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ORIGINAL ARTICLE

The Interactive Effect of Organic and Chemical Fertilizers on Bread Wheat Yield in Subtropical Environmental Conditions

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ABSTRACT

Increasing concerns about the environmental pollution by chemical inputs and the need to conserve the resources for the next generations have drawn the researchers' attentions towards the sustainable agriculture. In this research, a factorial split plot experiment was carried out in the form of randomized complete block experiment with three replications. The main plot included two sowing dates of green manure of the mung bean and fallow. The sub plot included three levels of nitrogen fertilizer as the first factor and three levels of phosphorus fertilizer as the second factor. Planting the mung bean as green manure increased the amount of organic materials and minerals in the soil. The effect of green manure and the interactive effect of experimental treatments on the grain yield were significant at 5% level and the effect of phosphorus and nitrogen on this trait was significant at 1% level. Delay in sowing date of green manure of the mung bean decreased its useful effects on the grain yield. The highest rate of grain yield belonged to the treatment with 120 kg nitrogen and 90 kg phosphorus on the planting date of July 3. Sowing the mung bean on July 3 to be used as the green manure increased the grain yield of wheat compared to the fallow conditions. Moreover, during the use of the mung bean as the green manure, the grain yield in the treatment with 60 kg/ha nitrogen and 45 kg/ha phosphorus was more than that of the treatment with 120 kg/ha nitrogen and 90 kg/ha phosphorus in the fallow conditions. The increase of grain yield in green manure treatments in comparison to the fallow treatment was due to the increase of the number of grains per area unit and biological yield.
Keywords: *green manure, mineral fertilizers, wheat*

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INTRODUCTION

During the past century, Major changes have been made in agricultural economy and technology. Consumption of chemical inputs has increased and several tillage operations are performed to increase production and economic interest. Increasing concerns about environmental pollution by chemical inputs and the need to preserve resources for future generations has drawn the researchers' attention towards sustainable agricultural systems. Application of some crops as green manure has increased the cultivation system sustainability via decreasing the soil erosion, controlling grass weeds, increasing soil's organic matters and fertility [1, 2]. Green manure can be used for amending the soil or as a food source for plants [3]. This fertilizer has an important role in regulating the period of agricultural systems particularly the organic ones. Even though a major part of the research on green manure has just focused on the rate and the method of nitrogen fixation by them, the results of some other research show that the soil phosphorus increases while using such manures [4]. Green manures might increase the rate of accessible phosphorus for the next crops through different mechanisms. Such manures change the chemical fertilizers into usable forms for plants by absorbing the remaining phosphorus of chemical fertilizers. Some species of legumes such as alfalfa, red clover, lupin, etc are able to absorb phosphorus more than other crops [5]. The phosphorus available in organic compounds of green plants provides the absorbable and changeable form for the next plants. Organic phosphorus gradually changes into inorganic phosphorus through moralization process and will be absorbed by the next crop (Kavikli and Singh, 2003). It has been reported that green manures increase the percentage of organic matters, microorganisms' biomass, soil dehydrogenase and urease compared to the control treatment without fertilizer [6]. Moreover, some

Mohammadpour, Adel Modhejresearch has shown that cultivating legumes as green manure has increased the rate of available nutrients for wheat and organic matter of the soil [7]. Shah et al. [8] reported in a several-year research that alternate cultivation of legumes family as the green manure with along with the whet and application of nitrogen chemical fertilizer increased the efficiency of the nutrient uptake.

Application of chemical fertilizers has greatly increased recently. Such fertilizer are used in little volume are less expensive than animal manures and thus there is a high tendency to use them. However, consumption of chemical fertilizers does not have a positive effect on the soil characteristics. Cultivation of nitrogen fixating crops not only provides some needed food for the next crops but also increases soil organic matter and improves its chemical and physical properties [9]. It should be noted that even though the consumption of green manures influence the food supply, the release of their nitrogen might not coincide with the peak crop demand [10]. In such circumstances the use of appropriate green plant, further tillage, changing plant density and more importantly selecting an appropriate planting date for green manure can lead to the increase of nitrogen use efficiency [11].

