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Effect of pre-sowing plants and different nitrogen levels on the yield and yield components of wheat (*Triticum aestivum* L.)

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Key words: Buko, oilseed radish, perko PVH, pre-sowing, ramtil, clover, phacelia.

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Abstract

A field experiment was conducted to determine the most appropriate level of nitrogen fertilizer and wheat pre-sowing plants during 2012- 2013 sowing season under the temperate climate of Ilam province, IRAN. The experiment was performed in a split plot arrangement based on randomized complete block design with 4 replications. The main plots consisted of 6 pre-sowing plant treatments (control, Perko PVH, Buko, Clover, Oilseed radish and the combination of three plants Ramtil, Phacelia and clover), and sub-plots were allocated to four levels of nitrogen fertilizer (0, 75, 150 and 225 kg/ ha). The results showed that there were significant differences among the treatments for the biological yield, total dry weight, protein content, protein yield and the percentage of organic carbon in soil after planting. Boko and Perko produced the highest yield as a pre-sowing plant. The type of Pre-sowing plant significantly affected grain yield, number of spikelets per spike and harvest index. However, the effect of pre-sowing plant type was not significant on the number of grains per spike, thousand grain weight, spike number and grain weight per spike. Increasing the nitrogen levels significantly improved the number of spikelets per spike, grains per spike, grain weight, and the number of spikes per unit area. However, there was a reduction in harvest index and grain weight per spike by increasing the levels of nitrogen. The highest wheat grain yield (8440.8 kg ha^{-1}) was achieved at 150 kg N ha^{-1} and the lowest (5039 kg ha^{-1}) belonged to control (no N fertilizer). The highest and lowest grain yields were obtained for Buko and no pre-sowing plant with 8345, and 4491 kg ha^{-1}, respectively.

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Introduction

Almost 75% of food needed by the population comes from only 12 plant species . Today, only 3 plants, wheat, rice and maize to provide about 60% calories and 56% protein needed for human being (*Janick 2001*).

Perko varieties were derived from the crosses between tetraploid plants of winter rapeseed (*Brassica napus* L.*varnapus*) and Chinese cabbage (*Brassica campestris* L.var. *sensulato*). New plants are superior to their parents in different aspects. Buko variety is a new amphiploid plant obtained by crossing tetraploid winter rapeseed, Chinese cabbage and turnips (*Brassica campestris* L.var. *Rapa*). Oilseed radish with scientific name (*Raphanus sativus* L.) is a genus belong to the *Brassica* and for various uses, e.g. oil, green manure, feed and fodder (*Kashani et al ,1986* :Lupashku*, 1980:* Nasri *et al., 2014*). This plant in many countries, including Canada, is cultivated in gardens as a cover crop. Oilseed radish is growing quickly in the cool seasons. Ramtil (*Guizotia abyssinica*) belongs to *Asteraceae* family, Phasilia (*Phacelia tanacetifolia*) to Boraginaceae (Marianne*, 1994*) and clover to *Fabaceae* family which all are grown for feeding(Nasri *et al., 2014*).

The cultivation of Perko (tetraploid *Brassica napus* var. *oleifera* X tetraploid *B. Chinese*) cv. PVH for fodder production has been reported in Moldavia. It produced 55.8 t/ha fresh fodder and 5.76 t/ha dry matter; the regrowth in spring also gave high yields (Lupashku*, 1980).* According to Karsli *et al., (1999)* the crude protein Egyptian clover is 22% and fiber content in this crop has an average of 32 percent. Clark*, (2007)* has also reported that Egyptian clover contains 18-28 percent protein.

