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Evaluation of Nano biofertilizer efficiency on Agronomic traits of Spring Wheat at Different Sowing Date

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ABSTRACT: In order to investigate the effect of seed sowing date and nano biofertilizer foliar application on some agronomic traits of spring wheat an experiment was conducted in 2010 growing season. The experimental design was a complete randomized block design arranged in factorial with three replications. The first factor was included two sowing date (middle of November and middle of December) and the second factor was included three nano biofertilizer levels (0, 4 and 8 litre ha^{-1}). The results indicated that late seed sowing lead to significant reduction in agronomic traits such as tiller number, peduncle length, spike length, spike number, seed number, number of day until spike emergence, number of days until pollination and number of days until physiological maturity. By contrast, nano biofertilizer application increased spike length, spike number, seed number, seed number in spike, seed weight and number of days until physiological maturity. Generally nano biofertilizer application increased crop growth and improved yield and yield components through extending growing period.

Keywords: Wheat, Humic acid, Seed sowing date, Yield and yield components

INTRODUCTION

Wheat is the most important cereal crop grown in different parts of the world. It is the staple food for over 35% of the global population and provides more calories and proteins in the diet (Laegreid *et al.,* 1999). Investigations show that, the world population is expected to be 9.1 billion people by 2050. If food consumption in developed countries is coordinated by the other parts of the world and all of these people are to be fed adequately, total food consumption will have to rise by 50–70% (Jaggard *et al.,* 2010).

Planting date is one of the most important agronomic factors involved in producing high yielding small grain cereal crops, which affects the timing and duration of the vegetative and reproductive stages (Nasser and El-Gizawy, 2009). The choice of sowing date is an important management option to optimize grain yield (Radmehr *et al.,* 2003; Turner, 2004). Numerous publications (Bassu *et al.,* 2009; Bannayan *et al.,* 2013) have reported an increased yield with early sowing and a reduction in yield when sowing is delayed after the optimum time. These authors reported an advantage of early sowing dates when combined with cultivars that avoid frost risk at anthesis or in regions or seasons with low frost risk, aiming at high aboveground biomass at flowering to maximize radiation interception. The delay in sowing date not only affects yield, but it affects the yield components and other aspects of the growth and development of wheat (Andarzian *et al.,* 2014).

Now-a-days attention to bio-fertilizer has been increased due to the advancement in countries research development, prices of chemical fertilizers and attention to sustainable agricultural systems (Yosefi *et al.,* 2011). There are some evidences in support of bio-fertilizers including; that plant growth and yield increase may be stimulated by plant growth promoting bacteria due to their ability of N_2-fixing, phosphate solubility and production of plant growth hormones (Sahin *et al.*, 2004).

Bio-fertilizer with 50% of chemical fertilizers (N and P) led to an increase in plant growth, plant height, branch numbers, fresh and dry weight of safflower in comparison with chemical fertilizers application alone Ojaghloo *et al.,* 2007). Also the utilization of *Azotobacter* bio-fertilizer, bio-phosphate fertilizer, organic fertilizers, with half rate of chemical fertilizers increased the grain yield of safflower (Ojaghloo *et al.*, 2007). Mirzaei *et al.*, (2010) applied *Azotobacter* and *Azospirillum* bacteria in different levels of nitrogen for safflower plant. Their results showed that combined application of these two types of bacteria increased plant growth characteristics and reduce nitrogen fertilizer application by 50%. Cereals yield responses to inoculation may also depend on plant genotype, bacterial strains and soil type as well as environmental conditions (Salantur *et al.*, 2005). Biofertilizers are able to fix atmospheric nitrogen in the available form for plant (Chen, 2006) and have beneficial upon plant growth by production of antibiotic (Zahir *et al.,* 2004). *Azotobacter* is used as biofertilizer in the cultivation of most crops (Yasari *et al.,* 2007). Nowadays, nanotechnology is progressively moved away from the experimental into the practical areas (Baruah and Dutta, 2009).

For example, the development of slow/controlled release fertilizers, conditional release of pesticides and herbicides, on the basis of nano-technology has become critically important for promoting the development of environment friendly and sustainable agriculture. Indeed, nanotechnology has provided the feasibility of exploiting nano-scale or nano-structured materials as fertilizer carriers or controlled-release vectors for building of so-called “smart fertilizer” as new facilities to enhance nutrient use efficiency and reduce costs of environmental protection (Cui *et al.,* 2010; Chinnamuthu and Boopathi, 2009).

