International Journal of Advanced Technology in Engineering and Science
Vol. No.3, Issue 09, September 2015
www.ijates.com
ijates
ISSN 2348 - 7550

IMPACT OF Fe AND Zn ON YIELD AND YIELD PARAMETERS OF BARLEY (*HORDEUM VULGARE L*)

Gunjan Singh[1], M. V. Boswal[2], Kowsar Jan[3]

[1,2,3]*Department of Botany, Christ Church College/C.S.J.M. University, Kanpur (India)*

ABSTRACT

The present study was done to evaluate the effect of various levels of Fe and Zn alone and in combination on yield and yield contributing parameters of barley (Hordeum vulgare L.)" var. K-125 (Azad). For this application of 20, 40, 60 ppm of Fe or Zn, and their combinations i.e. Fe20 + Zn20, Fe20 + Zn40, Fe40 + Zn20, Fe40 + Zn40 and Fe + Zn (chelated) as seed soaking for 48 hrs, plus three foliar sprays on were given. Among the three concentrations of Fe applied alone, Fe20 ppm was the best dose for inducing maximum yield parameters studied except early booting where Fe40 was better. Among the Zn treatments applied alone Zn20 promoted best effect in early anthesis, awn length and grain number / plant. All other yield and yield parameters were promoted most with Zn40 application. Combined treatments of Fe + Zn were in all respect better in promoting yield parameters than their treatments given individually. Results showed that Fe and Zn treatments promoted yield and yield parameters. A significant increase in yield parameters was observed and all were positively and significantly correlated to yield. On comparing the effect of the best dose of Fe and Zn i.e. Fe20 + Zn40 with its chelated form it was found that the latter gave better results.

Keywords: Iron (Fe), Zinc (Zn), Hordeum Vulgare L.

I. INTRODUCTION

Barley a member of *Poaceae* is one of the first crop domesticated for human consumption and among the most important cereals cultivated worldwide since it can grow in large number of environmental conditions. The growing worldwide demand for barley is placing pressure on new innovations to improve the cultivars with greater yield (World Barley Outlook, 2010). It is fourth in terms of total world Production (Barley World, 2006). Barley contains nitrogenous compounds (12.981%), gum (6.744%), sugar (3.2%), starch 59.95% and fat (2.17%). It also contains astounding amounts of proteins, vitamins and minerals, beta carotene, B1, B2, B6, C, folic acid, panthothenic acid, essential and non essential amino acids making it the most nourishing food stuff known to man. It contains high levels of chlorophyll, a substance said to inhibit cancer and several antioxidants that prevent degenerative disease. It is consumed in the form of chapatti, sattu etc but it's by-product at industrial level is very important for preparing barley water, malt and barley wines. Barley is used in industries for making baby food, milk based drinks, malt chocolates. Barley is used as a major animal feed crop, as a popular seasoning, in malting and in health food.

Zinc is essential for sugar regulation and enzymes that control plant growth (Halvin *et al.*, 1999). Formation of some growth hormones, auxin metabolism, activity of dehydrogenases enzymes, synthesis of cytochrome etc. are influenced by zinc. Iron on the other hand is essential in chlorophyll synthesis. It is a component of flavo

proteins and functions in iron prophyrin proteins. It is present in ferrodoxin, ferredoxin reducing substances and cytochromes. Iron is critical for chlorophyll formation and photosynthesis and is important in enzyme systems and respiration in plants (Halvin *et al.*, 1999).

A global investigation of FAO has brought to light that Zinc is the most widely deficient micronutrient, About 50% of the soils used for cereal production in the world contain low levels of plant available Zn which reduces not only grain yield, but also nutritional quality (Cakmak *et al.*, 1996). Zn has a critical role in synthesis of protein and metabolism of DNA and RNA. Protein content of Zn deficient plant is dramatically reduced (Vallee and Falchuk, 1993). Some work on effect of Fe and Zn on wheat has been done (Narimani *et al*., 2010; Zhao *et al.* 2011).

