

The Influence of Legume and Non-Legume Green Manures Along with Nitrogen Fertilizer Levels on Some Traits of Wheat (*Triticum aestivum* L.) as Subsequent Crop

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Authors' contributions

This work was carried out in collaboration between all authors. Authors FG and AA designed the study, performed the statistical analysis, wrote the protocol and managed the analyses of the study. Author ET managed the literature searches and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

In order to evaluate the effects of green manures and various nitrogen fertilizer levels on some traits of wheat, a field experiment was conducted at the experimental farm of the Faculty of Shahid Chamran University of Ahvaz, Iran, during the 2010-2011 growing season. The experimental design was split-plot, N levels (i.e. 0, 50, 100 and 150 kg N ha⁻¹) as main plots, and green manures (i.e. millet; GM_{Mi}, sesbania; GM_S, amaranth; GM_A, cowpea; GM_C, mung bean; GM_{Mb} and control; NO-GM) as sub-plots with three replications. In this study some of the traits such as plant height, number of tillers in per plant and straw yield were investigated. According to the results, the main effect of N levels, green manures and interaction of treatment (N × GM) were significant effects on all traits. The highest plant height (95.67 cm), number of tillers in per plant (5.57) and straw yield (9.01 ton h⁻¹) were obtained by using of 100, 100 and 150 kg N h⁻¹, respectively. Meanwhile, the highest plant height (92.01 cm), number of tillers in per plant (5.03) and straw yield (8.88 ton h⁻¹) were obtained as affected by GM_{Mb}, GM_C and NO-GM (without

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green manure application), respectively. In this perspective, application of 100 to 150 Kg N h⁻¹ and use of convenient legume crops as green manure especially GM_{Mb} and GM_C can be useful to increase the studied wheat traits.

Keywords: Wheat; green manure; tiller; plant height; straw yield.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is not only a main crop for more than one third of the earth population [1], but also the most abundant source of energy and nourishment for humanity [2]. It's ranked among the top three most produced cereal crops in the world, along with corn and rice [3]. Therefore, this is necessary that provide a good condition for better growth of wheat crops in achieving high qualitative and quantitative yield. Nitrogen is the key element in achieving consistently high yields in cereals. It is involved in all the plant's metabolic processes, its rate of uptake and partition being largely determined by supply and demand during the various stages of the plant's growth such as tillering, stem elongation etc. [4]. Also, nitrogen affects dry matter accumulation directly and indirectly. The direct effects of nitrogen deficiency are decreasing or even prohibiting cell dividing, reduction in growth enzymes, cell walls and layers abnormalities, leaf area index decreasing, yellow and dried older leaves (because of nitrogen remobilization to vegetative organs) and finally growth reduction [5]. Soil with high fertility or application of adequate nitrogen, leads to increase in grain yield and 1000-grain weight [6].

Decline in soil productivity will be aggravated if follow is included in the rotation or when crop residues are removed from the soil [7]. Traditionally, the practice of green manuring in South Asia is as old as the practice of manuring itself. Biological nitrogen fixation systems based on leguminous green manures offer economically attractive and ecologically sound alternative to chemical fertilizers [8]. Actually, by using green manures, nitrogen is released over a long period. Thus, nitrogen uptake by crops remains balanced throughout the vegetation period, contributing to the high quality of wheat [9].

The nitrogen released from green manures can be used by succeeding crops throughout their growing period. Therefore, the nitrogen has taken up in the later growing period increases the protein content of grains. Significant amounts of nitrogen are applied into the soil with green manures, but nitrogen is released gradually with long-term decomposition of organic matter, thus decreasing the risk of leaching nutrients [9].

Also, green manuring along with application of nitrogenous fertilizer helps to release nutrient elements slowly during the period of crop growth. Therefore, more study is necessary to find out the best level of N and suitable green manure for wheat fields.