The goal of this paper was to study the effects of seed sowing date and nano-bio-fertilizers (Biozar®) containing *Azotobacter* and *Pseudomonas* bacteria and nano fertilizers such as Fe, Zn and Mn on yield and yield components of wheat.

MATERIALS AND METHODS

In order to investigate the effects of sowing date and nano-bio-fertilizers (Biozar®) containing *Azotobacter* and *Pseudomonas* bacteria and nano fertilizers such as Fe, Zn and Mn on yield and yield components and some agronomic characteristics of spring wheat a field experiment was conducted at Islamic Azad University, Islamshahr, Iran during 2010 growing season. Thus, a factorial experiment in randomized complete block design with three replications was carried out. The first factor was included two sowing date (middle of November and middle of December) and the second factor was included three nano biofertilizers levels (0, 4 and 8 litre ha^{-1}). The experimental filed was tilled with mouldboard plow and disk in fall. The experimental plots were 4×2 m, with ten sowing rows. Wheat seeds (cv. Bahar) were disinfected using fungicide (Thiram, Tetramethyl thiuram disulfide) and then sown in the middle of November and December as different sowing dates. A seed rate of 150 kg ha^{-1} was used to maintain a plant population of 4 million plants ha^{-1}. Irrigation was applied as required during the crop growing season. The foliar treatment was carried out with nano-bio-fertilizers solution (0, 4 and 8 litre ha^{-1}). These three solutions were sprayed on top of the leaves weekly, starting from the beginning of stem elongation until grain filling, when the flag leaf was green and showed a consistent photosynthetic activity. Distilled water was sprayed on leaves of control treatments for uniformity.

Number of days until spike emergence (50% appearance), number of days until pollination and number of days until physiological maturity were counted and registered.

After tiller counting, spike length (from the end of peduncle to the end of spike) and awn length (from middle spikelets) were measured.

Plant height was measured from crown to the end of spike. Spike length was subtracted from plant height to calculate stem length. The length of the last internode was considered as peduncle length.

Spike number was in 0.3 m^2 was recorded. In order to study yield and yield components plots were harvested and then 50 plants were selected randomly, weighted and dried at 70°C for 48 h. Seed number in spike, Seed number in m^2 and seed weight were calculated. Seed filling rate was calculated using following formula.

Seed filling rate = seed yield/ number of days from pollination to physiological maturity

The results were submitted to statistical analysis using SAS. The analysis of variance was carried out based on the level of significance in the F test ($p < 0.05$). Mean values were compared using Duncan’s Multiple Range Test. In addition, Pearson correlation and was performed.

RESULTS AND DISCUSSION

Analysis of variance demonstrated that the effect of seed sowing data was significant on tiller number, peduncle length, spike length, stem length, plant height, spike number in m^2, seed number in m^2, number of days until spike emergence, number of days until pollination and number of days until physiological maturity (Table 1 and 2). In addition, application of nano biofertilizer significantly affect spike length, stem length, plant height, spike number in m^2, seed number in m^2, seed number in spike, seed weight and number of days until physiological maturity (Table 1 and 2). Interaction between seed sowing date and nano biofertilizer was significant on stem length and plant height (Table 1). Main effect of seed sowing date on some agronomic traits is shown in table 3. According to the results, late seed sowing significantly decreased tiller number, peduncle length, spike length, spike number in m^2, seed number in m^2, number of days until spike emergence, number of days until pollination and number of days until physiological maturity (Table 3). The purpose of choosing the appropriate sowing date is determining the best time for plant growth in accordance with suitable conditions. It has been reported that sowing date has a considerable effect on seed yield and its components and is crucial for success production (De Ruiter and Brooking, 1996). Our results are in accordance with those of Aslam *et al.,* (2003). Less number of tillers in late sowing was the result of less germination count per unit area which occurs due to low temperature. Decrease in plant height in late sowing was due to shorter growing period. Early sown crop may have enjoyed the better environmental conditions especially the temperature and solar radiation which resulted to tallest plants. These results are in line with those reported by Shahzad *et al.,* (2002).

Table 1: Analysis of variance on some agronomic traits of wheat affected by seed sowing date and nano biofertilizer foliar application.