Zinc deficiency is a critical problem in wheat and barley (Cakmak *et al.*, 1996) and it has been found that only a few cultivars proved to be Zn efficient (Kinaci and Kinaci, 2005; Imtiaz *et al.*, 2010). Cereal is a good and easily accessible source of Fe and Zn for both feed and food. The micronutrients play an important role in increasing crop yield (Asad and Rafique 2000; Hussain *et al.*, 2002; Ghavami et al., 2015; Mosanna and Behrozyar, 2015). Several reports indicate that either soil or foliar application of micronutrients have positive correlation with wheat yield (Habib, 2009; Mitra et al., 2015).

The objective of this study was to evaluate the effect of various levels of Fe and Zn alone and in combination on yield with yield parameters of barley. Their effect on vegetative morphology has already been studied (Gunjan and Boswal, 2015). Nutrient deficiencies have also been corrected by using metal chelators (Szladils, 1956; Pandey and Pandey 2002). Metal chelators are soluble in water and dissociate slightly. It is because of this fact that they are ideally suited for application to the crops deficient in particular micronutrient. They are more effective than normal salts of these nutrients (Sekhon, 2003). The rate of absorption of chelating agents associated with metallic cations is relatively higher than that of chelating agents without the associate of cations. The absorption of Fe was greater with Fe-EDTA than when Fe was given alone (Erdal *et al.*, 2004). Application of metal chelators on different plants increased their growth (Duhan and Dudeja, 1998; Qadir et al., 2014). Chelates may be applied to the soil or as spray to the foliage. There are reports that foliar application was more effective than soil application which increased yield significantly (Fareghi naeini, 2014; Rahman et al., 2014; Zain et al., 2015).

Keeping in mind the above importance, the present study has been undertaken to investigate the effect of Fe and Zn on the yield of *Hordeum vulgare* L. with the following objectives:

1. To study the effect of Fe or Zn on yield and yield parameters.
2. To estimate the combined effect of Fe and Zn on yield and phenological characters.
3. To compare the effect the best dose of Fe+Zn in terms of yield with its chelated form.

A number of parameters help to indicate the effect of extrinsic factors on plant growth (Godin *et al.*, 1999) and yield. Some of the traits studied by Mohamoud and Mohamoud, (2011) in rice were plant height, days to heading (booting), panicle length (spike length), number of tillers / plant for vegetative traits, grain yield/plant, 100-grain weight, harvest index, number of panicles/plant, dry matter production (straw weight) for yield traits. Thus such parameters have been considered in the present study. The flag leaf is the primary source of assimilates for grain filling and grain yield (Briggs & Aytenfish, 1980; Khaliq *et al.*, 2008). Awns have also

been observed as important photosynthetic organs which act as source of assimilates for grain formation as they are nearest plant parts to developing grains in spikelets (Khaliq *et al.*, 2008).

II. MATERIAL AND METHODS

The seeds of *Hordeum vulgare* L. var. K-125 (Azad) were obtained from Chandra Shekhar Azad University of Agriculture and Technology, Kanpur.

2.1 Preparation of Solutions

For preparation of the experimental chemicals one gram each of the chemical was taken in an individual neat and clean beaker. These chemicals were dissolved in 500 ml distilled water with constant stirring. The volume of solution was finally constituted to one litre. This was the 1000 ppm stock solution of each chemical; the flasks containing the chemicals were covered with muslin cloth to avoid any contamination. For preparation of 20, 40, 60 ppm solution of each chemical 20, 40, 60 ml of liquid from the stock solution was taken in a well cleaned measuring flask and continued to 1000 ml.

2.2 Treatments

Maximum Fe and Zn absorption by plants takes place upto tillering or preflowering stage. Split application of Zn is recommended i.e. foliar sprays two or three times (Singh, 2004). Fe and Zn application prior to sowing is considered best. Therefore, in the present investigation four applications were given, one prior to the seed sowing followed by three sprays at an interval of 14 days, starting with 20 DAS.

