2009 at the rate of 60 kg/ha. Each plot was supplied with P fertilizer before sowing at a rate of 100 kg p ha-1. Ten irrigations were applied during the whole season according to the requirement of the crop. The plots were kept free of weeds by hand weeding, throughout the growing period of the crop. All treatments were applied during three stage of growth, before swing, six leaf stages, and anthesis stage. 1/3 of each treatment was applied for mentioned stages in 3 cm dept of soil between rows.

Experimental design

The factorial design of the study comprised of randomized complete block with three replications. Factors this experiment involved: first factor was two levels of fertilizer application method which include pellet and mixed with soil, and four levels of nitrogen fertilizer pulse dry cow dung (46+600, 92+600, 138+600 and 184+600 kg/ha). The plot sizes were 3.0 x 5.0 m.

Plant sampling and analysis

The crop was harvested at maturity, on 18 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 grains per ear was calculated by counting the number of grains of ten randomly selected ear from each plot. The total number of grains from selected ear was divided by 10, to get average number of grains per ear. Grain weight was recorded by weighing 1000 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 SAS and the mean comparisons were made by LSD at 5% probability level.

RESULTS AND DISCUSSION

Biological yield

There were significant ($p<0.01$) differences in biological yield between the different treatments and T8, T7 and T4 having significantly higher biological yields than the rest of the treatments (Figure 3). The minimum biological yield was obtained in T1, but the difference between treatments T8, T3 and T2 were not significant (Figure 3). The higher biological yields are attributable to the pelleted fertilizer, which released nitrogen slowly and was available to the corn plant throughout its growth duration. Nonetheless, in the control treatment coupled with irrigation, a lot of urea got leached by irrigation and only a fraction of the total amount applied being available to the corn plant. William and Gorden (1999) stated that, when urea fertilizers are applied to the surface without incorporation, losses of fertilizer N as NH_3 can exceed 40% and generally greater with increasing temperature, soil pH and surface residue. Amal et al. (2007) reported that, slow-release nitrogen fertilizer significantly increased biological yield of grain sorghum compared with other nitrogenous fertilizers in the order; ammonium nitrate, ammonium sulphate and urea. Further, El-Kramany (2001) had found that, slow-release nitrogen fertilizer gave the highest biological yield/ha of wheat.

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 (12.247 kg ha^{-1})

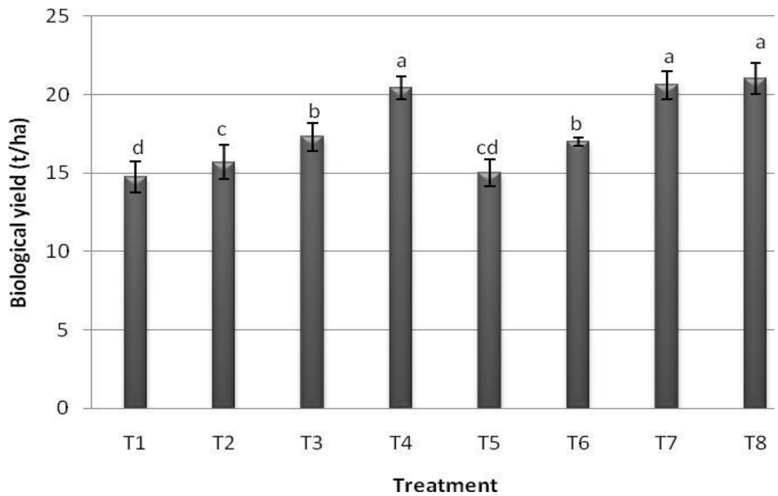

Figure 3. The effect of different rates of pellet and mixed with soil fertilizer on biological yield.

