AU DOI: 10.15740/HAS/AU/12.TECHSEAR(5)2017/1291-1295 *Agriculture Update*
Volume **12** | TECHSEAR-5 | 2017 | 1291-1295
Visit us : *www.researchjournal.co.in*

RESEARCH ARTICLE :

Effect of seed inoculation of zinc and iron solubilizing micro-organisms on yield and nutrient uptake by wheat in inceptisol

ARIGELA KIRAN, P.P. KADU, K. SANTHOSH KUMAR, VADDEPALLY PAVAN AND B. CHANDRA SHEKER

ARTICLE CHRONICLE :
Received :
15.07.2017;
Accepted :
30.07.2017

SUMMARY : A field experiment was conducted during the year 2015-16 at Post Graduate Institute Farm, Mahatma PhuleKrishiVidyapeeth, Rahuri, to study the "Effect of seed inoculation of zinc and iron solubilizing micro-organisms on yield and nutrient uptake of wheat in inceptisol. The highest wheat grain yield was significantly increased in treatment T_7 *i.e.* GRDF + 20 kg $ZnSO_4$ + 25 kg $FeSO_4$ + seed inoculation of Fe and Zn solubilizers(45.46 q ha^{-1}) which was at par with treatment T_5 (45 q ha^{-1}) and T_6 (44.46 q ha^{-1}). Total uptake of N, K, Fe, Mn, Zn and Cu significantly increased in treatment of T_7,over all the treatments, however total P uptake of was significantly increased in treatment of T_5, over other treatments except T_4 andT_6.

How to cite this article : Kiran, Arigela, Kadu, P.P., Kumar, K. Santhosh, Pavan, Vaddepally and Sheker, B. Chandra (2017). Effect of seed inoculation of zinc and iron solubilizing micro-organisms on yield and nutrient uptake by wheat in inceptisol. *Agric. Update*, **12**(TECHSEAR-5) : 1291-1295; **DOI: 10.15740/HAS/AU/12.TECHSEAR(5)2017/1291-1295.**

KEY WORDS :
Wheat, Zinc, Iron solubilising micro-organisms, Uptake of N, P, K, Fe, Mn, Zn, Cu

Author for correspondence :
ARIGELA KIRAN
Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, AHMEDNAGAR (M.S.) INDIA
See end of the article for authors' affiliations

BACKGROUND AND OBJECTIVES

Wheat (*Triticum aestivum* L.) is the second most important cereal crop in India next to rice in respect of area and production.In 2016, global wheat production was 749 million tonnes.Wheat is the primary food staple in North Africa and the Middle East, and is growing in uses in Asia. Unlike rice, wheat production is more widespread globally, though 47% of the world total in 2014 was produced by just four countries – China, India, Russia and the United States. In India, area under wheat cropping in 2015-16 was 29.25 million hectares with the annual production of 85.93 million tonnes with average productivity of 2938 kg ha^{-1}. In Maharashtra, wheat occupied 1.08 million hectare and annual production was 1.74 million tonnes with average productivity of 1483 kg ha^{-1} (Anonymous, 2015). The average productivity of wheat in Maharashtra is quite low. Therefore, it is very essential to increase the production and productivity of wheat in the state. The deficiencies of micronutrients (Zn and Fe) have been increasing on many agricultural soils. It can be grown in tropics, sub tropics and temperate region. Wheat is cultivated in alluvial soil and black cotton soils. Wheat is an important source of carbohydrate, proteins and minerals like P, Mg, Fe, Cu and Zn and vitamins like thiamine, riboflavin, niacin and Vitamin E.The micronutrient deficiencies have been verified in many soils through soil testing and plant analysis. The application of micronutrient fertilizers have proved better in many agricultural crops *viz*., wheat, maize, rice etc.