Based on preliminary experiments and experiments on seedling growth the doses of 20, 40 and 60 ppm of Fe, Zn were applied alone or in combinations at soaking seed stage and three sprays at intervals of 14 days, the first spray being 20 DAS (days after sowing). Since combined dose of Fe20 + Zn40 ppm generally gave the best result a comparative study of this combined dose was made with 20 ppm of Fe – EDTA + 40 ppm of Zn – EDTA, written later as Fe + Zn (chelated).

2.3 Twelve Treatments Were Applied As Follows

1. Control
2. Fe 20 ppm (Fe20)
3. Fe 40 ppm (Fe40)
4. Fe 60 ppm (Fe60)
5. Zn 20 ppm (Zn20)
6. Zn 40 ppm (Zn40)
7. Zn 60 ppm (Zn60)
8. Fe20 + Zn20
9. Fe20 + Zn40
10. Fe40 + Zn20
11. Fe40 + Zn40
12. 20 ppm of Fe – EDTA + 40 ppm of Zn EDTA i.e. Fe + Zn (Chelated)

III. RESULTS AND DISCUSSION

Summing up the results of yield and yield parameters it can be concluded that Fe and Zn treatments had a promoting effect. Chart A and B reveals the best effect and maximum percentage increase over control with treatmeants. Comparing Fe application alone, Fe20 induced earliest anthesis (minimum time taken was 80.92 days), maximum increase in flag leaf area (9.63 cm2), tiller number /plant (2.41), spike number (2.33), spikelet

number on main spike (17.33). spikelet number / plant (50.39), peduncle length (7.33 cm), spike length (8.16 cm)…Chart A, grain number on main spike (46.16), grain number / plant (123.00), grain weight of 100 seeds (4.650g), grain weight / plant (4.63g) straw weight/ plant (15.16 g) and harvest index (22.66)…Chart B. However, Fe40 was better for promoting early booting (70.58 days) and increasing awn length (13.10cm).

Among the Zn treatments applied alone Zn20 promoted best effect in early anthesis (79.50 DAS), awn length (13.76 cm) and grain number / plant (133.92) i.e. percent increase over control being 4.70%, 22.20% and 33.65%, respectively. All other yield and yield parameters were promoted most with Zn40 application. The effect of Fe60 and Zn60 showed a decreasing trend as compared to their lower doses and so not shown in the Charts.

Combined treatments of Fe + Zn were in all respect better in promoting yield parameters than their treatments given individually. Fe20 + Zn20 was best in inducing early anthesis (75.75 DAS i.e. 9.19% earliness over control) .Fe20 + Zn40 was the best application for most yield parameters like flag leaf area (13.07 cm2), tiller number/plant (3.25) spike number (3.17) spikelet number (20.66) spikelet number /plant (64.58), awn length (14.90 cm) spike length (9.83 cm) grain number on main shoot (54.58%), grain wt of 100 seeds (4.88), grain wt/plant (10.34), straw wt. (22.56) and harvest index (31.16). Fig.1a shows that Fe20 brought 9.05 percentage increase over control in the harvest index. Zn40 increased it by 12.22%, Fe20 + Zn40 promoted the increase to 49.95%. With Fe + Zn (chelated) the percentage increase over control was further promoted to 72.14. Fig.1b indicates that results on harvest index with Fe+Zn chelated was far above other treatments..Harvest index with all single treatments were at par with control.

In the present investigation Fe or Zn when given alone as foliar spray increased the flag leaf area, spike length, peduncle and awn length. Combined applications and Fe + Zn (chelated) were still more effective. Flag leaf plays an important role in grain yield (Wan and Shong, 1981; Sheela *et al.*, 1990; Raj and Tripathi, 2000), spikelet fertility (Sheela *et al.*, 1990; Regina *et al.*, 1994); spike length (Bashar *et al.*, 1990; Rao, 1992) and grain size and weight (Das *et al.*, 1981; Faisal, 2014). The grain yield and yield related traits were positively related to flag leaf area (Ashrafuzzaman, *et al.*, 2009). Broader flag leaves help in greater yield (Dutta *et al.*, 2002) as also observed in the present investigation.

