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Effect of K nano-fertilizer and N bio-fertilizer on yield and yield components of red bean (*Phaseolus vulgaris* L.)

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Abstract

A field experiment was laid out in order to study on effect of Nano and Bio fertilizers on yield and yield components of red bean (*pheseolus vulgaris* L.) in Islamic Azad University, Boroujerd branch, Iran at 2014. The experiment was laid out in a factorial design based on randomized block design with three replications. Treatments were Nitrogen bio-fertilizers in four levels (Azot Barvar 1, Nitrokara, Nitroxin and control) with 27% Khazraa K chelate Nano-fertilizer (KKCNF) in four levels (foliar 1, 2 and 3 in 1000 and control). Analysis of variance results showed that effect of N-biofertilizer and KKCNF treatments on yield and all yield components were significant at 1% probability level. Interaction effect of them was significant on all treats except number of grain per pod. According to the mean comparison charts, higher number of grain per pod , 1000 grain weight, biomass yield and grain yield for N bio-fertilizer found in Azot Barvar 1 and the control treatment had the lowest of them. For foliar application of KKCNF comparison of the mean values of them obtained at 2 in 1000 solution and control treatment had the lowest. Interaction effect between N bio-fertilizer and KKCNF showed that combined application of Azot Barvar 1 and 2 in 1000 solution had the highest of the above treats and the control combined treatment had the lowest. In final our results indicated that yield and yield components of red bean increased with application of N bio-fertilizer and KKCNF and could be replaced chemical fertilizers by these fertilizers.

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Introduction

Overuse of different chemical fertilizers is one of the causes for the degradation of environment and soil. Bio and Nano fertilizers are the newest and most technically advanced way of supplying mineral nutrients to crops. Compared to chemical fertilizers, their supply nutrient for plant needs, minimizes leaching, and therefore improves fertilizer use efficiency (Subbarao *et al*, 2013). Fertilizer management is one of the most important factors in successful cultivation of crops affecting yield quality and quantity (Tahmasbi *et al*, 2011). In the present century environmental protection is more important for the agrarian, considering the sustainable agriculture (Pepo *et al*, 2005). Bio-fertilizers are more environmental friendly and in many cases, they have given the same or even better crop yields compared to mineral fertilizers (Saghir Khan *et al*, 2007; Vessey, 2003).

Bio-fertilizers include mainly the nitrogen fixing, phosphate solubilizing and plant growth promoting microorganisms (Goel *et al*, 1999) providing a more balanced nutrition for plants (Belimov *et al*, 1995). Badran and Safwat (2004) and El-Ghadban *et al* (2006) found that fennel responded to biofertilizer by increasing growth and oil yield and changing the chemical composition. Chandrasekar *et al* (2005) studied the influence of biofertilizers and nitrogen source level on the growth and yield of *Echinochloa frumentacea*. Increasing yield was attributed to the plant growth promoting substances by root colonizing bacteria more than the biological nitrogen fixation, (Lin *et al*, 1983) stated that yield increased due to promoting root growth which in turn enhancing nutrients and water uptake from the soil. There were positive and synergistic interactions between factors like interactions between mycorrhizal inoculation and phosphate biofertilizer on N concentration and phosphate biofertilizer and vermicompost on P concentration (Darzi *et al* , 2009).

The nanofertilizer showed an initial burst and a subsequent slow-release even on day 60 compared to the commercial fertilizer, which released heavily early followed by the release of low and non-uniform quantities until around day 30 (Fujinuma and Balster, 2010) Work was also reported for Nitrogen release of the nanofertilizer from three elevations in Sri Lanka (pH 4.2, 5.2 and 7) and these studies were compared with that of a commercial fertilizer (Corradini *et al*, 2010). Nanofertilizers will combine nanodevices in order to synchronize the release of fertilizer-N and -k with their uptake by crops, so preventing undesirable nutrient losses to soil, water and air via direct internalization by crops, and avoiding the interaction of nutrients with soil, microorganisms, water, and air (DeRosa *et al*, 2010). The antibacterial efficiency of the nanoparticles was investigated by introducing the particles into a media containing *E. coli* and it was found that they exhibited antibacterial effect at low concentrations (Baker *et al*, 2005). Kim *et al* (2009) have found that fungi growth in the presence of nanoparticles was inhibited significantly in a dose dependent manner. Microscopic observation revealed that silver nanoparticles had detrimental effects not only on fungal hyphae but also on conidial germination.