Some of the general purposes of crop rotation are: to maintain soil structure, increase soil organic matter, increase water use efficiency, reduce soil erosion, reduce the pest infestation, reduce reliance on agricultural chemicals and improve crop nutrient use efficiency *(*Halvorson *et al., 2002).*

Pre-planting can be used for specific purposes, such as adding nitrogen and carbon in agricultural systems, improve the C/N ratio and soil erosion control. Three major groups of plants, including grasses, legumes and brassica are used as green manure. In many cases *Brassica* as a good substitute for legumes and grasses is planted as green manure which can significantly increase soil organic carbon and soil porosity *(*Collin *et al., 2007).* Wheat grain yield was higher when planted after clover up to 200 to 300 kg per hectare *(*Shahbazian and Allahdadi*, 2004).*

One reason for the doubling of agricultural production in the past 4 decades is due to the use of nitrogen fertilizers. Now, the excessive use of nitrogen fertilizers has caused a wide range of health, environmental, economic problems. Ecological systems are even more dependent on chemical inputs and agricultural use of fossil fuels and may contribute to plant production (Crews and Peoples *2004;* Hirel *et al., 2007*). Nitrogen is essential for cell division and growth and increases leaf area and leaf area duration and improves tiller survival (Simons 1982: Delfin *et al.*, 2005). Nitrogen at different growth stages increased of wheat grain yield, number of grains per spike, grain weight, harvest index, protein percentage and increase the efficiency of nitrogen use efficient *(*Subedi *et al., 2007:* Semenov *et al., 2007:* Michael and Adoerge*, 2003).* According to Rahimizadeh *et al., (2011)* crop rotation and nitrogen fertilizer on crop yield significant effects of seed sowing, biomass, and number of spikes per unit area and spike length of wheat. The increased use of nitrogen fertilizer in wheat enhanced tiller number, number of ears per square meter, grain weight, grain yield, biological yield and straw yield *(*Zebart and Sheard*, 1992:* Mc Donald*, 2002:* Nasri *et al,. 2014:* Ejaz *et al., 2003).*

The yield components of wheat are directly affected by increasing nitrogen rate. The first prerequisite to achieve optimal performance (number of spikes per area) is proportional to increase in nitrogen rate (Zebart and Sheard, *1992:* Giovanni *et al., 2004:* Ayoub *et al., 1994:* Camberato and Bock, *2001).* Increased nitrogen levels significantly enhanced the number of spikes per square meter (Halvorson *et al., 2002:* Lopez-Bellido and Lopez-Bellido, *2001:* Semenov *et al., 2007:* Wiese *et al., 1994:* Rasmussen *et al., 1997).*Appropriate rate of nitrogen fertilizer, increased seed yield mainly by improving the number of spikes and number of seeds per unit area *(*Ayoub *et al.,1994:* Fischer*, 1999:* Gharangeik and Ghaleshei*, 2001:* Mc Donald*, 2002:* Giovanni *et al., 2004).*

Thousand grain weight, the number of spikes per square meter, the number of spikelets per spike, protein content and grain yield of wheat (Pishtaz cv.) significantly increased with higher amounts of nitrogen fertilizer, but the harvest index decreased with increasing nitrogen fertilizer *(*Nasri *et al.,2014).*

This research was aimed to recognize the ways to improve soil organic matter, to understand the effects of pre-sowing plants and nitrogen fertilizer level on yield and yield components of wheat.

Materials and methods

Experimental site and design

The field experiment was conducted from 2011 to 2013 at the Karezan region of Ilam, Iran (42°33′N, 33°46′ E) on a Silty- Clay with low organic carbon (1.26%and slightly alkaline soil (pH= 7.9). Other soil test parameters is presented in Table 1.This site characterized by temperate climates with 370 mm annual precipitation.

Design and application of treatments

The experiment was arranged in a split plot based on randomized complete block design with four replications. The main plots consisted of 6 pre-sowing plant treatments (control, Perko PVH, Buko, Clover, Oilseed radish and the combination of three plants Ramtil, Phaselia, clover), and Sub plots were four N fertilizer rates including no fertilizer N(Control), 50% lower than recommended N rate, recommended N rate and 50% more than recommended N rate.

Winter wheat (Cv. Pishtaz) was planted on mid-November with row spacing of 15 cm and a seeding rate of 200 kg ha^{-1}. Weeds were controlled by 2,4-D and Clodinafop-propargyl herbicides. Soil samples were taken after harvest of each crop from the 0 to 30 cm and 30 to 60 cm soil depths using a soil auger. Grain yield (with 14% moisture) was estimated by harvesting an area of 30m^2 with a plot combine, but yield components were determined from two randomly selected areas (2m^2) within each plot. Plant samples collected at harvest, were separated into grain and straw and oven-dried at 60˚C for 72hr. Biomass and grain sub samples analyzed for total N content using a micro-Kjeldahl digestion with Sulfuric acid. In this experiment was determined grain yield, yield components (number of spikes per square meter, number of spikelets per spike, number of grains per spike, thousand grain weight, and grain weight per spike), harvest index, biological yield and protein content. Forage produced on each plot, was chopped and mixed. After 15 days soil organic carbon percentage was determined.