Flag leaf area, awn length, number of grains per spike and 1000 grain weight demonstrated positive and significant association with grain yield/plant (Ali et al., 2010) in wheat as also observed in barley in the present work. Awns and flag leaf play a dominate role in carbohydrate production in wheat (Li et al., 2006; Khaliq et al., 2008). Early tillering, early booting, early anthesis and early maturity of grain was a phenomenon observed with treatments. The results of many researchers revealed the application of balanced fertilization significantly increased grain yield. Fe and Zn had a significant effect on important traits, tiller number, 1000 kernel weight, spike length grain number/spike and protein content (Narimani *et al.*, 2010). Foliar application with Fe or Zn increased number of spikes/plant, number of grains/spike can be the result of higher photosynthetic processes, biochemical and physiological activities. Similar results were reported by Habib, 2009 and Zeidan *et al.*, 2010.

A study of literature reveals that mineral and chelating agents when supplied alone or in combination increased growth and yield (Sekhon, 2003; Mosanna and Behrozyar, 2015). The literature has also helped understand that enhanced growth with chelators like EDTA could be due to its ability to act as auxins and also to combine with

metals and transport them into the plant system thus decreasing mineral deficiencies and increasing productivity of crops.

IV. TABLES AND FIGURE

Chart A: Effect of Fe and Zn on yield and yield parameters of *Hordeum vulgare L.*

Treatments / Parameters	Control	Fe alone		Zn alone		Fe + Zn				Fe+Zn (Chelated)
		Fe_{20}	Fe_{40}	Zn_{20}	Zn_{40}	$Fe_{20}+Zn_{20}$	$Fe_{20}+Zn_{40}$	$Fe_{40}+Zn_{20}$	$Fe_{40}+Zn_{40}$	
Booting (DAS)	74.08	70.9*	70.58* (-4.72)	71.16	70.08* (-5.40)	71.08	67.58*	66.83* (-9.79)	68.75*	66.66* (-10.02)
Anthesis (DAS)	83.42	80.92* (-3.00)	81.00*	79.50* (-4.70)	79.67*	75.75* (-9.19)	77.17*	79.00*	77.83*	75.33* (-9.70)
Flag leaf area (cm^2)	7.37	9.63* (30.66)	9.13	9.82*	10.18* (38.12)	12.17*	13.07* (77.34)	11.92*	11.37*	14.96* (102.99)
Tiller no. /plant	1.33	2.41* (81.20)	2.08*	2.83*	2.91* (118.79)	2.83*	3.25* (144.36)	3.00*	2.91*	3.41* (156.39)
Spike no./plant	1.33	2.33* (75.18)	2.08*	2.67*	2.75* (106.77)	2.83*	3.17* (138.34)	2.92*	2.83*	3.25* (144.36)
Spikelet No. on main axis	13.50	17.33* (28.37)	17.30*	17.33*	18.00* (33.33)	17.16*	20.66* (53.03)	18.50*	18.50*	20.83* (54.29)
Spikelet No. / plant	29.58	50.39 (70.35)	44.20*	52.58*	54.17* (83.09)	54.58*	64.58* (118.32)	57.83*	57.50*	65.50* (121.43)
Peduncle length (cm)	6.83	7.33 (7.32)	7.00	7.00	8.00* (17.13)	7.33	12.66*	13.66* (100.00)	5.83	13.85* (102.78)
Awn length (cm)	11.26	12.73	13.10 (16.34)	13.76* (22.20)	13.73*	14.23*	14.90* (32.33)	14.20*	12.13	15.00* (33.21)
Spike length (cm)	6.66	8.16 (22.52)	7.66	7.33	9.50* (42.64)	8.00	9.83* (47.60)	8.66	6.50	9.94* (49.25)

**significant earliness/increase at 5%level*

Figures in parenthesis depicts percentage increase over control for best effect with Fe/Zn, Fe+Zn and Fe+Zn chelated treatments

Chart B: Effect of Fe and Zn on yield and yield parameters of *Hordeum vulgare L.*