Application of green manures plus chemical fertilizer is found to produce significantly higher yields than that of the sole application of chemical fertilizer [10]. The combination of plant residue with chemical fertilizer further enhanced the biomass and grain yield of wheat [11]. Hasanuzzaman et al. [12] revealed that, green manuring with *Sesbania rostrata* significantly increased number of productive tillers and straw yield of rice. Continued supply of nitrogen from sesbania application probability resulted in a higher number of productive tillers until the reproductive stage of wheat was reached.

However, the present study was undertaken to investigate the effects of green manures integrated with or without N fertilization on some of succeeding wheat traits.

2. MATERIAL AND METHOD

The study was conducted on the experimental farm of the Faculty of Shahid Chamran University of Ahvaz, Iran during 2010–2011. Ahvaz is located at 31°20' N latitude and 48°41' E longitudes at an elevation of 20 m above mean sea level. The soil type was sandy loam with pH 7.8. The 0-30 cm soil layers contained a 0.52% average soil organic matter, 0.039% nitrogen, 13 mg kg⁻¹ phosphorus rate and 151 mg kg⁻¹ potassium exchange. The experiment was conducted in a split-plot design with three replicates for each treatment. N levels as urea resource (i.e. 0, 50, 100 and 150 kg N ha⁻¹) as main plots, and five green manures (GM) including millet (GM_{Mi}; *Pennisetum* sp.), sesbania (GM_S; *Sesbania* sp.), amaranth (GM_A; *Amaranthus* sp.), cowpea (GM_C; *Vigna unguiculata* L.), mung bean (GM_{Mb}; *Vigna radiata* L.) and control (NO-GM) as sub-plots. This field experiment had the two parts. First, legume and non-legume green manures (GM) were planted the first week of Sep. 2010, and then, these plants (GM) incorporated into the soil on the first week of Oct. 2010. Second, the wheat crop was planted on 16 Nov. 2010, and harvested on the third week of Apr. 2011. Each plot consisted of 8 rows, 4 m in length, interrow spacing was 20 cm and interplant spacing was 3 cm. To determine the effect of the treatments, two border rows in each plot were considered as sidelines, and five plants randomly selected from each plot and some characters (plant height and number of tillers in per plant) were investigated. At maturity stage, total parts of wheat plants were harvested in one m² quadrat per plot, were harvested. Then samples dried in a dryer at 78°C for 48 hours before weighting. Then straw yield calculated by following formula:

$$\text{Straw yield} = \text{Biological yield} - \text{Grain yield}$$

Data were subjected to analysis of variance (ANOVA) by using of SAS program. The means were compared using the LSD test at 0.05 probability level and Excel software was used to graph drawing.

3. RESULTS AND DISCUSSION

3.1 Plant Height

According to the analysis of variance results (Table 1), application of N fertilizer levels and various GM showed significant effect on plant height at 1% probability level, while the interaction of treatments (N × GM) had a significant effect on this trait at 5% probability level. The mean comparison results showed that, wheat plant height as affected by all GM were significantly higher than NO-GM, probably due to release of various macro- and micro-nutrients especially nitrogen from these GM residues that have a positive effect on stem elongation of succeeding crop. Also, maximum and minimum plant height (95.67 and 72.69 cm) were obtained by using of 100 and 0 kg N h⁻¹, respectively (Table 2). In other hands, among different green manures, GM_{Mb} and GM_C showed better results as compared with others, although had no significant differences among various GM except for GM_S (Table 2). GM_S probably due to delay in nitrogen release from residue caused lower stem elongation of wheat crop. The highest plant height (92.01 cm) was obtained as influenced by GM_{Mb}, and the lowest (80.61 cm) value for this trait was obtained as affected by NO-GM (Table 2). Also, interaction of treatments (N × GM) indicated that, maximum plant height was observed in

150 kg N ha⁻¹ with application of GM_{Mb}, and minimum plant height was observed in GM_S without nitrogen fertilizer application (Fig. 1).

