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To find out the effect of method of sowing (S), level of NPK (F), and zinc doses (Z) on plant growth, yield attributing characters and seed yield on bread wheat (*Triticum aestivum* L.)

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Abstract
The present investigation entitled “Effect of sowing methods, doses of NPK and Zn on growth, seed yield and quality parameters on Bread Wheat (*Triticum aestivum* L.)” was carried out during the *rabi* 2013-14 & 2014-15 at New Dairy Farm, Kalyanpur of C. S. Azad University of Agriculture and Technology, Kanpur. The experiment was laid out in Split Plot Design (S.P.D.) with four replications and eighteen treatments *i.e.* two levels of method of sowing (Ridge and Plain), three levels of fertilizer doses (RDF, 1.25×RDF, 1.50×RDF) and three levels of zinc doses (2.5, 5.0 and 7.5 Kg/ha). Experimental findings reveals that ridge sowing method, application of 1.25 RDF (NPK) @ 187.50: 75: 50 kg/ha along with 5.0 kg Zn/ha was best practice to get the best performance in form of plant height (cm), chlorophyll intensity (C. I.) before 10 days of anthesis of wheat, leaf area index at the time of anthesis, number of effective tillers per plant, spike length (cm), chlorophyll intensity (C. I.) after 10 days of anthesis, number of seed per spike, raw and graded seed yield kg per plot, raw and graded seed yield (q per ha), seed recovery percent and benefit: cost ratio in both the year and pooled, respectively.

Keywords: Bread wheat**,** sowing methods**,** NPK**,** RDF, growth and seed yield

Introduction

Wheat (*Triticum aestivum* L.) belongs to the family Poaceae. It is a hexaploid i.e. 2n=42 basic chromosome number. Wheat is grown in tropics and sub-tropics making it the main food crop of temperate zone. Bread wheat originated about 5000 years ago besides the Nile river civilization and spreads further to other valleys i.e. Indus, Euphrates by 4000 BC and England by 2000 BC etc. China is the largest producer of wheat followed by India in the second position. Wheat contributes about 20% of the total calories of the people of the world making it the “King of Cereals”. Wheat has always been the predominant crop of temperate regions, though it is now grown with moderate success in tropical and subtropical climate (Saunder and Hettel, 1994) [11]. Globally, wheat contributes approximately 30 percent of the total cereal production. Wheat contains 12.6-14 g protein, 1.5-1.9 g fat, 68-71 g carbohydrate, 12.2 g dietary fibre, 360 kcal energy, 39 mg calcium, 239 mg magnesium, 842 mg phosphorus, 892 mg potassium, 12.29 mg zinc and 6.26 mg of iron, 17-20% of the daily requirement in human body (Watt and Breyer-Brandwijk, 1962) [24].

The origin of ridge sowing of wheat has traditionally been associated with water management issues either by providing opportunities to reduce the impact of excess water in rain fed conditions or to more efficiently deliver irrigation water in high production irrigation systems. (Hobbs and Gupta, 2003) [4]. Judicious use of fertilizer is also very useful for the growth of wheat plant and high seed yield. Nitrogen supply to the plant will influence the amount of protein, protoplasm and chlorophyll formed thus increasing cell size, leaf area and photosynthetic activity. Generally 70% of the fertilizer nitrogen is contained in the seed with the remaining 30% in the straw. Along with nitrogen at all sites where wheat yields was increased by K fertilizer, due to increase in number of seed/ear and kernel weight. Phosphorus is also important for seed formation & root development.

The young plant has limited root surface for absorption so a high concentration of available phosphorus in the root zone aids in early season development. Abundant phosphorus results in an early proliferation of tillers which increase forage and grain yield potential. Zinc is an essential micronutrient needed by all types of soils used for crop production. In India almost all cereal crops suffer from zinc deficiency. Zinc is an essential micronutrient for plant growth and is absorbed by the plant roots in the form of Zn2+. It is involved in diverse metabolic activities, influences the activities of hydrogenase and carbonic anhydrase, synthesis of cytochrome and the stabilization of ribosomal fractions and auxin metabolism (Tisdale *et al*., 1984) [19].