Therefore the aim of this study is evaluation of effects of Nano and Bio fertilizers on yield and yield components of red bean (*pheseolus vulgaris* L.).

Material and methods

Field material and Experimental design

A field experiment was conducted at Islamic Azad University, Boroujerd branch, Iran, during 2014. The soil type was a clay loam, pH of 7.81.The experiment was laid out in a factorial design based on randomized block design with three replications. Each plot was planted in a 5 m long, 6-row. Row to row and plant - plant distance was maintained at 20 and 10 cm, respectively.

Treatments

Treatments were Nitrogen bio-fertilizers in four levels (Azot Barvar 1, Nitrokara, Nitroxin and control) with 27% Khazraa K chelate Nano-fertilizer (KKCNF) in four levels (foliar 1, 2 and 3 in 1000 and control).

Yield and yield components determination

To determine yield, we removed and cleaned all the seeds produced within a per square meter area in the field. The seeds were air-dried and weighed, and seed yield recorded on a dry weight basis. Yield was defined in terms of grams per square meter and quintals per hectare. The number of grain per pod and was determined. Replicated samples of clean seed (broken grain and foreign material removed) were sampled randomly and 1000-grain were counted and weighed. The biomass production was measured on 1 square meter from each treatment at maturity stage. The harvest index was accounted for with the following:

HI = (economical yield / biological yield)

Statistical analysis

The statistical analysis to determine the individual and interactive effects of drought stress, N fertilization and cultivar were conducted using JMP 5.0.1.2 (Statistical analyses system Institute incorporated , 2002). Statistical significance was declared at P≤0.05 and P≤0.01. Treatment effects from the two runs of experiments followed a similar trend, and thus the data from the two independent runs were combined in the analysis.

Results

Number of grain per pod

The results of analysis of variance showed that, the effect of N bio-fertilizers and KKCNF on the number of grains per pod were significant and interaction between them was not significant (table 1).

Table 1. Analysis of variance (mean squares) for yield and yield components of Red Bean under application of N bio-fertilizers and Khazraa K chelate Nano-fertilizer (KKCNF).

S.O.V	DF	Number of grain per pod	1000 grain w	biological yield	grain yield	HI
R	2	0.33	35.45	8633333	5245	0.99
N bio-fertilizers(a)	3	0.86**	2765.61**	44551491**	2928983**	2.12**
KKCNF (b)	3	1.18**	3369.79**	18613643**	2866405**	24.92**
a*b	9	0.13ns	220.01**	3653098**	335903**	16.09**
Error	24	0.19	57.48	270000	10965	0.33
CV		8.5	2.97	3.4	2.81	2.36

ns: Non-significant, * and **:Significant at 5 and 1% probability levels, respectively.

The comparison of the mean values for N bio-fertilizers on number of grain per pod for red bean showed that Azot Barvar 1 had the highest (5.46) and the control treatment had the lowest number of grains per pod (4.9) although difference between Azot Barvar 1 and Nitroxin was not significant (table 2). For foliar application of KKCNF comparison of the mean values of the number of grain per pod showed that 2 in 1000 solution had the highest (5.44) and control treatment had the lowest (4.73) of it (table 2).

Table 2. Mean comparisons for yield and yield components of Red Bean under application of N bio-fertilizers and Khazraa K chelate Nano-fertilizer (KKCNF).

Treatments	Number of grain per pod	1000 grain w(g)	biological yield(kg/ha)	grain yield(kg/ha)	HI(%)
N bio-fertilizer					
Azot Barvar 1	5.46a	263.81a	16821a	4152a	24.55a
Nitroxin	5.34a	261.57a	16311b	3899b	24b
Nitrokara	5b	261.76a	15375c	3826b	24.9a
control	4.9b	232.09b	12508d	3011c	24.07b
KKCNF (foliar spray)					
1 in 1000	5.34a	251.54b	15346b	3561c	23.3c
2 in 1000	5.44a	278.5a	16416a	4350a	26.4a
3 in 1000	5.19a	250b	15750b	3795b	24.1b
control	4.73b	239.13c	13508c	3182d	23.5c

Means by the uncommon letter in each column are significantly different (p<0.05).

1000 grain weight

The results showed that, the effect of N bio-fertilizers, KKCNF and interaction between them on For 1000 grain weight were significant at 1% (table 1).