Although the use of green manures can supply nutrients and improve the soil, it should be noted that they are not able to meet all nutritional needs of plants. Therefore, it seems that the combination of such manures and the reduced amounts of mineral fertilizers not only meets the nutritional needs of plants but also increases the soil organic matter and improves its physical and chemical properties. Mung bean (Vigna Radiata) is a crop that belongs to the legumes family which is capable of biological nitrogen fixation and is cultivated as the green manure in some tropical and subtropical regions. Limited studies have been done in country and in Khuzestan Province on the effect of mung bean as the green manure and also the interactive effect of the mung bean and different levels of mineral phosphorus and nitrogen on the soil properties, grain yield and yield components of wheat. The present study was conducted to evaluate the effect of planting date of mung bean as the green manure and different levels of phosphorus and nitrogen fertilizers on the grain yield and yield components of wheat in Dezful environmental conditions.

MATERIALS AND METHODS

The experiment was conducted in 2010 and 2011 in Southwest Iran. The experiment site was at latitude 32°36´ N and longitude 48°31´ E and is about 143 m above the sea level. It had hot dry climate with mild winters and hot dry summers.

It was a factorial split plot experiment with three replications. The main plot included two sowing dates of green manure of the mung bean (July 3, August 10) and the fallow conditions. The sub plot included three levels of nitrogen fertilizer (without fertilizer, 60, and 120 kg/ha nitrogen) as the first factor and three levels of phosphorus fertilizer (without fertilizer, 45, and 90 kg/ha phosphorus) as the second factor. Land preparation operations for mung bean cultivation included deep plowing, two perpendicular discs and trowel. In the mid flowering stage the mung bean was returned to the soil by plowing and it was well crushed and mixed with the soil by rotavator. Land preparation operations for the wheat (Chamran cultivar) included deep plowing, two perpendicular disks and trowel. The density of cultivated wheat seeds according to the research recommendations was 400 seeds per square meter. The weal was sowed in December 6. The amount of consumed mung bean seed was 100 kg/ha. Nitrogen fertilizer form the urea source and phosphorus from the triple super phosphate source were added to the soil according to the amount of fertilizer treatment. Half of nitrogen fertilizer and all the phosphorus fertilizer were distributed in the field as the base after the first disc and were mixed with soil by the second disk. The second half of nitrogen fertilizer in each treatment was used at stem elongation stage as top dressing. Some features of the soil such as the content of organic matter, phosphorus, nitrogen, potassium, acidity and the soil texture were measured in two depths of 0-30 cm and 30-60 cm before and after using the green manure.

In order to determine the grain yield and yield components, the grains were harvested at the final maturity stage and after the removal of half a meter of the beginning and end of each plot in lines 3 and 4 in an area of 1.2 m2. The weight of the seeds was calculated in four 250-seed samples. The data were analyzed by means of SAS statistical program and the means were compared via Duncan's multi range test at 5% level. In order to draw the diagrams, Excel software was used.

RESULTS AND DISCUSSION

Soil Characteristics

The results related to the content of soil organic matter and the elements of potassium and nitrogen before and after returning the green manure and before planting the wheat are shown in tables 1 and 2. Planting the mung bean as the green manure has increased the content of organic matters and mineral elements in soil. Goyal et al. [12] reported that conserving organic matters of the soil is possible via increasing crops residue in it. Mandal et al. [13] concluded that the use of grain manure increased the grain yield of wheat due to the improvement of soil structure, increase of organic matters and nitrogen in soil. By planting the mung bean in July 3, the growth period of this plant increased until the stage of using it as the green manure which somewhat increased the plant biomass while returning the soil. On the other hand, the flowering stage occurred earlier during the early planting date of mung bean and consequently the time interval between using the green manure and planting the wheat increased. It seems that this provided sufficient time for the disintegration of organic matters and the release of nutrients in the treatment.

Table (1): Some features of the soil of experimental site

Sample depth	EC (DS/m)	pH	Organic (%)	Phosphorus (p p m)	Potassium (ppm)	Soil texture			
						Clay (%)	Silt (%)	Sand (%)	Tissue
0-30	1	7.1	0.64	6.8	188	38	36	26	Clay loam
30-60	0.7	7.6	0.43	2.8	121	42	40	18	Silt clay

Table (2): Some of the feature of the soil in mung bean planting treatments as the green manure and fallow before planting the wheat