Materials and Methods

The present investigation was carried out to study the "Effect of sowing methods, Doses of NPK and Zn on growth, seed yield and quality parameters on Bread Wheat (*Triticum aestivum* L.)". The experiment was conducted at New Dairy Farm, Kalyanpur, situated at Kanpur during the year 2013-14 & 2014-15 and seed quality was assessed in the Laboratory of the Department of Seed Science and Technology, C.S. Azad University of Agriculture and Technology, Kanpur. Experimental material for the experimentation consisted of a wheat variety PBW 343, along with fertilizers i.e. urea, DAP, MOP, and zinc sulphate. The seeds were obtained from Processing Unit of C.S. Azad University of Agriculture and Technology, Kanpur. Crop was shown on 22 November 2013 and second year on 19 November. In the present investigation three factors i.e. method of sowing, fertilizer and zinc doses. The experiment was done in Split Plot Design with four replications and eighteen treatment combinations i.e. two method of sowing [Ridge sowing (S_1) and Plain sowing (S_2)], three doses of fertilizer [Recommended dose of fertilizer (N: P: K) 150:60:40 (M_1), 1.25×RDF (M_2) and 1.50× RDF (M_3)] and three doses of Zinc [2.5 (Z_1), 5.0 (Z_2) and 7.5 (Z_3) Kg/ha)]. The net plot size was 3.0 ×2.1 m^2 with planting distance of 20 cm × 15 cm. All the three doses of N, P, K, along with doses of Zinc was applied at the time of sowing. Nitrogen was given in the form of urea, Phosphorus in the form of DAP and Potassium in the form of MOP along with Zinc sulphate to provide zinc. Standard cultural practices were followed during the experimentation.

Results and Discussion

The findings of the present investigation entitled "Effect of sowing methods, Doses of NPK and Zn on growth, seed yield and quality parameters on Bread Wheat (*Triticum aestivum* L.)" was undertaken during two successive years *i.e.* 2013-14 and 2014-15 to find out the effect of method of sowing (S), level of NPK (M), and zinc doses (Z) on plant growth, yield attributing characters seed yield, seed quality and for higher yield of wheat seed production in Kanpur.

Effect of sowing method (S)

In present investigation basically two types of sowing methods were used *i.e.* ridge sowing (S_1) and plain sowing (S_2). The result showed the significant effect of sowing method *i.e.* ridge sowing (S_1) and plain sowing (S_2) on leaf area index, chlorophyll intensity-I & chlorophyll intensity-II, number of effective tillers per plant, number of seeds per spike, raw seed yield (kg/plot), raw seed yield (q/ha), graded seed yield (kg/plot), graded seed yield (q/ha) and benefit: cost ratio. The corresponding values for the above parameters were (1.60, 1.59 & 1.60) (S_1) and (1.52,1.55 & 1.54) (S_2), (44.75, 45.39 & 45.07) (S_1) and (41.75, 42.19 & 41.97) (S_2), (38.58, 38.95 & 38.77) (S_1) and (37.15, 36.10 & 36.63) (S_2), (7.94, 8.11 & 8.03) (S_1) and (6.78, 7.03 & 6.90) (S_2), (44.19, 45.92 & 45.63) (S_1) and (45.25, 44.94 & 45.10) (S_2), (3.29 kg/plot, 3.27 kg/plot & 3.28 kg/plot) (S_1) and (2.83 kg/plot, 2.84 kg/plot & kg/plot 2.83 kg/plot) (S_2), (52.29 q/ha, 51.04 q/ha & 51.67 q/ha) (S_1) and (44.88 q/ha, 45.07 q/ha & 44.97 q/ha) (S_2), (3.22 kg/plot, 3.21 kg/plot & 3.22 kg/plot) (S_1) and (2.76 kg/plot, 2.78 kg/plot & 2.77 kg/plot) (S_2), (50.21 q/ha, 50.23 q/ha & 50.22 q/ha) (S_1) and (43.88 q/ha, 44.19 q/ha & 44.04 q/ha) (S_2) and (2.59, 2.26 & 2.43) (S_1) and (2.04, 2.21 & 2.13) (S_2), both the years & pooled basis.

Plant height (cm), days to 50 percent heading and spike length (cm) did not influence significantly by sowing methods *i.e.* ridge and plain sowing.

Similar results have also been reported by various research workers like Makwana and Tank (2008) [7], Jani *et al.* (2008) [5], Singh and Uppal (2011) [2], Kumar *et al.* (2013) [6] and Sauste-Franco *et al.* (2013) [17]. Some other research workers like Kumar *et al.* (2013) [6] and Soomro *et al.* (2009) [16] also found that raised bed sowing was superior over flat sowing in terms of vigour, yield (grain and straw), water use efficiency and nutrient uptake.