Treatments Parameters	**Control**	**Fe alone**		**Zn alone**		**Fe + Zn**				**Fe+Zn (Chelated)**
		Fe_{20}	**Fe_{40}**	**Zn_{20}**	**Zn_{40}**	**$Fe_{20}+Zn_{20}$**	**$Fe_{20}+Zn_{40}$**	**$Fe_{40}+Zn_{20}$**	**$Fe_{40}+Zn_{40}$**	
Grain no. on main shoot	33.08	46.16* (39.54)	46.08*	44.91	47.08* (42.32)	43.41	54.58* (64.99)	49.33*	47.58*	54.83* (65.75)
Grain no. / plant	72.92	123.0* (68.68)	113.2*	133.9* (83.65)	132.9*	135.75*	144.33*	144.92*	145.75* (99.88)	167.17* (129.25)
Grain weight of 100 seeds (g)	4.588	4.65 (1.35)	4.61	4.75	4.85* (5.80)	4.73	4.88* (6.36)	4.85*	4.83*	4.975* (8.44)
Grain weight / plant (g)	2.93	4.63* (58.02)	4.18	4.95*	5.60* (91.13)	6.02*	10.34* (252.90)	5.19*	4.57	14.11* (381.57)
Straw weight (g)	11.30	15.16 (34.16)	15.16 (34.16)	15.88	18.43 (63.10)	13.55	22.56* (99.65)	15.30	13.10	25.32* (124.07)
Harvest index	20.78	22.66 (9.05)	21.55	22.91	23.32 (12.22)	30.72*	31.16* (49.95)	26.03*	25.54*	35.77* (72.14)

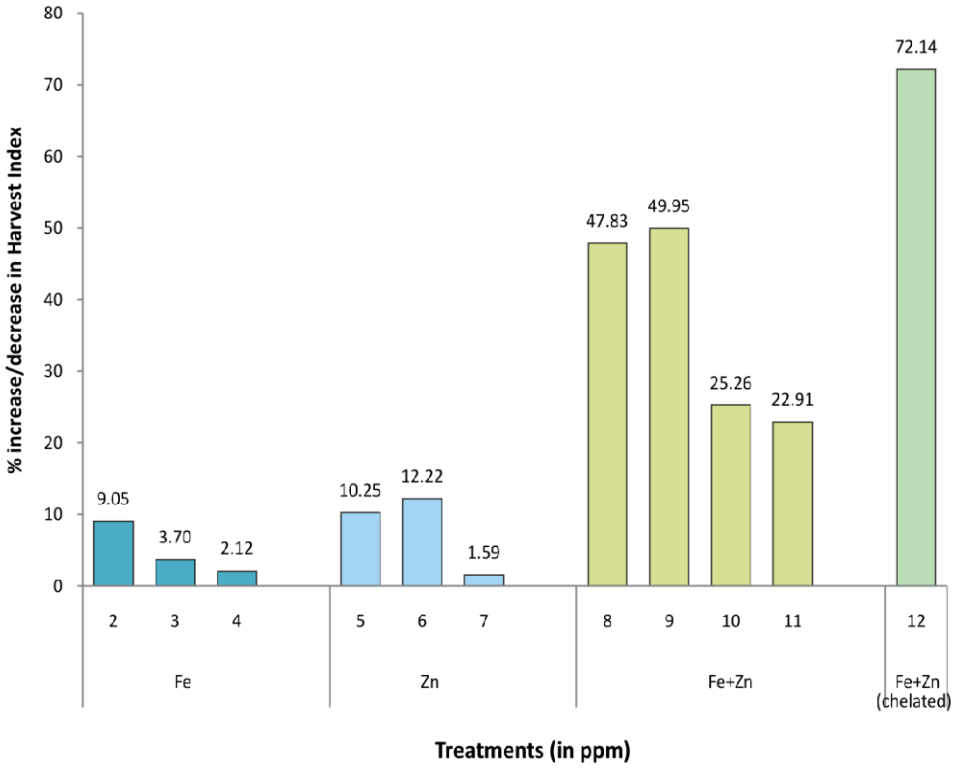
**significant increase at 5%level.*

Figures in parenthesis depicts percentage increase over control for best effect among Fe alone, Znalone, Fe+Zn and Fe+Zn chelated treatments