Statistical analysis

The differences between treatments were determined using analysis of variance (ANOVA) by the SAS software version 9.5. Mean comparisons were performed using Duncan's multiple range test procedures.

Results and discussion

Pre-sowing plants

Biological yield

The results showed that the varieties used in this study showed significant differences in biological yield ($P \le 0.01$) (Table 2). The highest biological yield belonged to Perko, oilseed radish and Buko, respectively with 69,59, 69,16and 67,41kg ha^{-1}, and the lowest biological yield was observed for Berseem clovers with 38,464 kg ha^{-1} (Table 3). Biological yield of oilseed radish and Perko was greater than the other varieties. There was an 81 percent increase for oilseed radish and 75 percent for Buko in their performance rate compared to berseem clover forage in these conditions. Similar results have already been reported (Kashani *et al, 1986:* Lichner*, 1990:* Veneni and Axamit, *1980:* Lvpashkvh*, 1980).*

Table 1. Results of soil tests implementation of experimental site.

Soil depth (cm)	Soil Texture	P (ppm)	K(ppm)	N%	OC%	pH	EC(ds/m)
0-30	Silty- Clay	10.5	760	0.11	1.26	7.9	0.58
31-60	Silty- Clay	4.4	420	0.07	0.76	7.8	0.58

Total Dry Weight

The results showed that there was a significant differences among plant varieties in total dry weight,($P \leq 0.05$) (Table 2). The higher total dry weight was observed for Perko (7147.5 kg ha^{-1}) and the lowest dry matter yield was belonged to the combination of three plants; Ramtil, Phaselia, clover producing 4866 kg ha^{-1} dry matter (Table 3).The results of this study showed a greater performance for Perko compared to clover up to 76.44 percent. The results were similar to those from some previous researches *(*Kashani *et al, 1986:* Hamdi *et al, 1992:*Lvpashkvh*, 1980).*

Table 2. Analysis of variance of different soil properties in response to various pre-sowing plants. The data were analyzed in for of a complete block design.

S.O.V	df	Mean-square(M.S)			
		Soil organic carbon before planting	Soil organic carbon after planting	Biological yield	Total dry matter
Replication	3	0.037	0.036	165379626^{ns}	954922^{ns}
Treatment	4	0.052*	0.483**	**828725925	*4211174
CV	-	10.80	18.92	98432412	864995

ns, * ,**: Non significant on 1 and 5 % levels of probability, respectively.

Percentage of organic carbon before planting in soil

The results showed that the varieties were significant for the percentage of organic carbon before planting in soil (Table 2).

Percentage of organic carbon after planting in soil

The results showed that the varieties were significant in the percentage of organic carbon after planting (Table 2). Buko and Perko varieties were applied to further increase the amount of soil organic carbon by increasing the percentage of organic carbon at a rate of 0.87 and 0.83 compared to the other treatments. The least increase in the percentage of organic carbon was observed from the combined treatments of Ramtil, clover and Phaselia with a rate of 0.027 (Table 3, Fig. 1).

Table 3. The mean comparisons of different plant characteristics at different preceding crops.

Treatment	Soil organic carbon before planting (%)	Soil organic carbon after planting (%)	Biological yield(Kg ha^{-1})	Total dry matter (Kg ha^{-1})
Perko	1.135 ^{a}	1.96 ^{a}	69586^{a}	7147.5^{a}
Buko	1.237 ^{a}	2.11 ^{a}	67408^{a}	5598.7 ^{bc}
Clover	1.147 ^{a}	1.68 ^{ab}	38464^{b}	4937.2 ^{c}
Combination (Ramtil, Phasilia, clover)	1.185 ^{a}	1.212 ^{b}	47950^{b}	4866 ^{c}
Oilseed radish	0.937 ^{b}	1.605 ^{ab}	69164^{a}	6664.4 ^{ab}

Treatment with the same letters don't show significant differences.