It should be noted that all green manures with using of nitrogen from 0 to 100 kg N ha⁻¹ caused to increase of wheat plant height, while this trait (plant height) showed no significant response to the increasing of nitrogen fertilizer from 100 to 150 kg N ha⁻¹ (Fig. 1). According to the results of this experiment, plant height increased as affected by N fertilizer due to increasing of spike length and elongation of stem internodes especially the uppermost internode (peduncle) of wheat (data not shown). Guarda et al. [13] revealed that the nitrogen effect was also evident on heading date, plant height and lodging index of bread wheat cultivars with significantly higher value from 0 to 160 kg N ha⁻¹. Use of NPK at 150, 115 and 60 kg ha⁻¹ respectively indicated highest wheat plant height (86.47 cm) possibly due to instant availability of nutrients from inorganic fertilizer source [14]. Gasim [15] concluded that the increase of maize plant height by application of nitrogen fertilizer is due to the nitrogen promotes growth of plant, increases the number of internodes and length of the internodes which results in gradual increase in plant height. Also Amin [16] reported similar result.

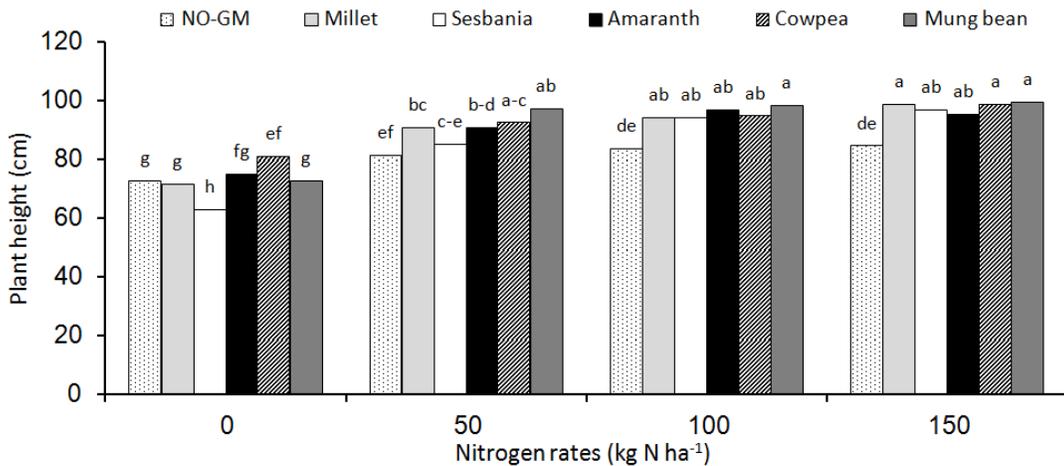


Fig. 1. Effect of nitrogen fertilizer levels and different green manures on wheat plant height

3.2 Number of Tillers in Per Plant

Analysis of variance that shown in Table 1 indicated that, number of tillers in per plant significantly affected by application of N fertilizer levels, GM and interaction of treatments (N × GM) in 1% probability level. The mean comparison showed that, this trait significantly increased by increasing of N fertilizer from 0 to 100 kg N ha⁻¹, while no significant differences observed between 100 and 150 kg N ha⁻¹.

Table 1. Results of analysis of variance (mean squares) treatments in wheat

Source of variation	d.f.	Plant height	Number of tillers in per plant	Straw yield
Rep	2	17.499 ^{n.s}	2.552	1.650 ^{n.s}
N	3	1971.895 ^{**}	35.769 ^{**}	85.444 ^{**}
Error (a)	6	30.092	0.168	1.751
GM	5	235.062 ^{**}	3.563 ^{**}	11.740 ^{**}
N × GM	15	45.892 [*]	4.007 ^{**}	10.718 [*]
Error (b)	40	18.755	0.072	1.905

^{*}, ^{**}, *n.s.*, Significant at $P = 0.05$, $P = 0.01$ and non-significant, respectively. *d.f.* degree of freedom. *Rep:* Replication.