The comparison of the mean values of the 1000 grain weight for N bio-fertilizer showed that Azot Barvar 1 had the highest (263.8 g) and the control treatment had the lowest 1000 grain weight (232 g) although difference between Azot Barvar 1 with Nitroxin and Nitrokara were not significant (table 2). For foliar application of KKCNF comparison of the mean values of the 1000 grain weight showed that 2 in 1000 solution had the highest (278 g) and control treatment had the lowest (239 g) of it (table 2). Interaction effect between N bio-fertilizer and KKCNF showed that combined application of Azot Barvar 1 and 2 in 1000 solution had the highest (296 g) and control combined treatment had the lowest (223 g) of 1000 grain weight (table 3).

Table 3. Interaction effect of N bio-fertilizers (a)× Khazraa K chelate Nano-fertilizer (KKCNF) (b) on yield and yield components of Red Bean.

a*b interaction	1000 grain w(g)	biological yield(kg/ha)	grain yield(kg/ha)	HI(%)
a1b1	260b	17350bc	3943c	22.7fg
a1b2	296a	18533a	4893a	26.3b
a1b3	257b	17200bc	4616b	26.8b
a1b4	240de	14200g	3156f	22.2gh
a2b1	255bc	14700fg	3676de	25c
a2b2	293a	18533a	4686b	25.2c
a2b3	254bc	17900ab	3663de	20.4i
a2b4	242de	14133g	3570e	25.2c
a3b1	255bc	16600cd	3596e	21.6h
a3b2	284a	15700de	4683b	29.8a
a3b3	256b	15333ef	3823cd	24.9c
a3b4	248b-d	13866g	3203f	23.1e-g
a4b1	235ef	12733hi	3030f	23.8de
a4b2	238de	12900h	3136f	24.3cd
a4b3	231ef	12566hi	3080f	24.5cd
a4b4	223f	11833i	2800g	23.6d-f

Means by the uncommon letter in each column are significantly different ($p<0.05$).

Biomass yield

Results showed that the effect of N bio-fertilizers, KKCNF and interaction between them on For 1000 grain weight were significant at 1% (table 1). The comparison of the mean values of the biomass yield for N bio-fertilizer showed that Azot Barvar 1 had the highest (16821 kg) and the control treatment had the lowest biomass yield (12508 kg). After Azot Barvar 1 Nitroxin had a highest biomass yield (16311 kg) (table 2). For foliar application of KKCNF comparison of the mean values of the biomass yield showed that 2 in 1000 solution had the highest (16416 kg) and control treatment had the lowest (13508 kg) (table 2). Interaction effect of treatments showed that combined application of Azot Barvar 1 and Nitroxin with 2 in 1000 solution had the highest (18533 kg) and control combined treatment had the lowest (11833 kg).

Grain yield

The results showed that, the effect of N bio-fertilizers, KKCNF and interaction between them on for grain yield were significant at 1% (table 1). The comparison of the mean values of grain yield for N bio-fertilizer showed that Azot Barvar 1 had the highest (4152 kg) and the control treatment had the lowest grain yield (3011 kg). After Azot Barvar 1 Nitroxin had a highest grain yield (3899 kg) although deference of it with Nitrokara (3826 kg) was not significant (table 2). For foliar application of KKCNF comparison of the mean values of the grain yield showed that 2 in 1000 solution had the highest (4350 kg) and control

treatment had the lowest (3182 kg) (table 2). Interaction effect of treatments showed that combined application of Azot Barvar 1 and Nitroxin with 2 in 1000 solution had the highest (4893 kg) and control combined treatment had the lowest (2800 kg) grain yield. Results were similar to previous research (Shekh, 2006, El-kholy *et al* , 2005).

Harvest index (HI)

Results of analysis of variance showed that the effect of N bio-fertilizers, KKCNF and interaction between them on for HI were significant at 1% (table 1). The comparison of the mean values of HI for N bio-fertilizer showed that Nitrokara had the highest (24.9%) and the Nitroxin treatment had the lowest HI (24%)(table 2). For foliar application of KKCNF comparison of the mean values of the HI showed that 2 in 1000 solution had the highest (26.4%) and 1 in 1000 solution treatment had the lowest (23.3%) of HI (table 2). Interaction effect of treatments showed that combined application of Nitrokara and with 2 in 1000 solution had the highest (29.8%) and combined application of Nitroxin and 3 in 1000 solution treatment had the lowest (20.4%) HI.