Zinc is one of the most important micronutrients. It has vital role in transformation of carbohydrates, regulation of consumption of sugar and increase source of energy for the production of chlorophyll. Zinc is also required for maintenance of auxin in an active state. Zinc is essential for the synthesis of tryptophan, a precursor of auxin. The basic function of zinc in plants relates to metabolism of carbohydrate, protein and phosphate, auxin and ribosome formation. The intensive cropping, imbalanced fertilization, non-use of micronutrients and inadequate supply of organic manures have resulted in the depletion of soil fertility. Iron is involved in the production of chlorophyll and iron chlorosis is easily recognized on iron sensitive crops growing on calcareous soil. Iron also is a component of many enzymes associated with energy transfer, nitrogen reduction and fixation and lignin formation. Iron is associated with sulphur in plants to form compounds that catalyse other reactions. Iron deficiencies are mainly manifested by yellow leaves due to low levels of chlorophyll. Leaf yellowing first appears on the younger upper leaves in interveinal tissues. Severe iron deficiencies cause leaves to turn completely yellow or almost white and then brown as leaves die. Iron deficiencies are found mainly on high pH soil, although some acid, sandy soil low in organic matter also may be iron deficient. Cool, wet weather enhances iron deficiencies, especially on soil with marginal level of available iron. Poorly aerated or compacted soil also reduce iron uptake by plants, uptake of iron decreases with increase in soil pH and is adversely affected by high level of available phosphorus, manganese and zinc in soil. Wheat is the crop species which is most susceptible to zinc deficiency. About 96 to 99 per cent of the applied zinc and iron is concerted to different insoluble forms depending upon the soil types, physico-chemical reactions of the soil. The solubility of zinc and iron is highly dependent on soil pH and moisture. Zinc occurs in soil as sphalerite, olivine, hornblende, augite and biotite. Adoption of recommended package of practices is a need of the day. Macro and micronutrients play a vital role in the physiology of plants. The application of micronutrient either foliar or through soil is very essential for higher production and quality improvement of wheat. Amongst the micronutrients, iron and zinc have recently assumed greater importance in crop production. The information on seed coating of iron and zinc solubilizing micro-organisms to solubilize the soil mineral zinc and iron is very scanty and staggered.

RESOURCES AND METHODS

The experiment was laid out in a Randomized Block Design with 7 treatments and 3 replications. The gross plot size was 3.60 x 4.50 m and net plot size was 3.15 x 4.10 m. The recommended spacing of 22.5 cm was adopted. The experimental plot belonging to Inceptisol order, deficient in Zn and Fe and low status of organic carbon content was selected for conduct of experiment. Composite soil sample from the experimental site was collected and processed for analysis of soil propertiesand fertility.After collection soil, the soil was air dried under diffused sunlight and processed for initial chemical properties. Well decomposed farmyard manure was procured from cattle project, M.P.K.V., Rahuri and applied as per recommendation @ 10 t ha^{-1}. The Fe-Zn solubilizing culture required for seed coating for this experiment, was brought from the Vasantdada Sugar Institute, Manjari, dist. Pune. The culture consisted of a consortium of zinc and iron solubilizing bacteria and fungi. The zinc solubilizers included a consortium of bacterial strains *viz*., *Baciluspolymyxa*, *Bacillus megaterium*, *Psuedomonas striata*, *Pseudomonas fluorescens*, *Gluconacetobacter diazotrophicus* and *Aspergillus awamorie* a fungal strain. The iron solubilizing micro-

Treatments details		
T_1	:	Absolute control
T_2	:	Absolute control + seed treatment of Zn and Fe solubilizers
T_3	:	GRDF only (120:60:40 kg ha^{-1} N, P_2O_5 and K_2O +10 t ha^{-1} FYM)
T_4	:	GRDF + seed treatment of Zn and Fe solubilizers
T_5	:	GRDF + 5 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} $FeSO_4$ + Zn and Fe solubilizers
T_6	:	GRDF+ 10 kg ha^{-1} $ZnSO_4$+ 15 kg ha^{-1} $FeSO_4$ + Zn and Fe solubilizers
T_7	:	GRDF + 20 kg ha^{-1} $ZnSO_4$ + 25 kg ha^{-1} $FeSO_4$ + Zn and Fe solubilizers

Note: Half of N, total P_2O_5 and K_2O was applied the time of sowing; remaining half of N was given at 30 DAS.

Methods of plant analysis		
Parameter	Method used	Reference
Total N	Microkjeldahl Wet digestion, (H_2O_2:H_2SO_4,1:1)	Jackson (1973)
Total P	Vanadomolybdate phosphoric acid yellow colour method (Diacid digestion 9:4 mixture of HNO_3:$HClO_4$)	Jackson (1973)
Total K	Flame Photometery, (Diacid digestion 9:4 mixture of HNO_3:$HClO_4$)	Chapman and Pratt (1961)
Micronutrients (Fe, Mn, Zn and Cu)	Atomic absorption spectrophotometery	Zososki and Burau (1977)

organisms included bacterial strains *viz.*, *Thiobacillusthioxidans*, *Thiobacillusferroxidans*and *Aspergillusniger* and *Trichodermaviridae*,which are the fungal strains. This consortium of iron and zinc solubilizing organisms were used for wheat seed inoculation.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Grain yield, straw yield and nutrient uptake of wheat:

The grain yield of wheat was observed to increase significantly from T_2 to T_7 over absolute control. The increase in yield was also significantly higher in treatment T_7, over other treatments.