Yield and yield components of wheat

Grain yield

The results showed that there was a significant difference between the main plot of the grain yield $P \leq 0.05$ (Table 4). Thus pre-sowing plants caused creating changes in grain yields were compared with the controls, so that the new plants Perko, Buko, Oilseed radish and combination of three plants

(Ramtil, Phaselia, and Clover) produced higher yield compared to Clover and control (Fallow). Grain yield production using Buko as a pre-sowing planting, was the highest with an average of 8345 kg ha^{-1} whereas control treatment produced the lowest grain yield with an average of 4491 kgha^{-1} (Table 5). The results showed significant difference between the levels of nitrogen for the grain yield (Table 4). The highest grain yield with 8440.4 kgha^{-1}, was achieved from the treatment of 150 kg ha^{-1}N and the lowest GY with 5039 kg ha^{-1} was from control treatment (N_0 fertilizer) (Table 5). Among the interactions the treatment of Buko pre-plant and 225 kg ha^{-1}Nhad the highest GY with 9793 kg ha^{-1} and the lowest GY was from the control treatment (Fallow) and zero fertilizer production with a GY of 3365 kg ha^{-1}. Other researchers also confirmed that brassica varieties as pre-sowing crops increase the yield and quality of wheat (Mc Donald, *2002:* Lehrsch, and Gallian. *2010:* Nasri *et al., 2014)*. The highest of wheat producing lack of nitrogen application the amount 7125 kg wheat belonging to the Buko treatment and the highest of wheat producing 75 kg of nitrogen application the amount 7550 kg Perko plant belonging and the highest production of wheat with nitrogen application the amount 150 kg 10150 kg of pre-owned oilseed radish plant, the highest wheat-producing with nitrogen application the amount 225 kg, 9793 kg and 9738 kg ha^{-1} were owned pre-planting, Buko and perko treatment.

Table 4. The mean of squares of Grain yield, Harvest index, Thousand grain weight, Number of grains per spike, Number of spikelets per spike, Number of grains per spikelet, Grain weight per spike and Number of fertile spikes.

S.O.V	df	Mean-square(M.S)							
		Grain yield	Harvest index	Thousand grain weight	Number of grain per spike	Number of spikelet per spike	Number of grain per spikelet	Grain weight per spike	Number of fertile spikes
Replication	3	77374.6*	79.26**	71.90**	22.66 ns	6.31*	0.444**	0.141*	83275ns
Rotation(A)	5	313645.6*	251.64**	31.30 ns	36.16 ns	17.74**	0.314**	0.06 ns	95430ns
E(a)	15	105349	36.56	37.08	33.08	3.77	0.058	0.106	50672
Fertilizer N rate(B)	3	627072**	39.56 ns	72.74**	232.51**	18.78**	0.317**	0.096ns	143712*
AB	15	29297.6ns	25.73 ns	22.04 ns	12.92 ns	1.28ns	0,031ns	0.053ns	48136ns
E(b)	54	21684.2	16.47	15.42	22.49	2.23	0.044	0.036	50672
%CV	-	20.96	10.64	11.03	18.01	12.23	9.74	20.12	23.4

*Significant at 0.05 probability level. ** Significant at 0.01 probability level.ns, non-significant.

Number of spikelets per spike

The results showed that there was a significant difference between different teatments for the number of spikelets per spike *$P \leq 0.01$* (Table 4). This means that the number of spikelets per spike were influenced by pre-sowing plants and nitrogen levels. Perko and Buko produced the highest number of spikelets per spike with an average of 13.37 and 13.24 spikelets. Control treatment (Fallow) produced the lowest number of spikelets per spike with a mean of 10.81. Other researchers on the effective yield of the next crop plant residues have confirmed (Cherr *et al., 2006:* Lehrsch and Gallian, *2010)*. Among the levels of N application 225 kg ha^{-1}N produced the highest number of spikelets per spike with an average of 13.24 and the others three levels showed no significant difference for this yield components. Other researchers have also reported that increasing nitrogen fertilizer will increase the number of spikelets per spike (Ayoub *et al.,1994*). In terms of interactions between treatments the highest number spikelets per spike were found for the interaction of pre-sowing Buko and 225 kg ha^{-1} N with14.05 spikelets per spike and the least number of spikelets per spike, were obtained for control treatment (fallow) and an application of 75 kg ha^{-1} N with 10.27 spikelets.