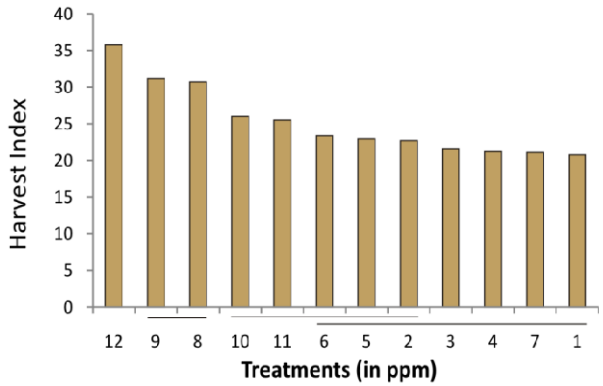
Figure - 1

Response of Fe and Zn treatments to Harvest Index of Hordeum vulgare L.

(a) percentage increase / decrease over control



(b) L.S.D. comparisons at 5% level



L.S.D. = Least Significant Difference
1 = Control
2= Fe20
3= Fe40
4=Fe60
5= Zn20
6=Zn40
7=Zn60
8= Fe20+Zn20
9=Fe20+Zn40
10= Fe40 + Zn20
11= Fe40+ Zn40
12= Fe20 + Zn40 (chelated)

L.S.D. is from mean data as seen in respective table.

V. CONCLUSION

Treatments of Fe and Zn increased yield and yield parameters of barley. Combined treatments of Fe and Zn were more effective than their treatments given individually. Fe20 + Zn40 was the best application for most yield parameters like flag leaf area , tiller number/plant, spike number , spikelet number , spikelet number /plant , awn length , spike length ,grain number on main shoot , grain wt of 100 seeds , grain wt/plant , straw wt. , and harvest index . Chelated form of the combination was still more promoting.

REFERENCES

[1]. World Barley Outlook (2010). CWB. www.canbar6.usak.ca/files/03

[2]. Barley World. Org. (2006). What Is Barley?. Oregon State University. Retrieved July 30, 2007.

[3]. Halvin, J.L.; Beaton, J.D.; Tisdale, S.L. and Nelson, W.L. (1999). Soil Fertility and Fertilizers – An introduction to nutrient management 6th Ed. Prentice Hall, New Jersey.

[4]. Cakmak, I.; Yilmaz, A.; Ekiz, H.; Torun, B.; Erenoglu, B. and Braun, H.J. (1996). Zinc deficiency as a critical nutritional problem in wheat production in Central Anatolia. Plant and Soil **180:**165–172.

[5]. Vallee, B.L. and Falchuk, K.H. (1993). The biochemical basis of zinc physiology. Physiol. Rev. **73**:79-118.

[6]. Narimani, H.; Rahimi, M.M.; Asadollah, Ahmadikhah, and Behrooz, Vaezi (2010). Study on the effects of foliar spray of micronutrient on yield and yield components of durum wheat Archives of Applied Science Research **2**(6):168-176.

[7]. Zhao Ai-Qing; Bao Qiong-Li; Tian Xiao-Hong; Lu Xin-Chun; William Jeff Gale (2011). Combined effect of iron and zinc on micronutrient levels in wheat (Triticum aestivum L.) J. Environ. Biol. **32**: 235-239.

[8]. Kinaci, G. and Kinaci, E. (2005). Effect of zinc application on quality traits of barley in semi arid zones of Turkey .Plant, Soil and Environment **51**(7):328-334.

[9]. Imtiaz, M.; Rashid, A.; Khan, P.; Memon, M.Y. and Aslam, M. (2010). The Role of Micronutrients in Crop Production and Human Health Pak. J. Bot. **42**(4): 2565-2578.

[10]. Asad, A. and Rafique, R. (2000). Effect of zinc, copper, manganese and boron on the yield and yield components of wheat crop in Tehsil Peshawar. Pakistan J. Biol. Sci. **3**: 1615–1620.

