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Modeling the effect of micronutrients on phyllochron and leaf appearance rate in Wheat (*Triticum aestivum*)

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ABSTRACT

Crop managements need accurate simulation of leaf development, specially in main stem. Thermal interval between the appearance of successive leaf tips (phyllochron) is critical for predicting duration of vegetative development. Quantitative information regarding effects of micronutrients such as Boron, Zinc and Copper on main stem leaf traits of wheat (Triticum aestivum) is scarce. Foliar application can guarantee the availability of nutrients to crops. in order to study of response of wheat phyllochron and leaf appearance rate to foliar application of these micronutrients. tow experimental design were factorial based on randomized complete block design(RCBD) with four replications and experiments conducted at Chenaran and Mashhad, Iran during 2010-11. Treatments of these experiments were Type of elements (Zinc, Boron and Copper) Doses of Foliar application (0, 1 and 2 lit/ha) and Varieties (Gaskojen and Pishtaz). The experiments were conducted under well-watered conditions. The relationship between main stem leaf numbers (HS) versus Growth-Degree-Day was described using non-linear, segmented regression model. The results indicated that significantly the leaf appearance rate therewith phyllochron affected by variety and dose of application in tow locations, and also by type of element in Chenaran,. Leaf appearance rate in Gaskojen was higher than Pishtaz and Certainly phyllochron was lower in Gaskojen. Also higher amount of leaf appearance rate was for highest dose of Zinc and Boron foliar application (2 lit/ha) at tow locations. Leaf appearance rate in Chenaran (0.0089) was higher than Mashhad (0.0081), and phyllochron and the time of cessation in leaf production were lower than this. Phyllochron in Chenaran was 113 Growth-Degree-Day, and also Chenaran with 8.25 was paramount than Mashhad with 8.07 in final leaf number in main stem. The findings found at this study can be used in management recommendations of wheat. Further, it was recommended that more attention should be paid to apply of Zn and B fertilizer in mentioned locations.

Keywords: Boron, Zinc, Copper, Wheat, leaf appearance rate, phyllochron.

INTRODUCTION

Wheat (*Triticum aestivum*) is the most important and strategic crop in Iran, so for sustainable production its requirements precise recognition in it's development [1, 2]. Crop development is a succession of phonological events regulated by the interaction between genotype and environmental factors. The rate of leaf appearance and Phyllochron (thermal interval between the appearance of successive leaf tips) are a developmental traits which together with the final number of differentiated leaves determines the length of the crop cycle [3, 4, 5, 6]. Leaf growth is the result of highly complex biochemical events, and several attempts have been made to simulate its growth [7].

so that the occurrence of key phenological events such as floral initiation and terminal spikelet can be related directly to leaf appearance. Similarly, the timing of flowering depends on leaf appearance rate and also on the final number of leaves on the main stem [8, 9].

Study of phyllochron is a suitable method to better realize the plant vegetative growth and helps simulation of plant growth. In addition, it is the basal parameter in predicting plant total leaf number and date of flowering [10]. Also Efficacy of herbicides and pesticides is largely a function of crop growth stage, and optimal irrigation and fertilizer applications are coordinated with specific developmental events and leaf appearance prediction [1, 11]. The effect of environmental changes on the rate of leaf emergence in wheat must be understood to make the accurate predictions of the cropping technologies [12].

Mechanistic simulation models can be useful in quantifying plant processes and their interactions, and have been constructed to estimate winter wheat development and growth [11].
A linear and segmented bilinear models for response of main stem leaf number to temperature above a base temperature in wheat [1, 13], sorghum [14], barley [15], maize [16], sorghum [17] and chickpea [18] are commonly assumed when the phyllochron is expressed in units of thermal time.
The phyllochron of plants is strongly related to air temperature. Other factors such as genotype [19, 20, 21], daylenght [22], plant density [1], planting date [23], water stress [24], carbohydrate reserves, and nutrients [25] may have been effect on the phyllochron of grasses [12, 16].

Jafari moghadam [1] informed The role of macro and micronutrients may be crucial in wheat phyllochron and leaf traits in main stem. Among micronutrients, Zinc (Zn) and Boron (B) play a key role in physiological processes [26]. Zinc as a micronutrient in wheat production has been clearly proved. Effects of Zinc Deficiency and response to wheat growth stages have been reported from various parts of the world [27], also zinc shortage has a worldwide problem in human nutrition [28]. The studies have been shown that one of the effective and productive way to improvement in cereal grains is application of Zn fertilizer either to the soil or foliar application [29].

Similarly, boron deficiency also results in impaired crop growth and development. Boron plays a major role in plant vital activities such as cell division and leaf and flower bud formation [30].

Also Copper as an essential micronutrient for normal growth and metabolism of plants is well documented [31]. This element plays role in protein and carbohydrate metabolism as well as enzymatic systems [32].

Although various studies have evaluated leaf traits in the main stem, but it seems more accurate comment would require carried out experiments on mentioned micronutrients, varieties and different regions of Iran. Therefore, the present study was conducted to explore the effect of foliar application of Boron, Zinc and Copper on wheat phyllochron, leaf appearance rate and other characteristics of leaf production in main stem, and comparing respond of tow wheat varieties to dose of applied micronutrients.