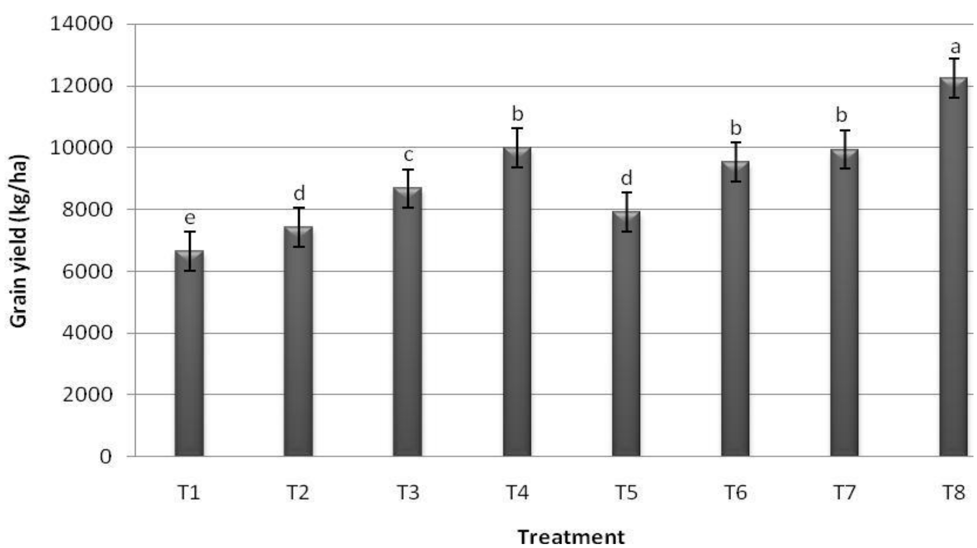

Figure 4. The effect of different rates of pellet and mixed with soil fertilizer on grain yield.

was achieved in T_8 and the lowest increase in grain yield (6.656 kg ha-1) was T1 (Figure 4). While the control treatment produced 9.996 kg ha^{-1} (Figure 4). These results could be attributed to the beneficial effect of coating urea which thus regulated nutrient release and reduced N losses through leaching and therefore enhanced nitrogen use efficiency of the corn plant. Besides, the manure component of the pellet fertilizer released N and P slowly as well as contributing to the soil organic matter (Amany et al., 2006; Eyvazi et al., 2008).

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 Eyvazi et al., (2008) who reported that a pellet fertilizer containing 150 and 200 kg/ha cow manure gave higher wheat grain yields.

Yield component of corn

Number of grains per ear

Different rates of pelleted fertilizers influenced significantly ($p< 0.01$) the number of grains per ear (Figure 5). The results of the current study revealed that treatment T8 significantly ($p< 0.01$) produced more grains per ear (690) compared to treatment T4 (602), and

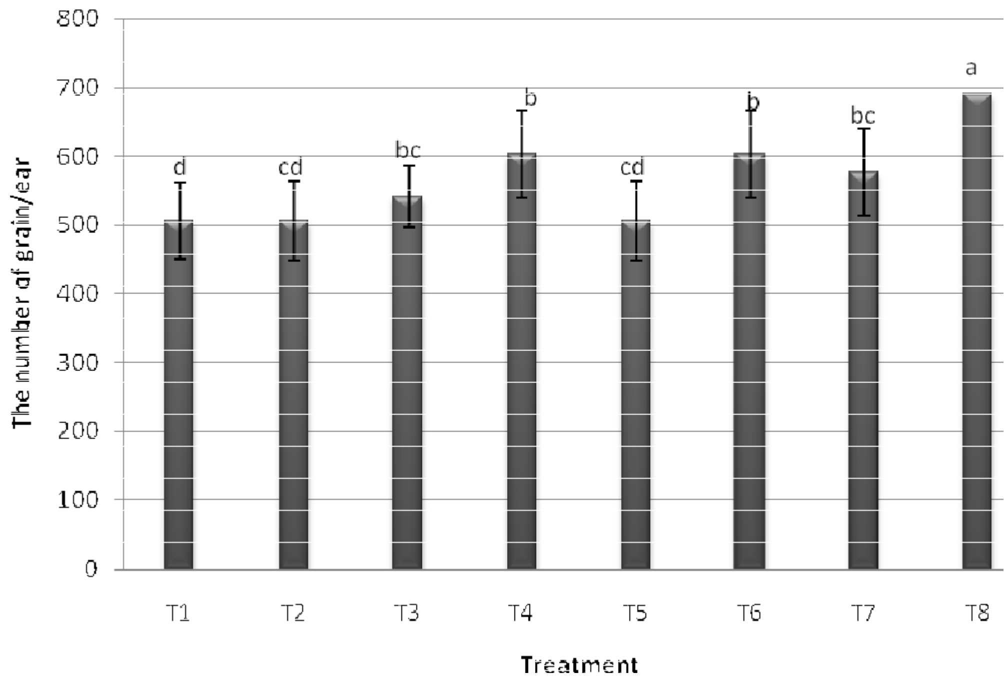

Figure 5. The effect of different rates of pellet and mixed with soil fertilizer application on number grains/ear.