[11]. Hussain, N.; Khan, M.A. and Javed, M.A. (2002). Effect of foliar application of plant micronutrients mixture on growth and yield of wheat. Pakistan J. Biol. Sci. **8**: 1096–1099.

[12]. Ghavami, S.H; Moghdasi, M.S.; Omiditabrizi, A.H. (2015). Use Fe and Zn Micronutrients On Quantitative And Qualitative traits Of safflower (Carthamus Tinctorius L.) Cumhuriyet University Faculty of Science, Science Journal (CSJ). 36(3); Special issue ISSN 1300-1949

[13]. Mosanna, Rand Behrozyar,E.K.(2015) Morpho-physiological response of maize (Zea mays l.) to zinc nano- chelate foliar and soil application at different growth stages, Journal of New Biological Reports(JNBR) 4(1) 46- (2015) ISSN 2319-1104 (online).

[14]. Habib, M. (2009). Effect of foliar application of Zn and Fe on wheat yield and quality. African J. Biotechnol. **8**: 6795–6798.

[15]. Mitra, B.; Payam, M. and Sani, B.(2015). The Effect of Iron Nanoparticles Spraying Time and Concentration on Wheat. Biological Forum – An Int. J. 7(1): 679-683.

[16]. Gunjan, Singh and Boswal, M. V. (2015). Influence of Fe and Zn on vegetative and growth parameters of barley (Hordeum vulgare L.) International Journal of Current Research (IJCR) **7**, (4):14268-14274.

[17]. Szladils, I. (1956). The agricultural use of chelates. Soil and Fertilzers. **19**:1-4.

[18]. 18. Pandey, A.K. and Meeta Pandey (2002). Studies on theeffect of EDTA on yield and mineral composition of barley grains. Res. J. Pl. Environ **18**: 77-80.

[19]. Sekhon, B.S. (2003) Chelates For Micronutrient Nutrition Among Crops. www.ias.ac.in/resonance/volumes08/07/0046-0053 pdf

[20]. Erdal, I.; Kepenek, K. and Kizilgos, I. (2004). Effect of foliar iron applications at different growth stages on iron and some nutrient concentrations in strawberry cultivars. Turk J. Agric. For. **28**: 421-427.

[21]. Duhan and Dudeja (1998). Effect of exogenous iron, synthetic chelator and rhizobial siderophores on iron acquisition by a pigeon-pea host in pigeon pea- Rhizobium symbioses. Microbial Research **153**(1): 37-45.

[22]. Qadir, M. A.;Ahmed, M.; Naveed-Ul-Ihsan; Ahmad, A.; Waseem, R. (2014) EDTA Chelated Micronutrients For Growth Of Rice, Onion And Lemon Plants And Enhancing Their Fruit Yields. Int. J. Chem. Sci,: 12(4): 1153-1160

[23]. Fareghi naeini, F.; Dehghanzadeh, H and Moafpourian, G. (2014) Effects of foliar application of micro fertilizers on grain yield and yield components of the rice Sazandegi,s cultivar (Oriza sativa L.) Agri. Sci. Dev. 3 (5): 191-193

[24]. Rahman, I.U.R,; Afzal, A.; Iqbal, z.; Manan, s. (2014) Foliar Application of Plant Mineral Nutrients on Wheat: Research and Reviews: Journal of Agriculture and Allied Sciences (RRJAAS) 3(2):**19-22**.

[25]. Zain, M. , Khan, I. , Khan Qadri, R. , Ashraf, U. , Hussain, S. , Minhas, S. , Siddiquei, A. , Jahangir, M. and Bashir, M. (2015) Foliar Application of Micronutrients Enhances Wheat Growth, Yield and Related Attributes. American Journal of Plant Sciences, 6, 864-869. doi: 10.4236/ajps.2015.67094.

[26]. Godin, C.; Costes, E. and Sinoquet, H. (1999). A method for describing plant architecture which integrates topology and geometry. Annals of Botany **84**:343-357.