MATERIALS AND METHODS

Two field experiments were carried out at Mashhad and Chenaran, Iran, (36º 47´ N, 59º 48´ E, altitude 999m, and 36º 61´ N, 59º 16´ E, altitude 1221m respectively) during 2010-1011 growing seasons. Each location, soil samples were taken from surface horizon (0- 30 cm) of the soil, air-dried, passed through a 2-mm sieve and analyzed for the following properties. Particle-size distribution determined by hydrometer method [33], soil pH and ECe were measured in saturated paste and saturated extract, respectively, organic compound (OC) were determined by Walkley- Black method [34]. Available Zn, Fe and Cu were determined by DTPA extraction [35], and phosphorus by sodium bicarbonate extraction [36]. Soil availability of B was extracted by hot water [37] and measured by azomethine-H colorimetric method [38]. The characteristics of the soil materials were shown in Table 1.

The treatments were compared in a factorial experiment based on Randomized Complete Block Design (RCBD) with three levels foliar application , 3 types of micronutrients (Zinc, Copper, Boron), 2 levels of wheat varieties

(Gaskojen and Pishtaz) and three levels of doses (control or water sprayed, 1 lit/1000, 2 lit/1000) in four replication. Each plot had 8 rows, 15 cm row spacing and 5 m plot length. Seeds were sown on the 27th October and 3th November, 2010 at Chenaran and Mashhad respectively.

Table 1. The characteristics of the soil in Chenaran and Mashhad.

Location	EC ds m^{-1}	pH	OC (%)	N (%)	P (ppm)	K (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Fe (ppm)
Chenaran	1.1	7.8	1.15	0.051	6	212	0.54	0.73	0.24	6.1
Mashhad	1.34	8	1.01	0.042	4.8	186	0.38	0.75	0.32	6

Final plant density was 300 plant in square meter. Also Foliar application were done at Mid-tillering, end-tillering, stem elongation and ear appearance stages with chelated fertilizers in format of EDTA %15. All recommended crop production practices were applied uniformly to all treatments. The experiments were maintained free from water and biotic stresses. First irrigation was given ten days after sowing and subsequent irrigations were applied to avoid drought stress and soil water in the 1 meter depth was kept above 50% of maximum available water during the all growing season. Weeds were periodically removed by hand. Diseases and insects were controlled by spraying pesticides at the recommended rates by their manufacturers. Fertilizer recommendations based on soil analysis results (Table 1) were applied including 120 kg ha^{-1} of triple superphosphate and 85 kg ha^{-1} potassium sulfate and 220 kg ha^{-1} urea . Phosphorus and potassium and one- third of urea fertilizers were applied at sowing and the remaining was applied during tillering and stem elongation growth stages.

Leaf number on the main stem was measured every 10 days in autumn and winter, and every 7 days in spring, using the scale proposed by Haun [39]. Thermal time units (Growth-Degree-Day, *GDD*) were calculated from mean air temperature assuming a base temperature of 0º C that followed by equation of (1):

$$GDD = \sum_{i=1}^{n}\left(\left(\frac{T_{\max} - T_{\min}}{2}\right) - T_b\right) \qquad \textbf{(1)}$$

models were fitted by SAS software, and also Graphs were performed in Excel software.

RESULTS AND DISCUSION

The changes of main stem leaf number versus *GDD* was describable using a non-linear, segmented regression model. The segmented model consists of two intersecting lines, a sloping line for the linear increase in leaf number and a horizontal line, which determines maximum leaf number on the main stem, that calculated with equation of (2):

$$y = a + bx \qquad if \qquad x \le x_0 \qquad \textbf{(2)}$$

$$y = a + bx_0 \qquad if \qquad x \rangle x_0$$

where *y* is the main stem leaf number; *x*, the *GDD* after sowing; *a*, the intercept with the vertical axis ($x = 0$), *b* the rate of linear increase in leaf number (leaf/GDD); x_0, the time of cessation of the linear increase in leaf number and $a + bx_0$ represents maximum leaf number on main stem (Ymax). Eq. (2) was used to obtain estimates of the time of cessation of effective leaf production on main stem and the maximum number of leaves on main stem.

Table 2. Parameters of the model fitted to leaf number on main stem Vs. GDD for different treatments in Mashhad. D= Dose of application, T= Type of element, V= Variety, G= Gaskojen, P=Pishtaz, B=Boron, Zn=Zinc and Cu= Copper.