Maximum number of tillers in per plant (5.57) was obtained by application of 100 kg N h⁻¹, and minimum number of tillers (2.41) was obtained by no nitrogen fertilizer application (Table 2). Among various GM, GM_C and GM_A had a better effect on wheat number of tillers per plant as compared to other GM plants. The highest number of tillers in per plant (5.03) was obtained by application of GM_C, and the least number (3.76) was obtained as influenced by GM_{Mb} (Table 2). GM_{Mb} Probability, due to low C to N ratio and speed decay of this green manure residue, releases essential nutrients to succeeding wheat. In other hand, GM_A probability provides suitable soil condition due to deeper root systems and high quality of vegetative parts of this GM. Also, mean comparison of the interaction of treatments (N × GM) showed that, use of 100 kg N h⁻¹ with the application of GM_A had the most number of tillers per plant, whereas use of GM_M without N fertilizer application caused the least number of tillers per plant (Fig. 2). Asghar malik et al. [17], reported that the number of tillers in rice significantly increased by increasing of nitrogen fertilizer application from 0 to 60 kg N ha⁻¹, while no significant differences observed by using nitrogen fertilizer from 60 to 90 kg N ha⁻¹. The information obtained from number of productive wheat tillers per unit area showed that effect of various organic fertilizer in different combination on number of fertile wheat tillers per unit area significantly affected [14].

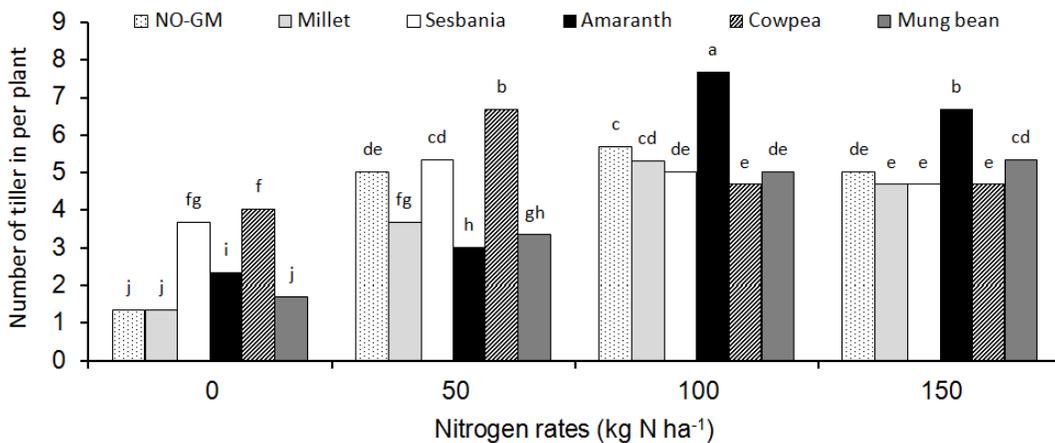


Fig. 2. Effect of nitrogen fertilizer levels and different green manures on wheat number of tillers per plant

3.3 Straw Yield

According to ANOVA results (Table 1), the use of N levels and GM showed significant effects on straw yield in 1% probability level, while interaction with them (N × GM) had a significant effect in 5% probability level. Increasing of N fertilizer application from 0 to 100 kg N ha⁻¹ caused significant increase of wheat straw yield. While, similar to other investigated traits (plant height and number of tillers in per plant), straw yield no significantly affected by increasing of nitrogen from 100 to 150 kg N ha⁻¹. The mean comparison showed that, among different GM treatments, NO-GM caused highest wheat straw yield that was significantly higher than the other GM probably due to low C to N ratio of NO-GM. Although NO-GM produced lower plant height and number of tillage as compared with various GM. Wheat plants as affected by NO-GM treatment produced high amount of leaves and chaff, so this treatment caused highest straw yield as compared with used GM. The most straw yield (9.01 ton h⁻¹) was obtained by using 150 kg N h⁻¹, and least value (4.04 ton h⁻¹) was obtained without N fertilizer application (Table 2). The highest straw yield (8.88 ton h⁻¹) was obtained by NO-GM, and the lowest amount of straw yield (6.15 ton h⁻¹) was obtained as affected by GM_S (Table 2). Also, interaction of treatments (N × GM) demonstrated that, highest straw yield was observed in 150 kg N h⁻¹ without GM application (NO-GM), and lowest straw yield was observed in GM_S and GM_A without N fertilizer application (Fig. 3). Aulakh et al. [18] showed that, wheat straw yield significantly increased by increasing of N fertilizer rates and using of various GM as compared with fallow (without GM application). Shah and Ahmad [19] studied on the effect of integrated use of farm yard manure and urea on yield and nitrogen uptake of wheat and concluded that straw yield was considerably further in treatment receiving N from urea and FYM. Also Amin [16] showed that the different nitrogen sources had significant effects on maize straw yield.