Discussion

Biofertilizers are good and beneficial tools to reduce environmental damages and enhance the yield (Lévai *et al*, 2006). Application of biofertilizers can increase the production efficiency of many plants and reduce the production costs. For example, Nitroxin biofertilizer consists the most effective species of nitrogen stabilizing bacteria including the genus Azotobacter, Azospirillum and phosphate solubilizing bacteria including the genus Pseudomonas has been recommended for potato as well as other crops by producing company (Tahmasebi *et al*, 2011). The efficiency of Azotobacter, Azospirillium and phosphate soloubilizing bacteria on growth and essential oil of marjoram (*Majorana hortensis* L.) plants were studied by Fatma *et al* (2006).

Positive effect of biofertilizer may resulted from its ability to increase the availability of phosphorus and other nutrients especially under the specialty of the calcareous nature of the soil which cause decreasing on the nutrients availability, results agree with (Kucey *et al*, 1989,Tiwari *et al*, 1989).

Sharaf (1995) showed that inoculation with a mixture of *Azotobacter* and *Azospirillum* with full doses of rock phosphate and inorganic N-fertilizer, in combination with inoculation with vascular arbuscular mycorrhiza (VAM), improved growth of both datura (*Datura stramonium*) and ammi (*Ammi visnaga*: Fam. Umbelliferae) plants. Sharifi and Haghnia (2006) and Rasipour and Asgharzadeh (2006) showed that the application of Nitroxin biofertilizer increased grain yield of wheat and soybean respectively. Long term field studies showed a significant contribution of biofertilizers for the yield increase of the field crops, which vary in range from 8–30% of control value depending on crop and soil fertility. Biomass yield was increased under application of biofertilizers, which positively influenced the plant photosynthesis and dry matter accumulation more actively that agree with (Shevananda, 2008).

Fallahi *et al* (2008) founded that Nitroxin biofertilizer had significant effects on main shoot, number of flower per plant, diameter of flower, fresh flower yield, dry flower yield, seed yield, essential oil and kamauzolen yield in Chamomile. They concluded that this biofertilizer can be considered as a replacement for chemical fertilizers in Chamomile medicinal plant production.

In the present study, significant differences were observed among N biofertilizers and KKCNF treatments regarding the average number of grain per pod, 1000 grain weight, biomass and grain yield. For N biofertilizers application of Azot barvar 1 and for KKCNF application of 2 in 1000 solution on its own increased number of grain per pod, 1000 grain weight, biomass, grain yield and HI in simple mean comparison. Application of Azot barvar 1 and 2 in 1000 solution KKCNF with together increased 1000 grain weight, biomass and grain yield rather application of them as single. Therefore this is a

synergic effect of these fertilizers on yield components of red bean. This means that we can apply N biofertilizer and KKCNF with together for achieved to maximum yield and it components as well. Bean yield is a complex and quantitative trait and its components are, pod number, seeds number in pod and seed weight (Padilla-Ramirez, K. S., *et al*, 2005). Teran and Singh (2002) reported that seed yield in cowpea with pods number in plant and seed number has a significantly positive correlation while negative correlation with seed weight. Given the importance of these elements by improving growth conditions and they can increase yield and its components somewhat. Meanwhile, plant type, variety and concentration of macro-nutrients in the root environment and stages of plant growth can be effective on how to use and how these elements impact on seed quality and quantity. Amounts of some macro and micro-nutrients in the environment of root was relatively abundant and soil alkalinity, can be prevent exposure these elements through the soil. However, spraying could have a positive impact on yield and yield components in unsuitable soil pH(Hoseynabadi, *et al*, 2006).

According to the results, it can be concluded that byapplication of N-biofertilizers specially Azot Barvar 1 and KKCNF 2 in 1000 yield and it components increased rather than other treatments. This would have positive environmental impacts. Interestingly, the application of nanofertilizer in combination with N-biofertilizer caused significantly higher yield probably due to its synergetic and antimicrobial effect. This effect of nanofertilizer might have helped seed to stay healthier for longer time and subsequently produced more vigorous plants. To the best of our knowledge, effects of nanofertilizer and N-biofertilizer on the efficiency of red bean production have not been evaluated in the field before. However, our results showed that yield and yield components of red bean increased with application of N bio-fertilizer and K nano-fertilizer.

Conclusion

According to obtained results, K Nano fertilizer and N bio-fertilizer has a positive effect on yield and yield components of red bean by increasing leaf area index, number of grain per pod an 1000 grain weigth of treated plants. Based on the results, combind application of N bio-fertilizer and KKCNF has a better effect on yield and yield components of red bean rather than single application of them. Therefore, we can replaced chemical fertilizers by these fertilizers for more efficiency because it is more economical and environmental and has better crop performance.

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