Effect of fertilizer doses

Effect of N, P, K (M)

Nitrogen, phosphorus, potassium are an important constituent for overall growth of plant. The overall physiological root development, chlorophyll intensity, spike length (cm), number of tillers per plant, grain yield and quality etc. are all affected greatly by the dose of fertilizer.

Nitrogen is absorbed as NO3- by plant roots and in case of rice NH4+ also. Nitrogen is a major component of plant cell and cell wall, the latter containing as much as 5 percent nitrogen. Nitrogen containing chlorophyll in the presence of solar energy fixes atmospheric CO2 as carbohydrates. Being a constituent of nucleic acid *viz*., (RNA) and (DNA), nitrogen is responsible for the transfer of genetic code to the off- springs. Nitrogen improves the quality of leaf vegetables and fodders. Nitrogen fertilization increases protein quality of the food grain by enhancing the proportion of glutamic acid, proline, phenylalanine, cystine, methionine, tyrosine, and decreasing the amount of lysine, histidine, arginine, aspartic acid, threonine, lycine, valine and leucine in the grain.

In case of phosphorus, plant roots absorb it mainly as the dihydrogen orthophosphate ion ($H_2P0_4^-$) but under neutral to alkaline environments it is also taken as mono hydrogen orthophosphate ($HP0_4^{2-}$) ion. It is involved in ATP and ADP which are the energy currency of the plants. Major processes involving ATP are generation of membrane electrical potentials, respiration, biosynthesis of cellulose, hemicelluloses, pectins, proteins, nucleic acids etc. Phosphorus is thus involved in the energy transfer, formation of sugar and starch, nutrient movement within the plant and transfer of genetic characteristics from one generation to another.

Along with nitrogen and phosphorus plants also absorb potassium by their roots as k^+ ion. It regulates the opening and closing of stomata which are essential for photosynthesis, water and nutrient transport and plant cooling. It also plays a major role in transport of water and nutrients throughout the plant in xylem. It increases root growth and improves drought tolerance along with reducing lodging and winter hardiness of crops. High concentration of available potassium improves physical qualities and shelf-life of fruits and vegetables. Potassium is also responsible for the activation and synthesis of protein-forming nitrate reductase enzyme.

The results revealed that, significance in influence of NPK doses @ RDF (150:60:40 NPK), 1.25 x RDF and 1.5 × RDF was exhibited for Leaf area index, number of seed per spike, raw seed yield (kg/plot), raw seed yield (q/ha), graded seed yield (kg/plot), graded seed yield (q/ha) seed recovery (%) and benefit: cost ratio in 2013-14, 2014-15 & pooled analysis respectively. Whereas parameters like plant height which was non- significant in 2013-14 but significant during 2014-15 & pooled basis, days to 50 percent flowering, chlorophyll intensity-I & chlorophyll intensity-II were significant in 2013-14 & pooled but non- significant in 2014-15 for number of effective tillers and spike length (cm) significant in 2014-15 & pooled but non-significant in 2013-14.

Beneficial effect of doses of NPK application had been reported by Jani *et al.* (2008) [5], Tripathi *et al.* (2013) [18], Tyagi *et al.* (2011) [21], Tyagi and Mahapatra (2012) [23], Kumar *et al.* (2010) [8] and Malghani *et al.* (2012) [26]: effect of NPK (Nitrogen, Phosphorus and Potash) on the growth and yield of wheat cultivars Sahar-2006.

Statistically, graded seed yield kg per plot showed similar performance in 1.25 x RDF and 1.5 x RDF along with leaf area index at the time of anthesis, number of effective tillers per plant, chlorophyll intensity (C.I.) after 10 days of anthesis, spike length (cm), raw seed yield kg per plot and raw and graded seed yield of wheat (q per ha) showed significant increase over M_1 (RDF @ 150:60:40) with values of (3.25,3.33 & 3.29) and (3.01, 1.83 & 2.29) for graded seed yield kg/plot, (1.57, 1.59 & 1.58) and (1.62, 1.61 & 1.62) for leaf area index at the time of anthesis, (7.54, 7.86 & 7.71) and (7.21, 7.08 & 7.15) for number of effective tillers/plant, (37.35, 37.58 & 37.46) and (38.08, 36.97 & 37.52) for chlorophyll intensity (C.I.) after 10 days of anthesis, (48.08, 51.04 & 49.56) and (43.58, 44.96 & 44.27) for spike length (cm), (3.31, 3.38 3.35) and (3.08, 2.88 & 2.98) for raw seed yield kg/plot, (52.53, 52.57 & 52.55) and (48.93, 45.74 & 47.33) for raw seed yield (q/ha), (51.59, 51.18 & 51.70) and (46.24, 44.87 & 45.56) for graded seed yield q/ha in both the year and pooled respectively.