Table 2. Mean comparison of nitrogen level and green manures on some traits of wheat

Studied factors	Plant height (cm)	Number of tillers in per plant	Straw yield (ton h ⁻¹)
N level (kg N ha⁻¹)			
0	72.69 c	2.41 c	4.04 c
50	89.73 b	4.52 b	7.8 b
100	95.67 a	5.57 a	8 ab
150	93.69 ab	5.19 a	9.01 a
Green manures			
NO-GM	80.61 c	4.27 c	8.88 a
GM _{Millet}	88.94 a	3.86 d	6.58 bc
GM _{Sesbania}	84.84 b	4.69 b	6.15 c
GM _{Amaranth}	89.52 a	4.94 a	6.63 bc
GM _{Cowpea}	91.75 a	5.03 a	7.68 b
GM _{Mung bean}	92.01 a	3.76 d	7.35 b

In each section, means followed by the same letter within columns are not significantly different ($p < 0.05$) according to LSD test.

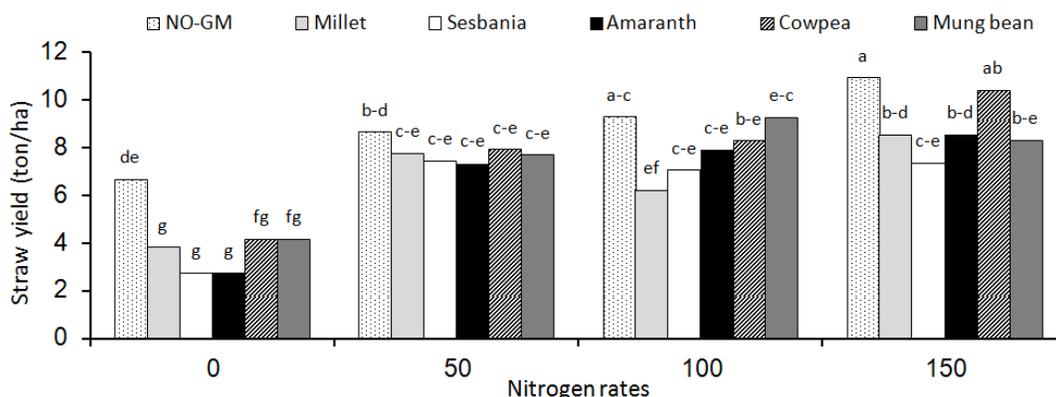


Fig. 3. Effect of nitrogen fertilizer levels and different green manure crops on wheat straw yield

4. CONCLUSIONS

Green manure helps to improve the fertility of soil in organic and conventional plant production. Green manure crops provide a significant increase in the N supply or other essential nutrients for the succeeding wheat crop without any yield loss of the main crop compared to the unfertilized variant (N).

Legumes green manure due to several reasons such as higher quality of plant residue, lower C to N ratio, speed decay of residue were better than non-legume green manure [20]. Although, among legume green manure, mung bean and cowpea provided suitable conditions for wheat as subsequent crop so, were better than sesbania. Also, using 100 kg N ha⁻¹ showed the best results in this experiment. Therefore, using of mung bean and cowpea along with 100 kg N ha⁻¹ recommended for wheat plant production of this region.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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