Number of grains per spike

The results showed that nitrogen fertilizer had a significant difference on the number of grains per spike but the effect of pre- sowing plants and the interaction of pre- sowing plants and nitrogen on the number of grains per spike were not significant (Table 4). The highest number of grains per spike were obtained in Perko pre-sowing with 27.63 and after that the oilseed radish pre- sowing produced 27.59 grains per spike and the lowest number of grain per spike were observed in clover pre-sowing with 23.95 grains. Results indicated that the highest number of grains per spike was achieved with 225 kg ha^{-1} N with30.46 grains per spike and the lowest number was found for 0 N application with 23.37kg ha^{-1} . The highest number of grains per spike with 32.99 grains in oilseed radish pre-sowing with 225 kg ha^{-1}N. While the lowest number of grains per spike with 20.86 belonged to oilseed radish oilseed radish pre-sowing and lack of nitrogen which indicated the lack of significant effect on this trait. Zebart and Sheard *(1992*) announced the number of grains per spike decreased with increasing nitrogen. Other researchers have reported nitrogen fertilizer increased the number of grains per spike (Ayoub *et al.,1994:* Michael and Adoerge*, 2003:* Semenov *et al., 2007:* Subedi *et al., 2007).*

Table 5. Mean comparisons of Grain yield, Harvest index, Thousand grain weight, Number of grains per spike, Number of spikelets per spike, Number of grains per spikelet, Grain weight per spike and Number of fertile spikes of wheat at rotations and N rates.

	Grain yield (kg ha^{-1})	Harvest index (%)	Thousand grain weight (g)	Number of grains per spike	Number of spikelets per spike	Number of grains per spikelet	Grain weight per spike (g)	Number of fertile spikes
Preceding crop								
Fallow	4491^{b}	31.27^{c}	32.92^{a}	26.44^{a}	10.81^{c}	2.43^{a}	0.897^{a}	812.5^{a}
perko	8125^{a}	40.03^{ab}	36.35^{a}	27.63^{a}	13.37^{a}	2.07^{b}	1.004^{a}	1024.1^{a}
Buko	8345^{a}	43.26^{a}	36.72^{a}	27.26^{a}	13.24a	2.02^{b}	1.0004^{a}	964.4^{a}
Clover	6550^{ab}	37.11^{b}	36.12^{a}	23.95^{a}	11.49^{bc}	2.08^{b}	0.860^{a}	957.7^{a}
Ramtil,Phacilia,Clover	7199^{a}	38.87^{ab}	36.21^{a}	25.11^{a}	11.57^{bc}	2.16^{b}	0.897^{a}	993.4^{a}
Oilseed radish	7438 ^{a}	38.29^{b}	35.25^{a}	27.59^{a}	12.70^{ab}	2.15^{b}	0.975^{a}	1013.06^{a}
N rate								
Control (no fertilizer)	5039.2^{c}	37.11^{a}	37.72^{ab}	23.37^{bc}	11.43^{b}	2.04^{bc}	0.90^{b}	854.7^{b}
50% lower than recommended rate	6379.2^{b}	39.77^{a}	36.13^{ab}	24.61^{bc}	11.79^{b}	2.09^{ab}	0.886^{b}	967.3^{b}
Recommended rate	8440.8^{a}	39.22^{a}	34.88^{bc}	26.87^{b}	12.32^{b}	2.19^{ab}	0.943^{ab}	991.7^{a}
50% more than recommended rate	8238.8^{a}	36.95^{a}	33.65^{c}	30.46^{a}	13.24^{a}	2.30^{a}	1.027^{a}	1039.7^{a}