Sampling depth (cm)	Organic matter (%)	Phosphorus (ppm)	Potassium (ppm)	Nitrogen (ppm)
Fallow				
0-30	0.6	7	159	620
30-60	0.34	4.2	86	380
Sowing date July 3				
0-30	0.7	7.5	178	680
30-60	0.36	4	77	500
Planting date August 10				
0-30	0.7	8	140	660
30-60	0.34	3.5	69	460

Grain yield and its Related Traits

The results showed that the effect of green manure and the interactive effect of green manure and phosphorus and nitrogen fertilizers on the number of spikes/m2 were significant at 5% level and the effect of phosphorus and nitrogen fertilizers on this trait was significant at 1%level. The highest and the lowest number of spikes per area unit respectively belonged to the planting date of the mung bean on July 3 and the fallow (Table 3). The number of spikes in treatments with planting dates of July 3 and August 10 compared to the fallow treatment was 14.5% and 7% more, respectively. The increase of nitrogen and phosphorus significantly increased the number of spikes. Consumption of 120 kg/ha nitrogen and 90 kg/ha phosphorus increased the number of spikes 20% and 13% respectively compared to the control treatment without fertilizer. The results were consistent with the findings of Mainard and Jeuffroy [12] on the increase of the number of spikes per area unit due to the increase of nitrogen fertilizer. [12] reported that lack of nitrogen due to the decrease of fertile tillers and their survival led to the decrease of the number of spikes per area unit. Examining the interactive effect of green manure and phosphorus and nitrogen fertilizers showed that the highest number of spikes per area unit belonged to the treatment with 120 kg/ha nitrogen and 90 kg/ha phosphorus during the planting date of green manure on July 3 (Table 4). The difference between this treatment and the treatment with 120 kg/ha nitrogen + 45 kg/ha phosphorus during the planting date of green manure on July 3 was not significant. The number of spikes in the treatment with the combination of 120 kg/ha nitrogen + 90 kg/ha phosphorus during the planting date on July 3 was about 11.2% more than the same combination in fallow conditions.

Table (3): Mean comparison of grain yield and its related traits in the studied treatments

Treatments	means							
	Spike per m2	Spikelet per spike	Grain per spike	Grain per spikelet	Gran per m2	1000-grain weight (g)	Grain yield (g/m2)	Biological yield (g/m2)
Mung bean planting date								
Fallow	392b	6.11b	8.19b	6.1b	7818b	38a	404b	763b
03-Jul	449a	7.11b	8.21a	8.1a	9827a	39a	477a	897a
10-Aug	422b	5.12a	3.21ab	6.1b	9125a	38a	417b	825a
Nitrogen (Kg/ha)								
Without fertilizer	371c	3.11b	5.18c	5.1b	6840c	37a	369b	740b
60	427b	1.12a	3.21b	6.1b	9040b	38a	449a	813b
120	467a	3.12a	1.23a	9.1a	10890a	39a	480a	930a
Phosphorus (Kg/ha)								
Without fertilizer	391b	8.11a	20a	6.1a	8004b	38a	405a	808a
45	424ab	8.11a	21a	7.1a	8984ab	38a	437a	830a
90	449a	1.12a	22a	8.1a	9781a	39a	456a	847a

In each column, there is a significant difference between the means with dissimilar letters according to Duncan's multi range test at 5% level.

The effect of green manure planting date and the interactive effect of the treatments on the number of spikelet per spike were significant at 5% level and the effect of nitrogen fertilizer on this trait was significant at 1% level. The effect of phosphorus fertilizer on the number of spikelet per spike was not significant. The results showed that the increase of nitrogen and phosphorus increased the number of spikelet per spike (Table 3). The effect of green manure planting date, nitrogen, and the interactive effect of the treatments on the number of grains per spikelet were significant at 1% level, while the effect of phosphorus on this trait was not significant. The increase of nitrogen level, lead to the significant increase of number of grains per spikelet.

Peltonen and Peltonen [13] concluded that as the nitrogen level decreased, the number of fertile florets per spikelet decreased significantly. In those researches, the decrease of number of grains per spikelet was due to the increasing number of infertile florets. The highest and the lowest number of grains per spikelet belonged to green manure planting date on July 3 and fallow treatments respectively (Table 3).