Effect of zinc (Z)

Applications of zinc play an important role in physiological processes/activities of plant.

It is involved in the synthesis of auxins and acts as an activator of various enzymes of the plant system. Zinc plays an important role in protein biosynthesis and also participates in chlorophyll formation. Plants absorb zinc as zinc ions (Zn2+). It is a constituent of three enzymes i.e. carbonic anhydrase, alcoholic dehydrogenase, and superoxide dismutase. It is also involved in the synthesis of Indole acetic acid, metabolism of gibberellic acid and synthesis of RNA.

Zinc is an important micronutrient which governs the yield and quality attributes of wheat. The characters such as plant height (cm), chlorophyll intensity (C.I.) before 10 days of anthesis of wheat, leaf area index at the time of anthesis, number of effective tillers per plant, spike length (cm), chlorophyll intensity (C.I.) after 10 days of anthesis, number of seed per spike, raw and graded seed yield kg per plot and raw and graded seed yield of wheat (q per ha) seed recovery percent of wheat and benefit: cost ratio are found to be superior numerically in Z2 dose @ 5.00 kg zinc/hectare.

Influence of the zinc doses @ 2.5 Kg/ha (Z1), 5.0 Kg/ha (Z2) and 7.5 Kg/ha (Z3) all were found significant for all parameters namely, plant height (cm), number of effective tillers, spike length (cm), number of seed per spike, raw seed yield kg/plot, raw seed yield q/ha, graded seed yield kg/plot, graded seed yield q/ha and benefit: cost ratio in both the year and on pooled basis.

Significantly plant height was observed and measured in Z1 i.e. (95.73, 96.38 & 96.06 cm respectively). Significantly maximum number of effective tillers, spike length (cm), number of seed per spike, raw seed yield kg/plot, raw seed yield q/ha, graded seed yield kg/plot, graded seed yield q/ha and benefit: cost ratio was obtained by application of Z2 @ 5.0 kg/ha. The values for the above parameters were (8.0, 8.83 & 8.19), (8.74 cm, 8.82 cm & 8.56 cm), (46.42, 48.79 & 86.71), (3.27 kg/plot, 3.26 kg/plot & 3.27 kg/plot), (51.95 q/ha, 51.74 q/ha & 51.84 q/ha.), (3.21 kg/plot, 3.21 kg/plot & 3.21 kg/plot), (50.99 q/ha, 50.89 q/ha & 50.94 q/ha) and (2.35, 2.46 &2.41) both the year and pooled basis.

Statistically minimum performance were showed by Z3 @ (7.50 kg/ha) for plant height (cm), number of effective tillers/plant, spike length (cm), number of seed per spike, raw and graded seed yield (q/ha) and benefit-cost ratio. The values of Z2 and Z3 for above parameters are (89.79, 89.21 & 89.50), (6.50, 6.79 & 6.65), (8.18 cm, 8.11 cm & 8.14 cm), (41.92, 42.54 & 42.23), (43.07 q/ha, 42.87 q/ha & 42.97 q/ha.), (42.04 q/ha, 41.99 q/ha & 42.01 q/ha.), (77.25, 74.50 & 75.87), and (2.31, 1.86 & 2.09) both the year and pooled respectively.

Beneficial effect of zinc application had been reported by Singh *et al.* (2009) [13], Habib, M. (2009) [3], Singh *et al.* (2009) [13], Rather and Sharma (2009) [9], Zeidan *et al.* (2010) [25] and Tyagi *et al.* (2011) [21] in wheat; Tyagi and Mahapatra (2012) [23] for growth, seed yield of wheat as well as benefit cost ratio.