Treatments	a±se	b±se	X_0±se	-a/b	phyllochron	Ymax	n	R^2	RMSE	CV(%)
D										
0	-1.85± 0.11	0.0079±0.0001	1252.8±11.2	234	126	8.04	19	99	0.1	1.9
1	-2.22± 0.16	0.0086±0.0002	1189.8±14.4	258	115	8.04	19	99	0.2	2.3
2	-2.64±0.16	0.0094±0.0002	1138.7±11.8	279	105	8.12	19	99	0.2	2.2
T										
B	-2.21±0.15	0.0086±0.0002	1186.1±13.05	256	115	8.05	19	99	0.2	2.1
Cu	-2.05±0.14	0.0082±0.0001	1222.6±12.42	248	120	8.05	19	99	0.1	2.3
Zn	-2.3±0.13	0.0088±0.0002	1178.3±11.53	261	113	8.05	19	99	0.1	2.9
V										
G	-2.39±0.16	0.0093±0.0002	1179.3±12.92	255	106	8.65	19	99	0.2	2.1
P	-1.96±0.13	0.0077±0.0001	1218.1±12.08	253	113	7.47	19	99	0.2	2.2
V* T										
G.B	-2.35±0.16	0.0093±0.0002	1183.3±13.28	253	107	8.65	19	99	0.2	2.2
G.Cu	-2.33±0.18	0.0092±0.0002	1187.9±14.58	252	108	8.63	19	99	0.2	2.4
G. Zn	-2.5±0.16	0.0095±0.0002	1167.1±12.03	261	104	8.68	19	99	0.2	2.1
P.B	-2.08±0.15	0.008±0.0002	1189.3±14.41	259	124	7.45	19	99	0.2	2.3
P.Cu	-1.95±0.14	0.0076±0.0002	1236.2±14.1	257	131	7.46	19	99	0.2	2.5
P.Zn	-2.1±0.14	0.008±0.0001	1191.7±13.92	262	126	7.46	19	99	0.1	2.1
T * D										
Water sprayed	-1.85±0.11	0.0079±0.0001	1253.9±11.3	234	126	8.04	19	99	0.1	1.9
B1	-2±0.15	0.0081±0.0001	1234.1±14.1	245	122	8.04	19	99	0.2	2.5
B2	-2.45±0.15	0.0093±0.0002	1135.4±11.52	271	106	8.11	19	99	0.1	2.2
Cu1	-2.26±0.14	0.0088±0.0001	1176.3±11.96	257	113	8.04	19	99	0.1	2
Cu2	-2.6±0.18	0.0092±0.0002	1153.7±14.32	280	107	8.08	19	99	0.2	2.6
Zn1	-1.85±0.11	0.0079±0.0001	1252.9±11.3	234	126	8.04	19	99	0.1	2.4
Zn2	-2.77±0.17	0.0097±0.0002	1124.9±12.15	257	113	8.04	19	99	0.1	3.7
V*D										
G0	-1.94±0.12	0.0084±0.0001	1247.8±11.2	229	117	8.63	19	99	0.1	1.9
G1	-2.43±0.18	0.0094±0.0002	1176.2±14.58	258	106	8.65	19	99	0.2	2.4
G2	-2.82±0.17	0.01±0.0002	1128.1±11.58	276	97	8.68	19	99	0.2	2.2
P0	-1.76±0.13	0.0073±0.0001	1258.6±13.72	241	136	7.43	19	99	0.1	2.3
P1	-1.9±0.13	0.0076±0.0001	1225.7±12.67	248	130	7.46	19	99	0.2	2.3
P2	-2.46±0.16	0.0086±0.0002	1149.2±13.31	283	115	7.51	19	99	0.1	2.5
All of data	-2.15±0.14	0.0081±0.0001	1200.2±15.12	254	118	8.07	341	99	0.2	3.7

The equation coefficients obtained for Mashhad (Table 2), showed that Gaskojenn and Pishtaz begins leaf production in its main stem after 255 and 253 Growth-Degree- Day, respectively. According to table (2) significantly leaf appearance rate in Gaskojen (0.0093) was higher than Pishtaz (0.0077),.

Certainly phyllochron (inverse of leaf appearance rate) was lower in Gaskojen (106 GDD). Also final leaf number in main stem in Gaskojen (8.65) was higher than Pishtaz (7.47).

Figure (1) shows that changes of main stem leaf number versus GDD for all treatments in Mashhad. Higher amount of leaf appearance rate was for highest dose of foliar application (2 lit/ha) with 0/0094. Also with increasing in dose of application, x_0 significantly decreased (Figure 2).

Type of element had no significant effect on model coefficients. Interaction effect of variety in type of element was significant on b and x_0, so that Gaskojen with Zinc application showed the highest amount of b (0/0095) and the lowest amount of phyllochron (104 GDD). for all of elements b increased and phyllochron decreased with increasing in dose of application, but variation of these coefficients were highest for zinc (Table 2, Fig 2).

Also the model coefficients obtained for Chenaran (Table 3), showed that Gaskojen and Pishtaz were differ statistically in leaf appearance rate and b in Gaskojen (0.0095) was higher than Pishtaz (0.0082). also phyllochron in Gaskojen with 104 GDD was lower than Pishtaz with 121 GDD.

Figure (3) showed that the changes of main stem leaf number versus GDD for all of treatments in Chenaran. In Chenaran dose of application had significant effect on all of model coefficients, lowest of leaf appearance rate was belong to water sprayed with 0.0079 and highest of this created by dose of 2 (lit/ha) with 0.0095 (table 3). Also the time of cessation in leaf production, decreased with increasing in dose of foliar application, so that water sprayed treatment cesser flag leaf production in 1233 Growth-Degree- Day (Table 3, Fig 4).

Table 3. Parameters of the model fitted to leaf number on main stem Vs. GDD for different treatments in Chenaran. D= Dose of application, T= Type of element, V= Variety, G= Gaskojen, P=Pishtaz, B=Boron, Zn=Zinc and Cu= Copper.