The highest grain yield was observed in treatment T_7 (45.46 q ha^{-1}), this increase was at par with treatment T_6 (44.46 q ha^{-1}) and T_5 (45 q ha^{-1}). The lowest grain yield was observed in the treatment T_1 (27.54 q ha^{-1}). The wheat yield seed inoculation treatments were much higher than treatment T_3 (41.72 q ha^{-1}), that is recommended dose of fertilizer. The results invariably indicate usefulness of seed coating of Fe and Zn solubilizers.

The straw yield of wheat was observed to increase significantly from T_2 to T_7 over absolute control. The increase in straw yield was also significantly higher in treatment T_7, over un inoculated treatments and absolute control.

The highest straw yield was observed in T_7 (58.99 q ha^{-1}), this increase was at par with treatment T_5 (58.45 q ha^{-1}) and T_6 (57.73 q ha^{-1}). The lowest straw yield was observed in the treatment T_1 (34.88 q ha^{-1}). The results invariably indicate usefulness of seed coating of Fe and Zn solubilizers.

The higher grain and straw yield inseed inoculation treatment may be associated with solubilization of native inorganic and organic phosphates and solubilization of native zinc and iron bearing minerals and their uptake by wheat. The zinc and iron uptake by wheat played important role in photosynthesis, nitrogen fixation, root development flowering, seed formation. Dubey *et al.* (1997) also reported increase in seed and grain yield of soybean with co inoculation of *Rhizobium* and PSM.

Uptake of nitrogen :

The uptake of nitrogen by wheat was observed to increase significantly from T_2 to T_7 over absolute control. The increase in uptake was also significantly higher in treatment T_7, over other treatments.

The highest uptake of nitrogen was observed in treatment T_7 (139.22 kg ha^{-1}) followed by T_6 (127.85 kg ha^{-1}), T_5 (112.18 kg ha^{-1}) and T_4 (92.86 kg ha^{-1}). The uptake in seed inoculation treatments were much higher than treatment T_3 (86.26 kg ha^{-1}) *i.e.* recommended dose of fertilizer.

The significant interaction between zinc and iron solubilizers and levels of zinc and iron sulphate fertilizers resulted higher nitrogen uptake by wheat due to solubilization of native zinc and iron bearing minerals. Nirmal *et al*. (2006) reported that the dual inoculation of *Rhizobium* and PSB resulted in more availability of soil N and P because of their associative effect plus solubilization from non-exchangeable to labile form.

Uptake of phosphorus :

The uptake of phosphorus by wheat was observed to increase significantly in T_5, over absolute control. The increase in uptake was also significantly higher in treatment T_5, over other treatments.

The highest uptake of phosphorus was observed in treatment T_5 (29.97 kg ha^{-1}). This increase was at par with treatment T_6 (28.56 kg ha^{-1}), T_7 (28.02 kg ha^{-1}) and T_4 (28.39 kg ha^{-1}). The uptake in seed inoculation treatments were much higher than treatment T_3 (26.15kg

ha^{-1}) i.e recommended dose of fertilizer which indicates that the seed inoculation of zinc and iron solubilizers solubilize the fixed phosphates and increase the P availability.

These findings are in consonance with Manna *et al*. (2007) who reported that the activity of alkaline phosphatase was significantly increased with increase in FYM levels and PSM inoculation resulting more solubilization of P and uptake by plant.

Uptake of potassium :

The uptake of potassium by wheat was observed to increase significantly from T_2 to T_7 over absolute control. The increase in uptake was also significantly higher in treatment T_7, over other treatments.

The highest uptake of potassium was observed in treatment T_7 (104.56 kg ha^{-1}), followed by T_6 (94.87 kg ha^{-1}), T_5 (89.90 kg ha^{-1}) and T_4 (82.28 kg ha^{-1}). and was significantly higher than all other treatments. The uptake in seed inoculation treatments were much higher than treatment T_3 (76.70 kg ha^{-1}) *i.e.* recommended dose of fertilizer.