S.O.V	d.f	Tiller number	Peduncle length	Peduncle	Awn length	Spike length	Stem length	Plant height	Seed weight in spike	Spike number in m^2	Seed number in m^2
Block	2	ns	ns	Ns	ns	**	*	ns	Ns	ns	ns
Sowing date	1	**	**	**	ns	**	**	**	Ns	*	*
Nano biofertilizer	2	ns	ns	Ns	ns	*	**	**	Ns	*	*
Interaction	2	ns	ns	Ns	ns	ns	*	*	Ns	ns	ns
Error	10	0.47	1.07	0.31	0.06	0.07	0.33	0.26	0.01	2857.52	1441269.06
C.V (%)		6.40	3.45	3.53	0.31	3.12	0.69	0.55	11.13	9.97	7.22

*, ** and ns: significant at 0.05, 0.01 probability level and no significant, respectively

Table 2: Analysis of variance on some agronomic traits of wheat affected by seed sowing date and nano biofertilizer application.

S.O.V	d.f	Seed number in spike	Seed weight	Seed filling rate	Number of days until spike emergence	Number of days until pollination	Number of days until physiological maturity	Seed yield	Biological yield	Harvest index
Block	2	ns	ns	Ns	Ns	ns	Ns	ns	ns	ns
Sowing date	1	ns	ns	Ns	**	**	**	ns	ns	ns
Nano biofertilizer	2	**	**	Ns	Ns	ns	**	ns	ns	ns
Interaction	2	ns	ns	Ns	Ns	ns	Ns	ns	ns	ns
Error	10	7.48	0.99	355.44	0.92	1.32	0.48	182816.16	1145259.85	0.002
C.V. (%)		8.76	3.06	10.13	0.57	0.65	0.34	7.95	7.96	0.12

*, ** and ns: significant at 0.05, 0.01 probability level and no significant, respectively

Table 3: Main effect of sowing date on some agronomic traits of wheat.

Sowing date	Tiller number	Peduncle length (cm)	Peduncle (cm)	Spike length (cm)	Spike number in m^2	Seed number in m^2	Number of days until spike emergence	Number of days until pollination	Number of days until physiological maturity
November	11.94a	31.81a	16.39a	9.25a	571.67a	17344.10	172.22a	178.66a	205.77a
December	9.52b	28.32b	15.19b	8.71b	499.78b	15883.10	161.66b	170.11b	201.11b

Values within the same column and followed by the same letter are not different at $P < 0.05$ by an ANOVA protected Duncan's Multiple Range Test

Table 4. Main effect of nano biofertilizer on some agronomic traits of wheat.

Nano biofertilizer	Stem length (cm)	Spike number in m^2	Seed number in m^2	Seed number in spike	Seed weight (g)	Number of days until physiological maturity
0 litre ha^{-1}	8.71b	485.83b	15613.80b	32.16a	30.31c	202.33c
4 litre ha^{-1}	9.26a	529.83ab	18018.50a	34.00a	32.62b	203.33b
8 litre ha^{-1}	8.97ab	591.50a	16208.50b	27.50b	34.44a	204.66a

Values within the same column and followed by the same letter are not different at $P < 0.05$ by an ANOVA protected Duncan's Multiple Range Test

Less number of seeds per spike in late sowing date was due to less production of photosynthates due to shorter growing period. These results are in line with those of Shahzad *et al.,* (2002). The early seed sowing resulted in better development of the seeds due to longer growing period. These findings are strongly supported by those of Spink *et al.,* (2000) and Shahzad *et al.,* (2002) who had also reported decreased seed grain weight with delay in sowing. Lower seed yield in late sowing was mainly due to less number of tillers, less number of seeds per spike and lower seed weight. These results are in accordance with those of Spink *et al.,* (2000) and Aslam *et al.,* (2003). They also reported that late sowing results in less seed yield per hectare. Higher growth in early sowing was mainly may be due to more number of tillers and more plant height. These results are in line with those of Donaldson *et al.,* (2001). They reported that early sowing resulted in higher straw yield due to more number of tillers. Reduction in number of days until spike emergence and physiological maturity indicates that delay in sowing date increases the days to heading which may be due to lower temperature during the vegetative stage. These results were in line with Ishaq and Ageeb (1991).