Thousand grain weight

Analysis of variance showed no significant differences between main plot levels of seed weight. But the subplot levels of seed weight was significant differences $P \leq 0.01$ (Table 4). The highest thousand grain weight was observed in Boko pre-sowing plants treatment with an average of 36.72 g and the lowest belonged to control treatment with 32.92g seed respectively. The mean comparison for different levels of showed that the control treatment (no nitrogen) with thousand grain weight of 37.72 g was the best treatment and with the rate of 225 kg N ha^{-1} with 33.65 g had the lowest thousand grain weight. Seed weight decreased with increasing nitrogen due to increased number of grains per spike and grain weight per spike. Other researchers have also reduced thousand grain weight have confirmed the effect of increasing nitrogen (Nasri *et al., 2014*). However, the results were not similar to the results of some other researches for thousand grain weight (Haddadi and Ataei *2013:* Ayoub *et al.,1994:* Bulman and Smith, *1993).*

The results indicate that grain weight was not affected pre-sowing plants treatments and interactions of nitrogen fertilizer and pre-sowing plants. This yield component is less affected by environmental conditions. (Rahimzada *et al., 2011*).

Number of fertile spike

The results indicated that the number of fertile spikes were not influenced by pre-sowing plants treatments and interactions pre- sowing plants and fertilizer nitrogen. However, nitrogen levels significantly affected the number of spikes per unit area. Because nitrogen has a positive impact on increasing the number of tillers and fertile tillers other researchers have also declared that nitrogen improved yield mainly by increasing the number of spike (Ayoub *et al.,1994:* Fischer*, 1999:* Gharangeik and Ghaleshei, *2001:* Mc Donald*, 2002:* Giovanni *et al., 2004)*. No-application of nitrogen fertilizer with an average of 854.7 heads showed the lowest number of spikes, and increasing the level of nitrogen up to 225 kg N ha^{-1} with an average of 1039.7 spikes per square meter produced the highest number of spikes (table 5).

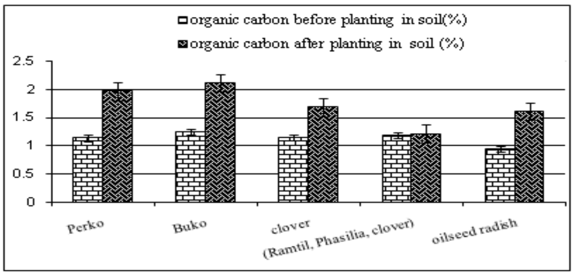

Fig. 1. Percentage of organic carbon before and after planting in soil using different varieties.

Grain weight per spike

Analysis of variance showed that grain weight per spike were not affected by nitrogen treatments, and interactions between pre-sowing plants and nitrogen fertilization. The highest grain weight per spike of was obtained by using 225 kg ha^{-1} N and pre-sowing of Buko with a weight of 1.027g and the lowest was observed for control (no fertilizer N and no pre-sowing plants) with a grain weight of 0.897g per spike (Table 5).

Number of grain per spikelet

The results showed that there was a significant difference between the main plot and sub plots of the number of grain per spikelet. $P \leq 0.01$ (Table 4). This means that the number of grain per spikelet were influenced by pre-sowing plants and nitrogen levels.

Harvest Index (HI)

According to the results of ANOVA, there was a significant difference between the pre-sowing plants treatments ($P \leq 0.01$) but there was no significant difference between nitrogen levels for HI (Table 4). The Highest HI was achieved from pre-sowing plant of Buko with a rate of 43.26% and the lowest HI belonged to the control treatment (no pre-sowing plants). By increasing nitrogen levels HI decreased (Table 5). Other researchers have also confirmed the reduction of HI when nitrogen rate was increased (Nasri *et al., 2014:* Ayoub *et al.,1994:* Zebart and Sheard*, 1992)*.

Conclusions

According to the results of this field experiment the pre-sowing plants had positive effect on wheat yield. The lowest grain yield was observed in conditions without pre-sowing plants and planting Buko . The brassica family plants cultivated in these experiments showed a positive effect on grain yield, harvest index, number of seeds per spikelet and spikelets per spike. Therefore it can be concluded that using the brassica family plants can improve the physical conditions of the soil and it can increase organic matter and have a positive impact on the subsequent crop. Effect of nitrogen fertilizer levels showed that the application of N fertilizer based on 150 kg ha^{-1}can be recommended for the regions similar to the conditions in the site of the experiment.

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