Table 1: M.S.S. for field observations of wheat variety PBW 343 Pooled

Source of Variation	D.F	M.S.S. (Mean Sum of Square)													
		Plant Height (cm)	Days to 50% Heading	Chlorophyll intensity (%)- I	Leaf Area Index	No. of Effective Tillers	Spike Length (cm)	Chlorophyll Intensity (%)- II	No. of Seed per spike	Raw seed yield (kg/plot)	Raw Seed yield (q/ha)	Graded Seed yield (kg/plot)	Graded Seed yield (q/ha)	Seed Recovery (%)	Benefit: Cost ratio
Replications	6	13.438	1.615	4.185	0.015	0.868	0.340	2.188	0.969	0.179	10.427	0.150	6.516	0.146	0.007
Factor A	1	49.811	9.444	16.801	0.010	2.428	1.235	6.280	16.952	0.084	54.427	0.155	14.397	0.209	0.019
Sowing method (S)	1	58.395	2.320	1438.142	0.195	8.502	2.236	79.345	45.608	3.564	1056.920	3.163	895.284	2.341	1.371
A×S	1	24.580	0.717	16.808	0.012	0.823	0.386	5.893	3.484	0.052	56.072	0.130	8.808	0.197	0.011
Error(a)	6	26.011	1.573	6.841	0.010	0.942	1.119	3.143	1.858	0.053	23.570	0.078	7.138	0.208	0.012
Fertilizer dose (M)	2	35.088	4.725	18.000	0.041	16.010	1.272	8.969	664.956	2.029	605.637	1.845	962.425	5.076	0.834
A×M	2	4.531	1.343	9.041	0.019	0.745	0.205	2.467	5.398	0.090	14.768	0.084	8.323	0.074	0.011
A×Z	2	10.350	7.439	9.068	0.013	0.481	3.321	2.238	5.228	0.068	34.604	0.006	13.289	0.324	0.011
S×M	2	2.562	1.217	18.005	0.031	1.241	0.295	5.056	10.265	1.372	27.009	0.624	17.686	1.202	0.082
S×Z	2	5.123	6.666	16.190	0.008	0.832	0.272	5.008	10.265	0.088	409.265	0.362	71.839	0.607	0.060
Zinc dose (Z)	2	294.789	1.291	24.096	0.037	16.926	1.391	5.056	478.784	2.288	737.136	1.997	2106.23	4.881	1.158
M×Z	4	73.737	1.268	1.878	0.003	1.281	0.071	1.292	34.520	0.092	20.705	1.311	14.031	0.519	0.067
A×S×M	2	14.367	1.872	2.253	0.003	0.886	0.109	0.984	9.237	0.091	22.757	0.075	12.323	0.387	0.022
A×S×Z	4	8.381	1.088	1.253	0.002	0.832	0.073	0.699	7.099	0.108	21.126	0.086	12.258	0.501	0.011
A×M×Z	4	4.205	0.546	19.249	0.001	0.919	0.073	3.595	32.677	0.094	56.409	0.086	37.384	0.606	0.050
A×S×M×Z	4	3.246	0.421	1.525	0.001	0.877	0.065	10.036	13.372	0.131	19.795	0.073	13.013	0.409	0.011
Error(b)	96	9.895	1.285	4.525	0.009	0.879	0.344	2.523	5.469	0.090	12.679	0.086	7.266	0.592	0.011
Total	143														

Conclusion

In conclusion, the investigation on the "Effect of sowing methods, doses of NPK, and Zn on growth, seed yield, and quality parameters on Bread Wheat (*Triticum aestivum* L.)" conducted over two years in Kanpur revealed significant insights. Ridge sowing demonstrated superiority over plain sowing concerning various parameters, aligning with previous studies. Similarly, the impact of NPK doses on wheat growth and yield was profound, with optimal doses showing significant improvements. Zinc application also proved beneficial, enhancing physiological processes and yield attributes. These findings underscore the importance of meticulous agricultural practices, emphasizing the role of sowing methods, fertilizer doses, and micronutrient supplementation in maximizing wheat productivity and quality. Such research contributes to sustainable agricultural practices, ensuring food security and economic viability for wheat farmers.