The main effect of nano biofertilizer is presented in table 4. From the results, nano biofertilizer application increased spike length compared with control treatment (Table 4). Although, there was no significant difference between 4 and 8 litre ha^{-1} nano biofertilizer treatments, 4 litre ha^{-1} nano biofertilizer caused longest spikes compared with 8 litre ha^{-1} nano biofertilizer application (Table 4). Similar results were observed in case of spike number in m^2 (Table 4). Seed number in m^2 increased on account of 4 litre ha^{-1} nano biofertilizer application, however when 8 litre ha^{-1} nano biofertilizer was applied there was signify cant reduction in seed number in m^2 (Table 4). The results suggest that nano biofertilizer application not only has no positive effect on seed number in spike, but 8 litre ha^{-1} nano biofertilizer decreases seed number in spike (Table 4). By contrast, nano biofertilizer application increased seed weight so that increase in nano biofertilizer application was parallel with increase in seed weigh (Table 4). Furthermore, nano biofertilizer increased number of days until physiological maturity, in other words, increased growing period length (Table 4). According to the results, interaction between seed sowing date and nano biofertilizer was significant on stem length (Fig. 1). Application of nano biofertilizer in November had no significant effect on stem length, whereas in December led to significant increase in stem length. Although, the highest stem length was observed in early seed sowing date and delay in sowing decreased stem length, nano biofertilizer could increase stem length in late sowing treatments. Similar results were obtained in case of plant height (Fig. 2). Nano biofertilizer application had no significant effect in early seed sowing treatments, while increased plant height in late seed sowing treatments. It should be note that there was no significant difference between 4 and 8 litre ha^{-1} nano biofertilizer application. In addition, plant height in early seed sowing treatment was more than late sowing treatments (Fig. 2). The improved performance with nano biofertilizer for seed yield, yield components and crop growth was probably due to the absorption of more nutrients by wheat plants because of *Azotobacter* and *Pseudomonas* as well as nano micro nutrients. The importance of additive effects of bio-inoculants was reported by earlier workers for component traits like plant height (Katiyar and Ahmad, 1996), spike length (Walia *et al.,* 1991), seed weight (Singh and Singh, 1992), flag leaf area (Prodanovic, 1993) and seed number per spike (Rosal *et al.,* 1991). Shaalan (2005) suggested that inoculation seeds with bio-fertilizer such as *Azespirillum*, *Azotobacter* and *Pseudomonas* caused improving plant growth trait due to inoculation nutrients uptake by plant microbial inoculation also led to improving the soil attributes such as organic matter content and increasing nitrogen content. Singh *et al.,* (2004) indicated that inoculation of wheat with *Azotobacter* under normal condition resulted in the maximum production. The results showed biological fertilizers not only increased yield but also reduced the consumption of chemical fertilizers.

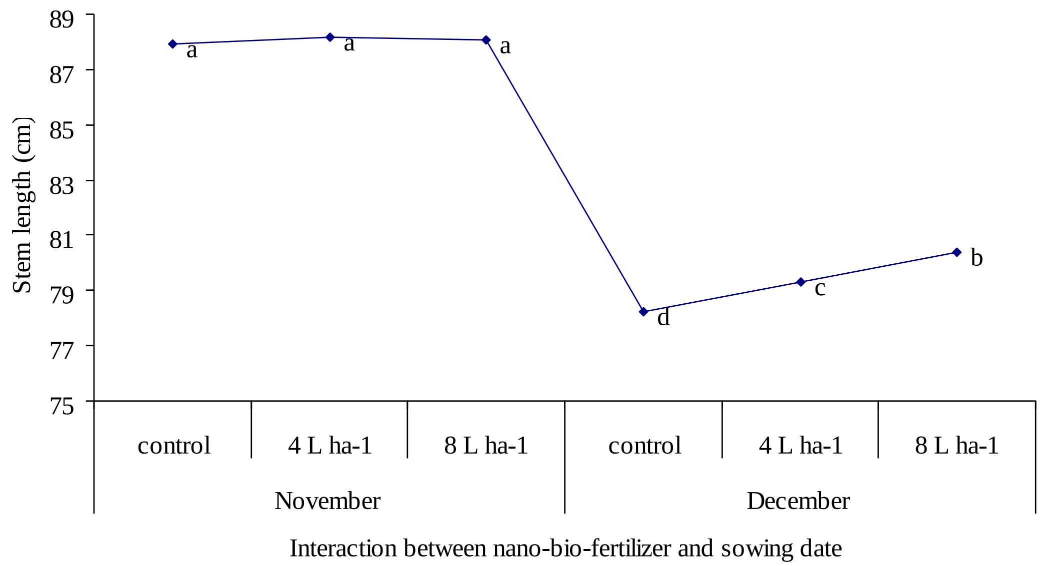

Fig. 1. Interaction between nano biofertilizer and sowing date on stem length. Values within the same column and followed by the same letter are not different at $P < 0.05$ by an ANOVA protected Duncan's Multiple Range Test.