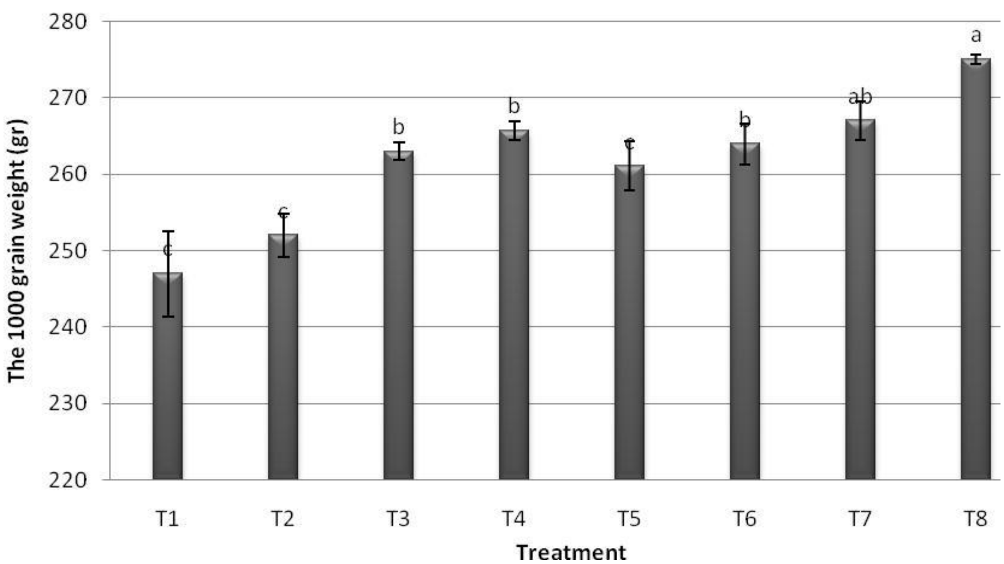

Figure 6. The effect of different rates of pellet and mixed with soil fertilizer on 1000 grain weight.

treatments of T7 (576) and T3 (541) (Figure 5). This is attributable to the fact that plants spend more energy to produce more grain and hence treatments with more ears produce less number of grains/ear. Amany et al. (2006) and Eyvazi et al. (2008) had also found that, slow-release nitrogen fertilizer gave the highest grains number in maize and wheat.

1000 grain weight

There were significant ($p < 0.01$) difference in 1000 grain weight with the application of the different rates of pelleted fertilizer (Figure 6). The highest 1000 grain weight was recorded in T8 (275 g) and T7 (267 g) compared to T2 (252g) and T1 (247g) (Figure 6).

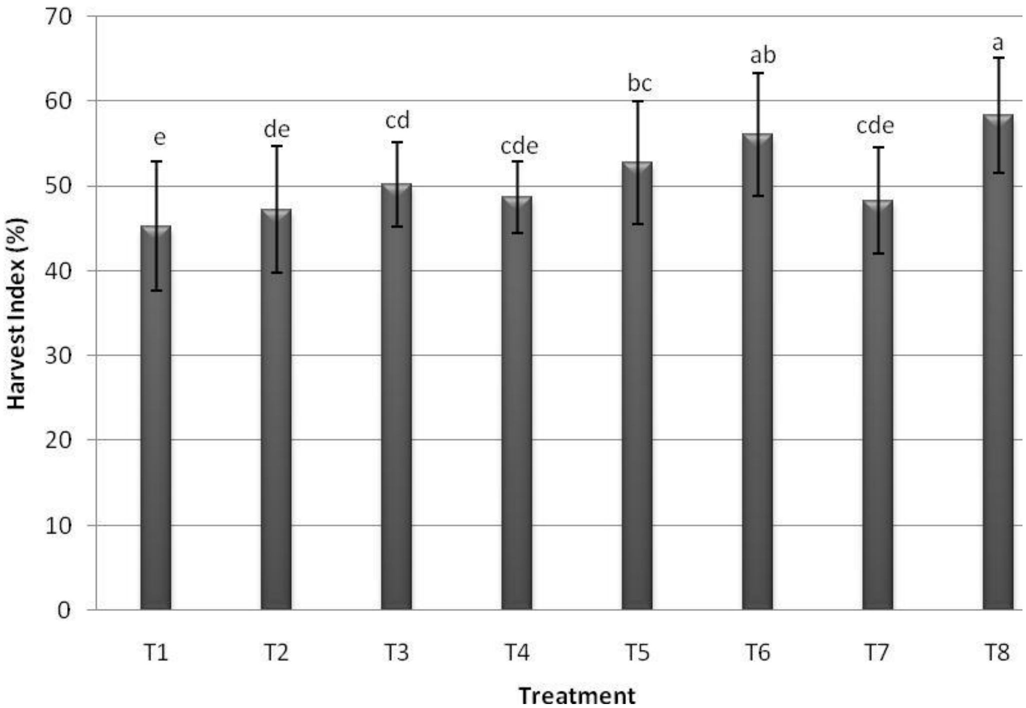

Figure 7. The effect of different rates of pellet and mixed with soil fertilizer on Harvest Index.