Reference

1. Abbas G, Ali MA, Azam M, Hussain I. Impact of planting methods on wheat grain yield and yield contributing parameters. J Anim Plant Sci. 2009;19(1):30-33.
2. Singh B, Uppal RS. Interaction effect of sowing time, planting method and seed rate on performance of wheat variety PBW 550. Environ Ecol. 2011;29(3):1087-1090.
3. Habib M. Effect of foliar application of Zn and Fe on wheat yield and quality. Afr J Biotechnol. 2009;8(24):6795-6798.
4. Hobbs PR, Gupta RK. Resource-conserving technologies for wheat in the rice-wheat system. In: ASA Special Publication No. 65. Madison, WI: American Society of Agronomy; 2003.
5. Jani PP, Tanwar SPS, Singhi SM. Performance of durum wheat (*Triticum durum* Desf.) varieties under varying sowing methods and input levels. Indian J Fertil. 2008;4(7):71-73.
6. Kumar V, Kumar P, Singh R. Growth and yield of rice-wheat cropping sequence in raised bed planting system. Indian J Agric Res. 2013;47(2):157-162.
7. Makwana CF, Tank DA. Effect of method of sowing and seed rate on yield and quality of irrigated durum wheat (*Triticum durum* Desf.) variety GW-1139. Res Crop. 2008;9(2):494-496.
8. Kumar M, Mahajan G, Kumar R, Singh R. Effect of methods of seeding and fertilizer application on growth and yield of late sown wheat (*Triticum aestivum* L.). Environ Ecol. 2010;28(2):934-936.
9. Rather SA, Sharma NL. Effect of integrated nutrient management (INM) on yield and economics of wheat. Asian J Soil Sci. 2009;4(1):15-17.
10. Rajiv R, Patra AK, Purakayastha TJ, Singh RD, Pathak H. Effect of super-optimal dose of NPK fertilizers on nutrient harvest index, uptake and soil fertility levels in wheat crop under a maize (*Zea mays* L.) - wheat (*Triticum aestivum* L.) cropping system. Int J Bio-resource Stress Manage. 2015;6(1):15-23.
11. Saunders DA, Hettel GP. Wheat in heat-stressed environments: irrigated, dry areas and rice-wheat farming systems. Mexico DF: CIMMYT; c1994. p. 402.
12. Singh B, Uppal RS. Interaction effect of sowing time, planting method and seed rate on performance of wheat variety PBW 550. Environ Ecol. 2011;29(3):1087-1090.
13. Singh BR, Singh RV, Rajput OP. Effect of nitrogen, phosphorus and zinc on growth, yield and nutrient uptake of wheat (*Triticum aestivum* L). Curr Adv Agric Sci. 2009;1(2):133-134.
14. Singh MV. Assessing extent of zinc deficiency for soil fertility mapping and nutritional security in humans and animals. Indian J Fertil. 2011;7(10):36-43.
15. Singh NB, Kumar V, Singh GS, *et al*. Variability in response to zinc application in wheat genotypes. Ind J Plant Physiol. 2009;14(4):413-417.
16. Soomro UA, Mujeeb-ur-Rahman, Odhano EA, Shereen Gul Tareen AQ. Effects of sowing method and seed rate on growth and yield of wheat (*Triticum aestivum*). World J Agric Sci. 2009;5(2):159-162.
17. Suaste-Franco MP, Solís-Moya E, Ledesma-Ramírez L, *et al*. Effect of plant density and sowing method on wheat (*Triticum aestivum* L.) grain yield. J Mex Agrocienc. 2013;47(2):170-199.
18. Tripathi SC, Subhash Chander, Meena RP. Effect of early sowing, N levels and seed rates on yield and yield attributes of different wheat (*Triticum aestivum*) varieties. Indian J Agron. 2013;58(1):63-66.
19. Tisdale SL, Nelson WL, Beaten JD. Zinc in Soil Fertility and Fertilizers. 4th ed. New York, USA: Macmillan Publishing Company; 1984. pp. 382-391.
20. Tyagi V, Singh RK, Nagargade M. Effect of hydrogel, NPK and irrigation levels on yield, nutrient uptake and water use efficiency of wheat (*Triticum aestivum* L.). Res Crop. 2015;16(4):653-656.
21. Tyagi S, Mahapatra BS, Kumar V, Shukla DK. Response of wheat to micronutrients applied in conjunction with NPK. Environ Ecol. 2011;28(1):194-197.
22. Tyagi S, Mahapatra BS, Tyagi K, Ansari MA. Nutrient dynamics and yield as affected by micronutrient nutrition in wheat (*Triticum aestivum* L.). Flora Fauna (Jhansi). 2011;17(1):53-58.
23. Tyagi S, Mahapatra BS. Yield, profitability, nutrient uptake residual soil fertility as influenced by micronutrient nutrition of wheat. Int J Agric Sci. 2012;8(1):44-47.
24. Watt JM, Breyer-Brandwijk MG. The Medicinal and Poisonous Plants of Southern and Eastern Africa. 2nd ed. Edinburgh and London: E. & S. Livingstone, Ltd.; 1962.
25. Zeidan MS, Mohamed MF, Hamouda HA. Effect of foliar fertilization of Fe, Mn and Zn on wheat yield and quality in low sandy soils fertility. World J Agric Sci. 2010;6(6):696-699.
26. Malik AU, Malghani AL, Hussain F. Growth and yield response of wheat (*Triticum aestivum* L.) to phosphobacterial inoculation. Russian agricultural sciences. 2012 Feb;38:11-13.