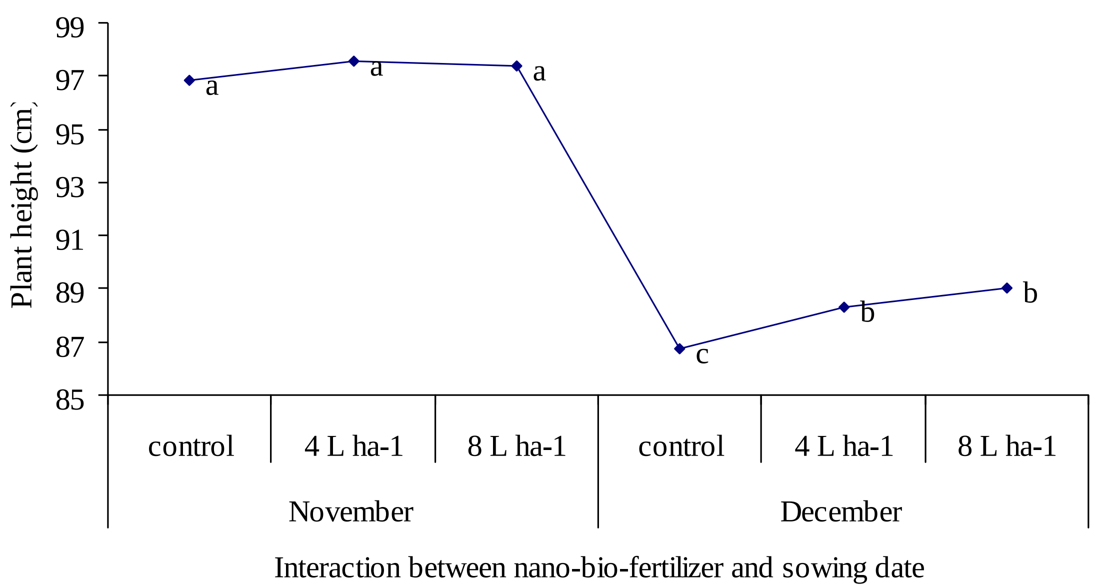

Fig. 2. Interaction between nano biofertilizer and sowing date on plant length. Values within the same column and followed by the same letter are not different at $P < 0.05$ by an ANOVA protected Duncan's Multiple Range Test

Table 5. Correlation between different traits of wheat affected by sowing date and nano biofertilizer application.