Treatments	a±se	b±se	X_0±se	-a/b	phyllochron	Ymax	n	R^2	RMSE	CV(%)
D										
0	-1.44± 0.08	0.0079±0.0001	1223.3±8.49	183	126	8.22	17	99	0.1	1.4
1	-1.87± 0.12	0.0091±0.0001	1105.3±9.62	204	109	8.25	17	99	0.1	1.8
2	-2.02±0.16	0.0095±0.0002	1081.1±12.07	212	104	8.03	17	99	0.2	2.4
T										
B	-1.84±0.1	0.009±0.0001	1115.1±8.69	203	110	8.25	17	99	0.1	1.5
Cu	-1.58±0.09	0.0084±0.0001	1168.6±8.35	187	118	8.25	17	99	0.1	1.5
Zn	-1.85±0.09	0.009±0.0001	1118.7±7.9	205	110	8.24	17	99	0.1	1.4
V										
G	-1.93±0.15	0.0095±0.0002	1090.1±11.64	202	104	8.48	17	99	0.2	2.2
P	-1.63±0.08	0.0082±0.0001	1177.9±7.92	199	121	8.02	17	99	0.1	1.4
V* T										
G.B	-1.97±0.15	0.0097±0.0002	1077.7±11.36	203	102	8.48	17	99	0.2	2.5
G.Cu	-1.78±0.17	0.0091±0.0002	1116.5±13.85	193	108	8.47	17	99	0.2	2.2
G. Zn	-2.03±0.15	0.0097±0.0002	1077.4±10.83	208	102	8.48	17	99	0.2	1.6
P.B	-1.67±0.09	0.0083±0.0001	1163.5±8.29	201	120	8.01	17	99	0.2	1.6
P.Cu	-1.57±0.09	0.008±0.0001	1201±9.14	197	125	8.02	17	99	0.2	1.6
P.Zn	-1.65±0.09	0.0082±0.0001	1170.2±8.58	200	120	8.01	17	99	0.2	2.6
T * D										
Water sprayed	-1.44±0.08	0.0079±0.0001	1223.2±8.51	183	126	8.22	17	99	0.1	1.4
B1	-2.01±0.13	0.0094±0.0001	1083±10.11	212	105	8.25	17	99	0.1	2
B2	-2.27±0.21	0.01±0.0003	1041.1±14.93	225	99	8.23	17	99	0.3	2.7
Cu1	-1.63±0.14	0.0086±0.0001	1148.4±12.91	189	116	8.25	17	99	0.1	2.1
Cu2	-1.85±0.15	0.009±0.0002	1117.8±12.42	204	110	8.29	17	99	0.1	2.2
Zn1	-1.99±0.1	0.0094±0.0001	1087.9±8.07	211	106	8.26	17	99	0.1	1.5
Zn2	-2.31±0.21	0.01±0.0003	1046.1±15.37	228	99	8.5	17	99	0.3	2.8
V*D										
G0	-1.51±0.13	0.0084±0.0001	1187±12.39	118	180	8.46	17	99	0.1	2.2
G1	-1.99±0.17	0.0098±0.0002	1068.9±12.38	203	101	8.5	17	99	0.2	2.5
G2	-2.41±0.22	0.01±0.0003	1020.9±14.45	225	93	8.5	17	99	0.3	2.8
P0	-1.38±0.13	0.0074±0.0001	1264.3±15.25	185	134	8	17	99	0.1	2.4
P1	-1.74±0.12	0.0084±0.0001	1149±11.83	205	117	8	17	99	0.1	2
P2	-1.88±0.14	0.0088±0.0002	1122.6±12.5	213	112	8.05	17	99	0.1	2.2
All of data	-1.78±0.11	0.0089±0.0002	1033.2±9.21	201	113	8.25	306	99	0.2	3.1

Unlike Mashhad, in Chenaran type of element had significant effect on all of equation coefficients, and highest leaf appearance rate and lowest x_0 and phyllochron was related to Boron and Zinc (table 3).

Interaction effect of variety in type of element was significant on all of model coefficients so that Gaskojen with Zinc and Boron application showed the highest amount of leaf appearance rate (0/0097) and the lowest amount of phyllochron. Also Interaction effect of dose of application in type of element was significant on leaf appearance rate and phyllochron, and although with increasing in dose of application *b* increased and phyllochron decreased, but response of Zinc and Boron was more sharp than Copper. Also Interaction effect of variety in type of element had no significant effect on model coefficients (Table 3, Fig 4).

Comparison between tow locations (table 2, 3) indicated except *a*, Mashhad and Chenaran were different in other coefficients. Leaf appearance rate in Chenaran (0.0089) is higher than Mashhad (0.0081), and phyllochron and the time of cessation in leaf production were lower than this. Phyllochron in Chenaran was 113 Growth-Degree-Day, and may be caused higher final main stem leaf number in Chenaran with 8.25 than Mashhad with 8.07.

this was in agreement with the findings of Jafari moghadam [1], Soltani [18] and madah yazdi [40] who indicated that the changes of main stem leaf number versus *GDD* was describable using a non-linear, segmented regression model. In experiment of Jafari moghadam [1] and madah yazdi [40] leaf appearance rate in wheat was 0.01, that its different with present research so can be due to differ in planting date and type of variety.

Abedelo [4] stated Final leaf number per main stem was higher in one of their experiments (10.9 leaves per main stem, averaged across genotypes) than other experiment (10.3). they declared nitrogen treatments did modify final leaf number, while treatment N20 presented a significantly lower final leaf number than the other treatments. They reported also at the lower nitrogen availabilities (20 and 50 kg N ha^{-1}) there was a trend to increase phyllochron of the early leaves.