The highest number of grains per spike belonged to the green manure planting date of July 3(Table 3). Green manure planting on July 3 and August 10, increased the number of grains per spike 9.1% and 7% respectively compared to the fallow treatment. The increase of nitrogen level significantly increased the number of grains per spike, so that the number of grains in treatments with 60 and 120 kg/ha nitrogen increased as 11.9% and 20.6% respectively. It seems that the increase of the number of grains per spike in the treatment with 120 kg/ha nitrogen was due to the increase of the number of spikelet per spike and the number of grains per spikelet. The results were consistent with the findings of Modhej et al. [14].

Even though the effect of phosphorus fertilizer on the number of grains was not significant, the consumption of 90 kg/ha phosphorus increased the number of grains per spike as 9%. The highest number of grains per spike belonged to the treatment with 120 kg/ha nitrogen + 90 kg phosphorus on planting date of July1 (Table 4). The difference between this treatment and the treatment with 120 kg/ha nitrogen + 45 kg/ha phosphorus in green manure planting date of July 3 was not significant.

The lowest number of grains per spike belonged to the low levels of mineral fertilizer in the fallow conditions. The highest number of spikelet belonged to the treatment with 120 kg/ha nitrogen + 90 kg/ha phosphorus on July 3, i.e. the green manure planting date.

Table (4): Mean comparison of the interactive effect of the studied treatments on the grain yield and its related traits

Treatments	Means							
	Spike per m^2	Spikelet per spike	Grain per spike	Grain per spikelet	Grain per m^2	1000g rain weight (g)	Grain yield (g/m^2)	Biological yield (g/m^2)
N_1P_1	232de	10c	17fg	1.1f	5683ij	36a	297f	696de
N_1P_2	383cde	11c	16g	1.3ef	6159ij	38a	312ef	648e
N_1P_3	403abcde	12ab	18efg	1.4def	7130fghij	39a	405bcdef	759cde
N_2P_1	411abcde	12ab	22abcdef	1.5bcdef	9287cdefgh	39a	437abcdef	872bcde
N_2P_2	457abc	11bc	22abcdef	1.5bcdef	9982bcdefg	37a	460abcde	806cde
N_2P_3	446abcd	12ab	22abcdef	1.5bcdef	10040bcdefg	37a	457abcde	825bcde
N_3P_1	450abcde	11bc	23abcde	1.7bcdef	10519bcde	39a	441abcde	900abcde
N_3P_2	458abc	12ab	24abcd	1.8abcd	11212abcd	38a	467abcde	956abcd
N_3P_3	473abc	12ab	25a	1.9abc	12115abc	38a	474abcd	961abcd
N_1P_1	325de	12ab	19cdefg	1.5bcdef	6043ij	37a	361def	763cde
N_1P_2	383cde	11bc	19cdefg	1.7abcdef	7318fghij	40a	408bcdef	792cde
N_1P_3	474abc	12ab	20def	1.7abcde	9366cdefg	38a	424bcdef	802cde
N_2P_1	440abcd	12ab	22abcdef	1.7abcde	9263defg	40a	430abcdef	802cde
N_2P_2	425abcd	12ab	23abcde	1.8abcde	9731cdefg	39a	498abcd	835bcde
N_2P_3	470abc	13a	22abcdef	1.8abcd	10281bcdef	39a	516abcd	843bcde
N_3P_1	472abc4	12ab	21bcdef	1.8abcd	10156bcdef	39a	529abc	1000abc
N_3P_2	520ab	13a	24abcd	1.9ab	12789ab	39a	533ab	1079ab
N_3P_3	533a	13a	25a	2a	13498a	40a	579a	1142a
N_1P_1	291e	10c	18efg	1.5abcde	5326j	36a	369def	693de
N_1P_2	361cde	11bc	19cdef	1.5abcdef	6756hij	37a	377cdef	779cde
N_1P_3	394bcde	11bc	20def	1.5abcdef	7778efghij	38a	372def	732de
N_2P_1	380cde	12ab	19cdefg	1.5abcdef	7155efghij	37a	377cdef	792cde
N_2P_2	401bcde	12ab	19cdefg	1.6abcdef	7575efghij	37a	428abcdef	795cde
N_2P_3	411abcde	11bc	20def	1.5abcdef	8046efghij	40a	441abcdef	749cde
N_3P_1	430abcd	12ab	20def	1.6abcdef	8607efghi	38a	409bcdef	737cde
N_3P_2	430abcd	12ab	22abcdef	1.9abcd	9337cdefgh	38a	431abcdef	748cde
N_3P_3	436abcd	13a	22abcdef	1.9abcd	9773cdefg	39a	436abcdef	802cde

In each column, there is a significant difference between the means with dissimilar letters according to Duncan's multi range test at 5% level. N and P: nitrogen and phosphorus treatments respectively.