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 higher 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. An observation also shared by Eyvazi et al., (2008) reported higher grain weight in wheat with application of pellet fertilizer comprising of 50 kg N/ha and 100 kg/ha cow manure.

Harvest index

The harvest index (HI) differed significantly ($p \leq 0.01$) across the different levels of pellet fertilizer applications (Figure 7). The highest HI was observed in T8 (58.32%) and lowest HI in T1 (45.27%). This observation is due to the fact that N was available in all stages of corn 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. Rizwan et al. (2003) found that HI is less sensitive to N fertilizer timing and splitting.

Grain protein content

There were significant ($p<0.01$) differences between different treatment in grain protein content (Figure 8). Maximum grain protein content was observed in T8 (8200 kg/ha) and T7 (8000 kg/ha) with minimum grain protein content in T1 (Figure 8). The availability of nitrogen in the grain filling stage of corn with pellet fertilizer application led to increased grain protein content. Rizwan et al., (2003) 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 160 kg N ha-1 rate was applied at stem elongation. Amany et al. (2006) reported an increase in grain protein content of about 0.50% with application of slow-release nitrogen fertilizer compared with urea.

Conclusion

Application of pelleted fertilizer - a slow-release nitrogen fertilizer - improved the quantity and quality of corn yield and its components compared to urea. The use of pellet fertilizer is thus a suitable alternative to uncoated urea for corn production and in ensuring a safe and healthy

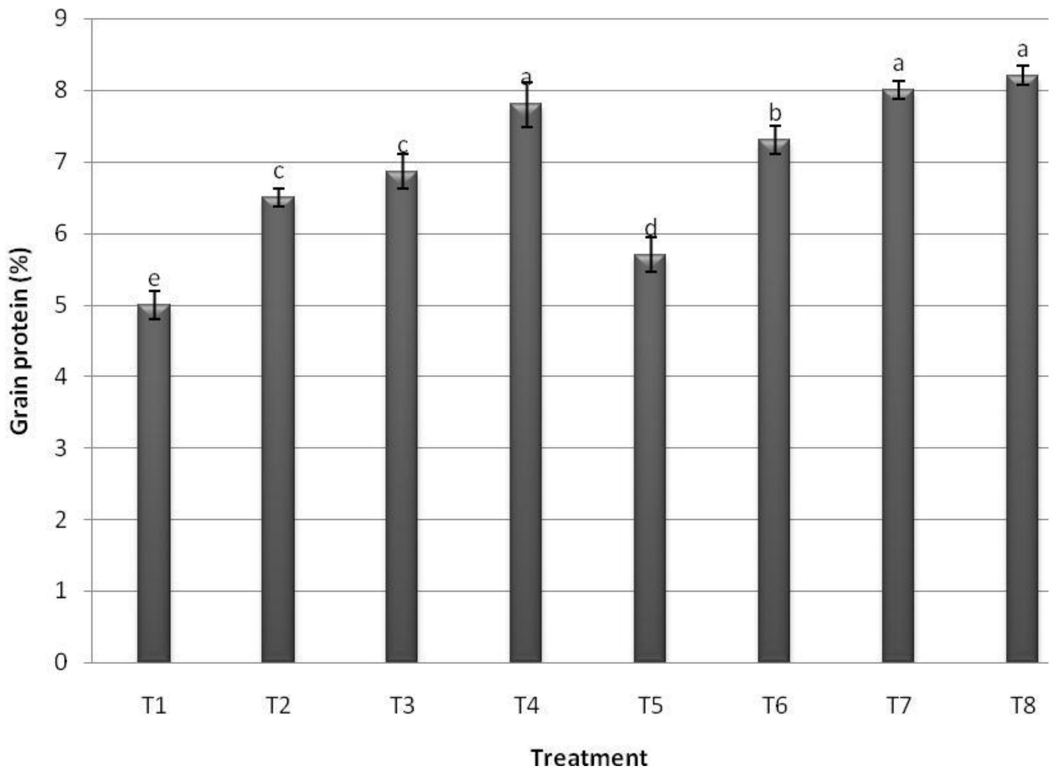

Figure 8. The effect of different rates of pellet and mixed with soil fertilizer grain protein content.

environment. Application of the slow-release nitrogen fertilizer to corn plants caused an increase in harvest index, 1000 grain weight, the biological yield, and the grain yield and grain protein content per hectare. Additionally, the production of the pellet fertilizer by combining dry cow dung manure and urea also contributes to the improvement of soil organic matter which is a key factor for sustained agricultural productions.

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