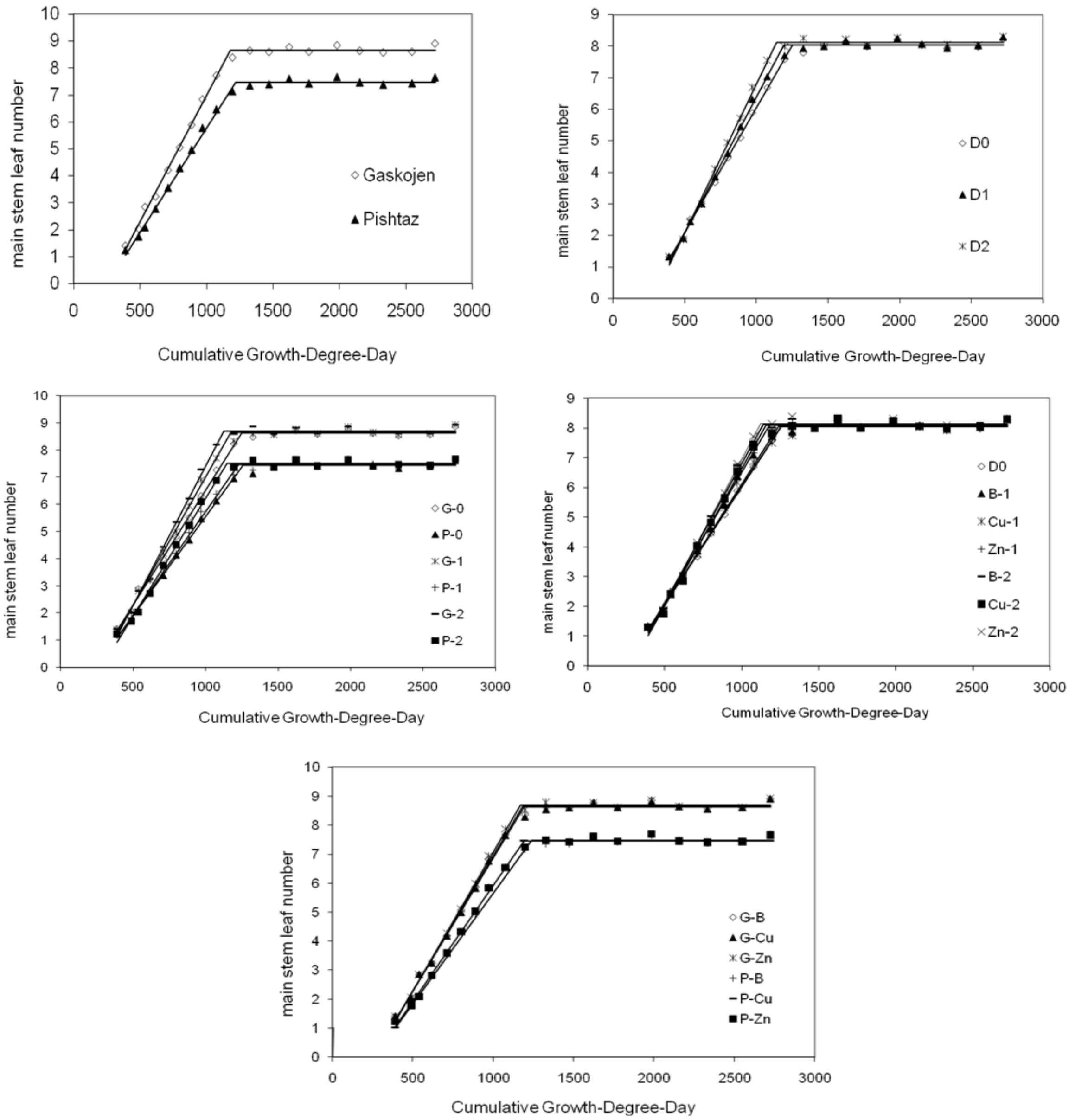

Figure 1. Fit of a segmented non-linear regression model to data of main stem leaf number vs. Growth-Degree-Days for various treatments in Mashhad.

Birch [5] in Mexico, Boras [6] and Ishag [20],showed that, the phyllochron varied somewhat among cultivars that endorsement no significant different between varieties in present experiment. In the experiment of Ishag [20] explained late-maturing cultivars had a long duration from sowing to double ridge, thus, more leaves were produced. In other experiment phyllochron and leaf appearance rates were affected by maize cultivars and nitrogen fertilizer levels. With increasing nitrogen amounts, leaf appearance rate was increased and Phyllochron was decreased. The highest (4.78 day) and the lowest Phyllochron rate (2.64 day) were obtained at Konsur cultivar without nitrogen application and kordona in highest levels of nitrogen fertilizers (180 kg N/ha) respectability. Also The highest leaf appearance rate (0.4 1/day) was observed at korduna cultivar and 180 kg nitrogen per hectare [10]. Longnecker and Rrobson [25] revealed that nitrogen deficit could decrease the leaf appearance rate. Rodroaguez [7] stated that phyllochron decreased with application of phosphorus and this decreased the duration of the leaf area expansion period. Also Eshghizade [41] reported Zinc and Iron elements yielded final leaf number in main stem of maiz. In these experiments, Increment and reduction in leaf appearance rate and phyllochron affected by Zinc respectively, may be due increasing in nitrogen and then auxin [2].