The effect of treatments on 1000-grain weight was not significant (Table 2). The effect of green manure and the interactive effect of experimental treatments on grain yield at 5% level and the effect of phosphorus and nitrogen treatments on this trait were significant at 1% level (Table 2). Green manure cultivation on July 3 and August 10 increased the grain yield by 15.3% and 3.1% compared to the fallow treatment (Table 3). Delay in planting date of green manure of the mung bean reduced its useful effects on the grain yield. The increase of grain yield in this treatment resulted from the increase of the number of spikes per area unit and the number of grains per spike. Singh et al. [7] reported that cultivation of legumes as green manure increased the grain yield through the increase of available nutrients and the content of soil organic matters. Consumption of 60 and 120 kg/ha nitrogen increased the grain yield by 15.3% and 23.1% respectively compared to the treatment without fertilizer. The increase of grain yield in treatments with 45 and 90 kg/ha phosphorus compared to the plot without phosphorus was 7.3% and 11.2% respectively. The increase of Phosphorus level had no significant effect on the grain yield. Khazaei et al. reported that as the soil phosphorus increased up to 10 mg per 1 kg of soil. The grain yield of the wheat didn't change significantly. The mean of grain yield in the treatment with 120 kg/ha nitrogen and green manure planting date of July 3 was 15.9% more than the treatment with 120 kg/ha nitrogen in the fallow conditions.

The highest grain yield belonged to the treatment with 120 kg/ha nitrogen + 90 kg/ha phosphorus and green manure planting date of July 3 (Table 4). The difference between this treatment and the treatment with 120 kg/ha nitrogen + 45 kg/ha phosphorus in this date was not significant. The results showed that the rate of consumed phosphorus fertilizer decreases due to green manure cultivation. Cultivating the mung bean as green manure on July 3 increased the grain yield in the treatment with 120 kg/ha nitrogen + 90 kg/ha phosphorus about 18.2% compared to this fertilizer combination in the fallow conditions. Measuring the grain yield in control plots without consumption of mineral fertilizers showed that cultivation of the mung bean as green manure on July 3 and August 10 increased the mean of grain yield by 18.5% compared to the fallow conditions. Moreover, the grain yield of the treatment with 60 kg/ha nitrogen + 45 kg/ha phosphorus during the use of green manure (planting date of July 30) was more than that of the treatment with 120 kg/ha nitrogen + 90 kg/ha phosphorus in the fallow conditions (Table 4).

Naidiu [15] concluded that supplying 75% of the wheat need through urea chemical fertilizer and 25% through green manure resulted in the highest grain yield. The positive effect of green manure on the increase of grain yield of wheat has been proves in other studies, too.

Mung bean cultivation as green manure on July 3st and August 10th increased the biological yield as 15% and 7.7% respectively compared to the fallow conditions (Table 3). As the level of nitrogen increased to 60 and 120 kg/ha, the biological yield increased as 18.9% and 28.4% respectively. The difference between two treatments of 60 and 120 kg/ha nitrogen was significant. The effect of phosphorus fertilizer on biological yield was not significant. Examining the interactive effect of the treatment on biological yield showed that in the treatment with 120 kg/ha nitrogen + 90 kg/ha phosphorus and mung cultivation on July 3, the biological yield increased 22% compared to the same fertilizer treatment in the fallow conditions (Table 4). In the control plot without mineral fertilizer, planting the mung bean on August 10 had no effect on biological yield while on July 3 as the planting date the trait increased about 9%.

In general, the results of the research showed that planting the mung bean as green manure on July 3 increased the grain yield of wheat compared to the fallow conditions. Moreover, during the use of green manure, the grain yield in the treatments with 60 kg/ha nitrogen + 45 kg/ha phosphorus was more than the treatment with 120 kg/ha nitrogen + 90 kg/ha phosphorus in the fallow conditions. The increase of grain yield in green manure treatments compared to the fallow treatment was due to the increase of the number of grains per area unit and the increase of biological yield. It sees that application of green manures and mineral fertilizers at the same time can increase mineral fertilizer uptake and also increase the consumption of available nutrients in green manures by the wheat.

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