It was observed that potassium uptake gradually increased with seed inoculation of zinc and iron solubilizers in all the treatments. The above results may be attributed to the synergistic effect of N, and P uptake. Similar observations were reported by Havlin *et al*. (2007).

Effect of seed inoculation of Zn and Fe solubilizers on total micronutrients uptake :

Uptake of Fe :

The total uptake of Fe (Table 2) in wheat was observed to increase significantly from T_2 to T_7 over absolute control. The increase in uptake was also significantly higher in treatment T_7, over other treatments.

The highest uptake of Fe was observed in treatment T_7 (4850 g ha^{-1}). Followed by T_6 (4353 g ha^{-1}), T_5 (4323 g ha^{-1}) and T_4 (3645 g ha^{-1}). The uptake in seed inoculation treatments were much higher than treatment T_3 (3424 g ha^{-1}) i.e recommended dose of fertilizer. Schmidt (1999) reported that plants assimilate iron from bacterial siderorophores by means of different mechanisms like chelate and release of iron and direct uptake of siderophores Fe complexas or by ligands exchange reaction.

Uptake of Mn :

The total uptake of Mn (Table 2) in was observed to increase significantly from T_2 to T_7 over absolute control. The increase in uptake was also significantly

Table 1 : Effect of seed inoculation of Zn and Fe solubilizers on yield and nutrient uptake by wheat

Tr. No.	Treatments	Yield (q ha^{-1})		Total nutrient uptake (kg ha^{-1})		
		Grain	Straw	N	P	K
T_1	Absolute control	27.54	34.88	50.88	19.15	33.17
T_2	Absolute control + seed treatment of Zn and Fe solubilizers	35.24	45.63	59.22	21.06	45.20
T_3	GRDF only (120:60:40 kg ha^{-1} N, P_2O_5 and K_2O +10 t ha^{-1} FYM)	41.72	54.21	86.26	26.15	76.70
T_4	GRDF + seed treatment of Zn and Fe solubilizers	41.93	54.45	92.86	28.39	82.28
T_5	GRDF + 5 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} $FeSO_4$ +Zn and Fe solubilizers	45.00	58.45	112.18	29.97	89.90
T_6	GRDF + 10 kg ha^{-1} $ZnSO_4$ + 15 kg ha^{-1} $FeSO_4$ + Zn and Fe solubilizers	44.46	57.73	127.85	28.56	94.87
T_7	GRDF + 20 kg ha^{-1} $ZnSO_4$ + 25 kg ha^{-1} $FeSO_4$ + Zn and Fe solubilizers	45.46	58.99	139.22	28.02	104.56
S.E.$\pm$		0.780	0.99	3.33	0.999	2.60
C.D. (P=0.05)		2.403	3.071	10.28	3.08	8.03

Table 2 : Effect of seed inoculation of Zn and Fe solubilizers on total uptake of micronutrients Fe, Mn, Zn and Cu by wheat

Tr. No.	Treatments	Total micro nutrient uptake (g ha^{-1})			
		Fe	Mn	Zn	Cu
T_1	Absolute control	1925	1208	389	25
T_2	Absolute control + seed treatment of Zn and Fe solubilizers	2813	1646	645	41
T_3	GRDF only (120:60:40 kg ha^{-1} N, P_2O_5 and K_2O +10 t ha^{-1} FYM)	3424	2133	875	65
T_4	GRDF + seed treatment of Zn and Fe solubilizers	3645	2277	945	77
T_5	GRDF + 5 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} $FeSO_4$ +Zn and Fe solubilizers	4323	2637	1073	108
T_6	GRDF +10 kg ha^{-1} $ZnSO_4$ + 15 kg ha^{-1} $FeSO_4$ + Zn and Fe solubilizers	4353	2699	1199	114
T_7	GRDF +20 kg ha^{-1} $ZnSO_4$ + 25 kg ha^{-1} $FeSO_4$ + Zn and Fe solubilizers	4850	2959	1289	133
S.E.$\pm$		56.85	47.98	29.09	4.27
C.D. (P=0.05)		175.17	147.85	89.64	13.17

higher in treatment T_7, over other treatments.

The highest uptake of Mn was observed in treatment T_7 (2959 g ha^{-1}). Followed by T_6 (2699 g ha^{-1}), T_5 (2637g ha^{-1}) and T_4 (2277g ha^{-1}). The uptake in seed inoculation treatments were much higher than treatment T_3 (2133 g ha^{-1}) *i.e.* recommended dose of fertilizer. These results are close confirmity with results observed by Soliman *et al*. (2012), who reported that the increase in Mn uptake might be due to study supply of Mn through organics due to mineralization.