[27]. Mahmoud, M. and Mahmoud, G. (2011). Studies on physiological and morphological traits associated with drought resistance in rice (Oryza sativa L.) www.kfs.edu.eg/post/display.aspx?topic=2130.

[28]. Briggs, K. G. and A. Aytenfish, (1980). Relationship between morphological characters above the flag leaf node and grain yield in spring wheat. Crop Sci. **20**:350-354.

[29]. Khaliq, I.; Irshad, A. and Ahsan, M. (2008). Awns and flag leaf contribution towards grain yield in spring wheat (Triticum aestivum L.). Cer. Res.Commun. **36**: 65–76.

[30]. Singh, M.V. (2004). Micronutrient deficiencies in Indian soils and field usable practices for their correction. IFA International Conference on Micronutrients Feb. 23-24, 2004 at N. Delhi.

[31]. Wan, A.L. and Y.M. Shong, (1981). Studies on the relationship between flag leaf area and panicle weight in rice cultivars. Scienctia Agricultura Sinica **6**: 21–28.

[32]. Sheela, G.; Shai, V.N. and Saran, (1990). Role of flag leaf on grain yield and spikelet sterility in rice cultivars. Oryza, **27**: 87–88.

[33]. Raj, A. and Tripathi, M.P. (2000). Varietal variations in flag leaf area and yield in deep water rice. Indian J. Plant Physiol. **5**: 293−295.

[34]. Regina, A.; Bai, N.R.; Devika, R. and Joseph, C.A. (1994). Flag leaf influence on yield and yield attributing characters in rice genotype. Environ. Ecol. **12**: 633–636.

[35]. Bashar, M.K.; Haque, E.; Das, R.K. and Miah, N.M. (1990). Relationship of flag leaf area to yield, filled grains per panicle and panicle length in upland rice varieties. Int. Rice Res. Newslett. **16**: 12.

[36]. Rao, S.P. (1992). Flag leaf: a selection criterion for exploiting potential yields in rice. Indian J. Plant Physiol. **35**:265–268.

[37]. Das, G.R., T. Ahmed and H.C. Bhattacharjee, 1981. Association Between Flag Leaf And Grain Dimension In Rice. J. Res. Assam Agric. University. 2; 96-98.

[38]. Faisal M. M. Al-Tahir (2014) Flag Leaf Characteristics and Relationship With Grain yield And Grain protein Percentage For Three Cereals. JMPS, 2(5): 01-07.

[39]. Ashrafuzzaman, M.; Islam, M.R.; Ismail, M.R.; Shahidullah, S.M. and Hanafi, M.M. (2009). Evaluation of six aromatic rice varieties for yield and yield contributing characters. Int. J. Agric. Biol. **11**: 616–620.

[40]. Dutta, R.K.; Baset, Mia, M.A. and Khanam, S. (2002). Plant architecture and growth characteristics of fine grain and aromatic rices and their relation with grain yield. IRC Newslett. **51**: 51–56.

[41]. Ali, M.A.; Hussain, M.; Khan, M.I.; Ali, Z.; Zulkiffal, M.; Anwar, J.; Sabir, W. and Zeeshan, M. (2010). Source-sink relationship between photosynthetic organs and grain yield attributes during grain filling stage in spring wheat (Triticum aestivum). Int. J. Agric. Biol. **12**: 509–515.

[42]. Li, X.; Wang, H.; Li, H.; Zhang, L.; Teng, N.; Lin, Q.; Wang, J.; Kuang, T.; Li, Z.; Li, B.; Zhang, A. and Lin, J. (2006). Awns play a dominant role in carbohydrate production during the grain-filling stages in wheat (Triticum aestivum L.). Physiol. Plant **127**: 701–709.

[43]. Zeidan, M.S.; Manal, I.; Mohamed, F. and Hamouda, H.A. (2010). Effect of Foliar Fertilization of Fe, Mn and Zn on Wheat Yield and Quality in Low Sandy Soils Fertility World Journal of Agricultural Sciences **6** (6): 696-699.