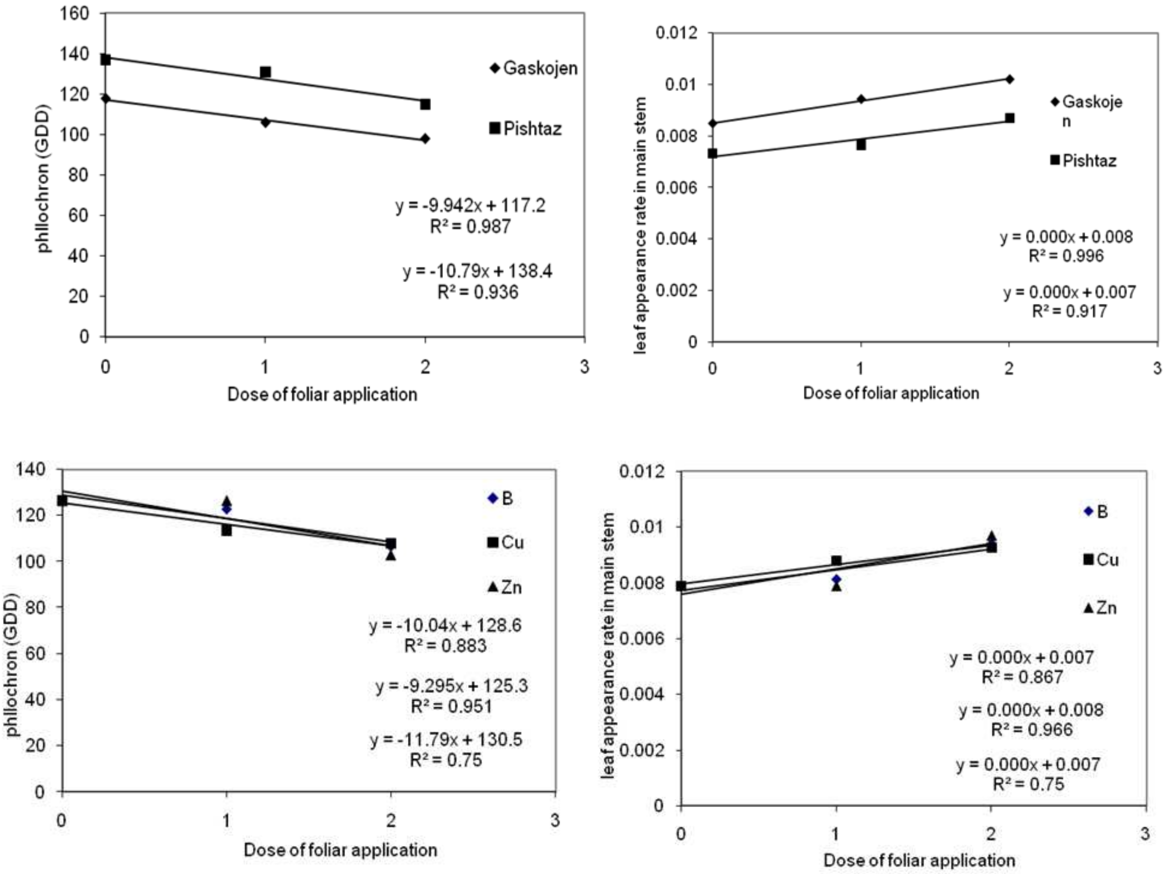

Figure 2. Fit of linear regression models to phyllochron and leaf appearance rate in main stem vs. Dose of foliar application in Mashhad.

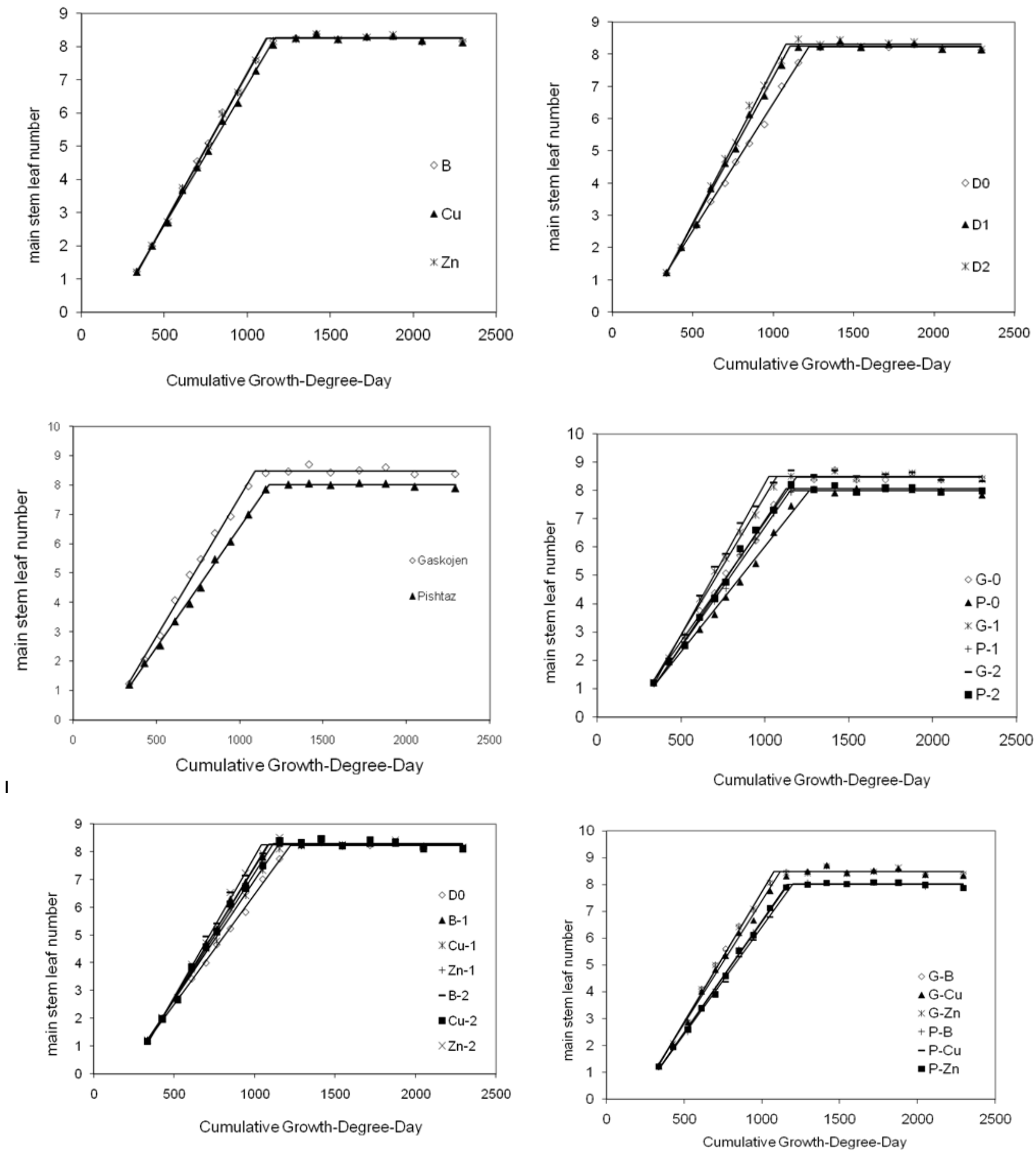

Figure 3. Fit of a segmented non-linear regression model to data of main stem leaf number vs. Growth-Degree-Days for various treatments in Chenaran.