Uptake of Zn :

The total uptake of Zn (Table 2) in wheat was observed to increase significantly from T_2 to T_7 over absolute control. The increase in uptake was also significantly higher in treatment T_7, over other treatments.

The highest uptake of Zn was observed in treatment T_7 (1289 g ha^{-1}). These increase was at par with treatment T_6 (1199 g ha^{-1}), significantly higher in treatment T_7, over other treatments. The uptake in seed inoculation treatments were much higher than treatment T_3 (875 g ha^{-1}) *i.e.* recommended dose of fertilizer. Janaki and Velu (2010) also reported that inoculation of different zinc solubilizing bacteria strains increased the grain and Stover yield and also increased the zinc uptake in grain and straw.

Uptake of Cu :

The total uptake of Cu (Table 2) in wheat was observed to increase significantly from T_2 to T_7 over absolute control. The increase in uptake was also significantly higher in treatment T_7, over other treatments.

The highest uptake of Cu was observed in treatment T_7 (133 g ha^{-1}), followed by T_6 (114 g ha^{-1}), T_5 (108 g ha^{-1}) T_4 (77 g ha^{-1}) and was significantly higher than all other treatments. The uptake in seed inoculation treatments were much higher than treatment T_3 (65 g ha^{-1}) *i.e.* recommended dose of fertilizer, Gurumurthy *et al*. (2009) reported increase in Cu uptake in grain and straw with N, P and K application and seed inoculation of PSB to soybean.

Authors' affiliations :

P.P. KADU, K. SANTHOSH KUMAR AND VADDEPALLY PAVAN, Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, AHMEDNAGAR (M.S.) INDIA

B. CHANDRA SHEKER, Department of Soil Science and Agricultural Chemistry, College of Agriculture, University of Agricultural Sciences, DHARWAD (KARNATAKA) INDIA

REFERENCES

Chapman, H.D. and Pratt, P.F. (1961). Methods of analysis of soil, plant and water. Division of Agriculture Science university of California. USA. pp. 309.

Dubey, S.K., Balasundaram, V.R., Pant, L.M., Jayasheela, N. Kawalge, B.R. and Mishra, B. (1997). Effect of phosphate dissolving bacteria applied with rock phosphate on nodulation and yield of rainfed soybean under different agro-climatic conditions. *J. Indian Soc. Soil Sci.,* **45** : 503-505.

Gurumurthy, K.T., Leena, N. and Prakasha, H.C. (2009). Micronutrient uptake and yield of soybean (*Glycine max* L) as influenced by integrated nutrient management practices. *Mysore J. Agric. Sci.,* **23** : 883-886.

Havlin, J.L., Beaton, J.D., Tisdale, S.L. and Nelson, W.L. (2007). Soil fertility and fertilizer. An introduction to nutrient management. 7th Ed., pp. 162-199.

Jackson, M.L. (1973). *Soil chemical analysis*, Prentice- Hall of India Pvt. Ltd., New Delhi. pp. 370-387.

Janaki, D. and Velu, V. (2010). Effect of different bacterial strains on zinc solubilization in maize. *J. Microbiol.,* **5** : 244-248.

Manna, M.C., Subba Rao, A. and Ganguly, T.K. (2007). Effect of fertilizer P and FYM on bioavailable P as influenced by rhizosphere microbial population in soybean-wheat rotation. *J. Sustainable Agric.,* **29** : 149-166.

Nirmal, D., Singh, R.K., Kumar, A. and Singh, J. (2006). Effect of organic inputs and biofertilizers on biomass, quality and yield parameters of vegetable pea (*Pisumsativum* L.). *Internat. J. Agric. Sci.,* 2 : 618-620.

Schmidt, W. (1999). Mechanisms and regulation of reduction-based iron uptake in plants. *New Phytologist*, **141** : 1-26.

Soliman, A.H., Abeer, A. Mahmoud and Gendy, A. (2012). Effect of fertilizers on growth, yield and active ingredients of safflower plant under sandy soil condition. *J. Appl. Sci. Res.,* **8** : 5572-5578.

Zososki, R.L. and Burau, R.G. (1977). A rapid nitric, perchloric acid digestion method for multielement tissue analysis. *Soil Sci. Plant Analysis*, **8** : 425-436.

WEBLIOGRAPHY

Anonymous (2015) www.india.stat.com.