	Traits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Tiller number	1																		
2	Peduncle length	0.70**	1																	
3	Peduncle	0.49*	0.65**	1																
4	Awn length	-0.26ns	-0.07 ns	-0.27 ns	1															
5	Spike length	0.45 ns	0.47*	0.46 ns	-0.16 ns	1														
6	Stem length	0.88**	0.88**	0.66**	-0.21 ns	0.46 ns	1													
7	Plant height	0.88**	0.89**	0.67**	-0.23 ns	0.54*	0.99**	1												
8	Seed weight in spike	-0.31 ns	-0.18 ns	0.06 ns	0.19 ns	-0.26 ns	-0.26ns	-0.27 ns	1											
9	Spike number in m^2	0.53*	0.50 ns	0.16 ns	-0.33 ns	0.50*	0.54*	0.56*	-0.77**	1										
10	Seed number in m^2	0.37 ns	0.49*	0.51*	-0.29669	0.68**	0.46 ns	0.51*	-0.01 ns	0.48*	1									
11	Seed number in spike	-0.24 ns	-0.11 ns	0.22 ns	0.11 ns	0.007 ns	-0.19 ns	-0.18 ns	0.85**	-0.70**	0.26 ns	1								
12	Seed weight	0.044 ns	-0.01 ns	-0.30 ns	0.08 ns	-0.43 ns	0.01 ns	-0.02 ns	-0.02 ns	0.14 ns	-0.49*	-0.53*	1							
13	Seed filling rate	-0.15 ns	-0.15 ns	-0.16 ns	-0.10 ns	-0.04 ns	-0.18 ns	-0.172 ns	0.05 ns	0.33 ns	0.39 ns	-0.05 ns	0.23 ns	1						
14	Number of days until spike emergence	-0.85**	-0.90**	-0.68**	0.23 ns	-0.53*	-0.98**	-0.98**	0.23 ns	-0.53*	-0.49*	0.16 ns	0.011 ns	0.23 ns	1					
15	Number of days until pollination	-0.86**	-0.88**	-0.64**	0.23 ns	-0.53*	-0.96**	-0.97**	0.25 ns	-0.54*	-0.47*	0.19 ns	-0.01 ns	0.25 ns	0.98 **	1				
16	Number of days until physiological maturity	-0.89**	-0.82**	-0.53*	0.24 ns	-0.48*	-0.94**	-0.94**	0.34 ns	-0.69**	-0.54*	0.30 ns	-0.10 ns	-0.06 ns	0.90 **	0.91 **	1			
17	Seed yield	0.45 ns	0.55*	0.39 ns	-0.30 ns	0.44 ns	0.54*	0.56*	-0.02 ns	0.64**	0.75**	-0.08 ns	0.19 ns	0.61 **	-0.55 *	-0.55 *	-0.6**	1		
18	Biological yield	0.45 ns	0.56*	0.39 ns	-0.30 ns	0.44 ns	0.54*	0.57*	-0.01 ns	0.64**	0.75**	-0.07 ns	0.19 ns	0.61 **	-0.56 *	-0.55 *	-0.69**	0.99 **	1	
19	Harvest index	0.06 ns	-0.22 ns	-0.23 ns	-0.23 ns	0.14 ns	-0.02 ns	-0.01ns	-0.46*	0.43ns	0.03ns	-0.46*	0.12 ns	0.26 ns	0.03 ns	0.02 ns	-0.10ns	0.13 ns	0.11 ns	1

*, ** and ns: significant at 0.05, 0.01 probability level and no significant, respectively

Correlations between different traits of wheat affected by sowing date and nano biofertilizer are given in Table 5. According to obtained results, tiller number showed a positive and significant correlation with peduncle length, stem length, plant height, spike number in m^2, number of days until spike emergence, number of days until pollination and number of days until physiological maturity. There was a positive and significant correlation between peduncle length and spike length, stem length, plant height, seed number in m^2, number of days until spike emergence, number of days until pollination and number of days until physiological maturity. Spike length correlated with plant height, seed number in m^2, number of days until spike emergence, number of days until pollination and number of days until physiological maturity. Similar correlation was obtained between stem length and plant height, stem length and spike number in m^2, number of days until spike emergence, number of days until pollination and number of days until physiological maturity. In addition, there was a positive and significant correlation between plant height and spike number in m^2, seed number in m^2, number of days until spike emergence, number of days until pollination and number of days until physiological maturity. Seed weigh correlated with spike number in m^2, seed number in spike and harvest index. The relationship between spike number in m^2 and seed number in spike, number of days until spike emergence, number of days until pollination and number of days until physiological maturity as well as seed yield and biological yield was significant. Seed number in m^2 also correlated with seed weight, number of days until spike emergence, number of days until pollination and number of days until physiological maturity as well as seed yield and biological yield. Seed number in spike correlated with seed weight and harvest index. Furthermore, there was positive and significant correlation between seed filling rate, seed yield and biological yield. Number of days until spike emergence with number of days until pollination and number of days until physiological maturity correlated significantly. Moreover, there was positive correlation between number of days until pollination and number of days until physiological maturity, number of days until pollination and seed yield and number of days until pollination and biological yield. Number of days until physiological maturity correlated with seed yield and biological yield and finally seed yield showed a positive correlation with biological yield.

CONCLUSIONS

In general, the results indicated that late seed sowing decreases wheat vegetative growth and growing period length, which are the main reasons for yield loss. In addition, nano biofertilizer application (4 litre ha^{-1}) increased spike length, spike number in m^2, seed number in m^2, seed number in spike, seed weight and number of days until physiological maturity. However, there was no further increase with increasing in nano biofertilizer application, except for seed weight and number of days until physiological maturity. In sum, early seed sowing and application of f litre ha^{-1} nano biofertilizer is recommended to gain the desirable yield.

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