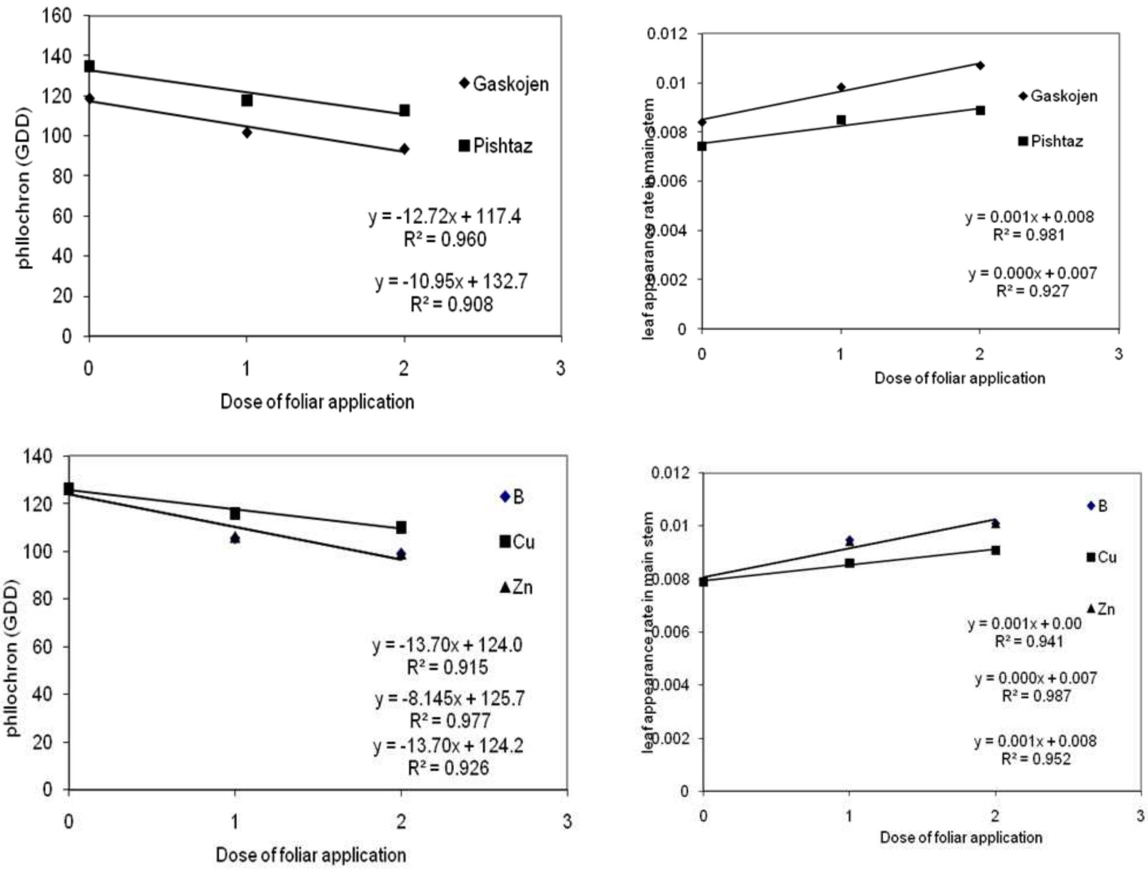

Figure 4. Fit of linear regression models to phyllochron and leaf appearance rate in main stem vs. Dose of foliar application in Chenaran.

CONCLOSION

1- It could be concluded that, application of micro nutritious elements especially Boron and Zinc had additive effect on leaf appearance rate and decline effect on phyllochron in wheat.
2- Tow wheat varieties had different nutritional demands regarding boron and zinc but generally Gaskojen had better response to mentioned elements than Pishtaz, about leaf traits in main stem.
3- According Soil analysis (table1), higher response of phyllochron and leaf appearance rate to Boron and Zinc was logical. So more attention to Boron and Zinc Application seems to be changed wheat leaf traits in main stem in these regions.
4- Chenaran showed lower amount in phyllochron, that might refer to sooner time of cessation in leaf production and long-term conditions such as higher soil fertility, or short-term conditions such as better environmental conditions especially precipitation so it could be the reason of priority of Chenaran than Mashhad .
5- Generally, except in the case of *a*, Mashhad and Chenaran are different in other coefficients. Leaf appearance rate in Chenaran (0.0089) was higher than Mashhad (0.0081), and phyllochron and the time of cessation in leaf production were lower than this. Phyllochron in Chenaran was 113 Growth-Degree-Day, and Chenaran with 8.25 was paramount than Mashhad with 8.07 in final leaf number in main stem.
6- it was suggestible to replicate experiments on these elements in other locations and regions and more evaluation of combined methods for elements application.

REFRENCES

[1] M. Jafari moghadam, M.Sc thesis, Gorgan university of agriculture sciences and natural resourses..(Gorgan, Iran, **2008**).
[2] M. Jafarimoghadam, H. Heidari Sharifabad, G.h. Noormohamadi, S.Y. Sadeghianmotahar, S. A. Siadat, *J, Annals of Biological Research***., 2012**, 3 ,3788.
[3] G.A. Slafer, H.M. Rawson, *J. Field Crops Res*., **1996**, 44,73.
[4] L. G. Abeledo, F. Daniel, L. Calderini, A. Gustavo, A Slafer, *J. Field Crops Research*.,**2004**, 86,23.
[5] C.J. Birch, J. Vosb, J. Kiniryc, H.J. Bosb, A. Elings, *J, Field Crops Research*., **1998**,59,187.
[6] S. A. G. Borras, A. Ignacio Romagosa, B. Fred van Eeuwijk, A. Gustavo, A.C. Slafer, *J, Field Crops Research*., **2009**,113,95.
[7] D. RodrõÂguez, F.H. Andrade, J. Goudriaan, *J, Field Crops Research*.,**2000**,67,227.
[8] J. Amir, T.R. Sinclair, *J, Field Crops Res*., **1991**, 28,47.
[9] P.D. Jamieson, I.R. Brooking, J.R. Porter, D.R. Wilson, *J, Field Crops Research*.,**1995**,41,35.
[10] S. Hokmalipour, *J, World Applied Sciences*.,**2011**,12,850.
[11] G. S. McMaster, J. A . Morgan, W. W. Wilhelm, *J, Agriculture and forest meteorology*.,**1992**, 60, 193.
[12] I.M. Petróczi, J. Matuz, *J, ActaBiologicaSzegediensis*., **2002**, 46, 209.
[13] P. Jamieson, I. Brooking, R. Zyskowski, C. Munro, *J, Field Crops Research*., **2008**, 108, 163.
[14] S. S. R. Kumar, L.Graeme Hammer, I. Broad, P. Harland, G. McLean, *J, Field Crops Research*.,**2009**,111,157.
[15] E.J.M. Kirby, *J, Crop Sci*., **1995**, 35, 11.
[16] J.R. Kiniry, W.D. Rosenthl, B.S. J.ackson, G.Hoogenboon, *J, Boca Raton, Florida: CRC Press,***1991**, 29, 18.
[17] G.L. Hammer, P.S. Carberry, R.C. Muchow, *J, Field Crops Research*.,**1993**, 33,293.
[18] A. Soltani, Robertson, Y. Mohammad-Nejad, A. Rahemi-Karizaki, *J, Field Crops Research*., **2006**, 99,14.
[19] A.B. Frank, A.Bauer, *J, Crop Sci*., **1995**, 35, 19.
[20] H. M. Ishag, B.A. Mohamed, K.H.M. Ishag, *J, Field Crops Res*., **1998,** 58, 167.
[21] C. Royo, N. Aparicio, R. Blanco, D. Villagas, *J, Agronomy*, **2004** , 20, 419.
[22] P.D. Jamieson, I.R. Brooking, M.A. Semenov, G.S. McMaster, J.W. White, J.R. Porter, *J, Field Crops Res*., **2007**, 103, 36.
[23] Q. Xue, A. Weiss, P. Baenziger, *J, Ecological Modeling*., **2004**, 175, 261.
[24] C.K. Baker, J.N. Gallagher, J.L. Monteith, *J, Agron*., **1980**, 3, 285.
[25] N. Longnecker, , A. Robson, *J, Annals of Botany*., **1994**., 74,1.
[26] A. H. Ziaeyan, M. Rajaiea, *J. Plant Production* ., **2009**, 3, 3, 1735.
[27] M. R. Shaheen, K. Samim, R. Mahmud, *J. Soil. Nature*., **2007**, 1 ,1, 7.
[28] G. A. Ranjbar, M. A. Bahmaniar, *J. Plant Sciences*,. **2007**, 6, 6, 1000.
[29] W. Jiang, P. C. Struik, H. van Keulen, M. Zhao, L.N. Jin, T.J. Stomph , *J.Annals of Applied Biology*., **2008**, 135, 147, 153.
[30] M. R. Moeinian, K. Zargari and J. Hasanpour, American-*Eurasian J. Agric. & Environ. Sci.*, **2011**, 10 (4): 593-599.
[31] R. Kumar1, N. K. Mehrotra, B. D. Nautiyal, Praveen Kumar and P.K. Singh, *Journal of Environmental Biology*, **2009**, 30(4) 485-488.
[32] M. R. Boorboori, D. Eradatmand Asli, M. Tehrani, *J. Advances in Environmental Biology*., **2012**, 6,2, 740.
[33] G.W. Gee, J.W. Bauder, In: Klute, A. (Ed.), *Methods of Soil Analysis* (Am. Soc. Agron., Madison WI **1986**) 404.
[34] D. W. Nelson, L. E. Sommers, In: Sparks, D. L. (ed.), *Methods of Soil Analysis* (Ed. Am. Soc Agron., Madison,WI. **1996**) 961.
[35] W.L. Lindsay, W.A. Norvell, *J. Soil Sci. Soc. Am*., **1978**, 42, 421.
[36] S. R. Olsen, C.V. Cole, F. S. Watanabe, L.A Dean, **1954**. USDA. Circ. 939. U. S. Gov. Print. Office, Washington, D.C
[37] K.C. Berger, E. Truog, *J. Eng. Chem*., **1993**, 11, 540.
[38] F.T. Bingham, In: Page, A.L. (Ed.), *Methods of Soil Analysis* (Am. Soc. Agron. Madison,WI **1982**) 431.
[39] J.R. Haun, *J, Agron.*,**1973**, 65, 116.
[40] V. Madah yazdi, MSc thesis, Gorgan university of agriculture sciences and natural resourses.(Gorgan, Iran, **2006**).
[41] H.R. Eshghizadeh, A.H. Khoshgoftarmanesh, P. Ehsanzadeh, M. Kafi, J**,** *Science and Technology of Agriculture and Natural Resources, Water and Soil Science***., 2011**,57, 159.