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EFFECT OF PHOSPHORUS AND ZINC FERTILIZATION ON BIOCHEMICAL COMPOSITION OF WHEAT

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ABSTRACT
Field trials were conducted to assess the response of conjunctive use of phosphorus and zinc fertilizer on the 1000-seed weight and certain biochemical components of three varieties of wheat (*Triticum aestivum*) viz: PBW-343, HW-2425 and NW-1014. Results indicated that the phosphorus and zinc application had an synergistic impact on the 1000-seed weight and protein content of the wheat varieties. The increase in the doses of phosphorus and zinc had a positive impact on all the physical and biochemical characters of the wheat varieties. Application of phosphorus @ 60kg/ha and zinc @ 10kg/ha was found suitable to enhance the nutrient composition and certain bread making qualities of the wheat varieties.

INTRODUCTION

The role of macro and micronutrients is crucial in crop nutrition and thus important for achieving higher yields. Nitrogen (N), phosphorus (P) and potassium (K), being primary essential nutrient, have prime importance in crop nutrition. Phosphorus (P) is involved in almost all biochemical pathways as a component part of energy carrier compounds, ATP and ADP. Phosphorus is one of the 17 essential elements required for plant growth and reproduction (Marschner, 1986). Phosphorus (P) is used in the plant for energy storage and transfer, maintenance and transfer of genetic code, and is structural component of cells and many biochemicals. Phosphorus deficiencies results in poor root growth, stunted top growth, reduced yield and crop quality alongwith delayed maturity. Six micronutrients *i.e.*, Mn, Fe, Cu, Zn, B and Mo are known to be required for all higher plants (Welch, 1995). These have been well documented to be involved in photosynthesis, N-fixation, respiration and other biochemical pathways (Marschner, 1986; Marschner *et al.*, 2005). Naheed *et al.* (2008) conducted studies where they found that P applied through rooting medium inhibit the accumulation of Na^+ and Cl^- (toxic ions) in leaf and roots, while enhance the leaf and root K^+, P along with Ca^{2+}. It can be easily noticed in the significant impact it has on the yield of the plant. Approximately 60% of the world arable land is considered to be difficult for the plant production due to mineral stress caused by the deficiency, unavailability, or toxicity of some essential nutritive elements (Foy, 1983).

Among the microelements, Zn is thought to be the most widespread (Graham *et al.*, 1992; Yilmaz *et al.*, 1995, Cakmak *et al.*, 1999). Zinc is an important essential element present in plant enzymatic systems. Genc *et al.*, (2006) reported that zinc has vast numbers of functions in plant metabolism and consequently zinc deficiency has a multitude of effects on plant growth. Zinc deficiency is a worldwide nutritional constraint for crop production in many types of soil in the world (Sillanpaa, 1982; Rengel and Graham, 1995). According to Graham and Welch (1996) about 50% of the soil used for cereal production in the world contains a low level of plant available zinc which reduces not only grain yield but also nutritional quality (low in micronutrients essential for good human health). According to the plant professional's research, zinc exerts a great influence on basic plant life processes, such as: nitrogen metabolism and uptake of nitrogen and protein quality; photosynthesis and chlorophyll synthesis, carbon anhydrase activity; resistance to abiotic and biotic stresses and protection against oxidative damage (Alloway, 2008; Cakmak, 2008; Potarzycki and Grzebisz, 2009). Increasing seed concentration of Zn by soil and/or foliar applications of zinc also brings several agronomic benefits for crop production. In plants zinc have main role in synthesis of proteins, enzyme activation, oxidation and reduction reactions and metabolism of carbohydrates. In general zinc application appears to improve the overall field performance of crop plants including wheat. Maralian, (2009) in his study concluded that foliar application of zinc along with iron increased wheat seed yield and its quality compared with control.

Among the interactions involving macro and micronutrients the interaction between phosphorus and zinc is of greatest potential significance. This interaction is often negative (antagonistic) especially when a soil is deficient in both the nutrients but only one of them is applied through fertilizers. But it is quite possible to increase productivity in wheat through balanced use of phosphorus and zinc in such a way that they act synergistically. The impact of phosphorus and zinc together on the quality aspects and yield of wheat varieties has been studied in the present investigation.

MATERIALS AND METHODS

Experimental design and sowing conditions

The field trial was conducted to study the effect of zinc and phosphorus fertilization on the nutritional qualities and yield of wheat (*Triticum aestivum*). Three varieties commonly used in India *i.e.* PBW-343, HW-2425 and NW-1014 were used for the experiment purpose. The trial was laid out in a split plot design with three phosphorus (control, 60 and 90Kg/hec) and three zinc (Control, 5 and 10Kg/hec) doses in the form of Single super phosphate and zinc sulphate respectively. Before fertilization pooled soil samples were analyzed for the available phosphorus and zinc (DTPA extractable) and it was 16.8mg/kg and 0.5mg/kg. The crop was sown on 12th December 2003 at a seed rate of 120Kg/hectare as per the recommended agronomic practices so as to rare a healthy and vibrant crop.

Biochemical and statistical analyses

The yield of the crop was obtained after harvest. The crop sample was obtained after the harvest and subjected to various biochemical analyses to ascertain the wheat quality. Bold healthy seeds were used to obtain the thousand seed weight. The sedimentation value and water absorption capacity were measured according to the method of The American Association of Cereal Chemistry (AACC, 2000). The protein content in the samples was determined by the method of Lowry *et al.* (1951). The amino acid composition such as Tryptophan content, lysine and methionine content was determined by the method of Spies and Chamber (1949); Felker *et al.* (1978) and Horn *et al.* (1940) respectively. The data obtained for different parameters was subjected to statistical analyses as per the method suggested by Gomez and Gomez (1984) for split plot design.

RESULTS AND DISCUSSION

1000 kernel weight showed significant variation among different wheat varieties (Table 1). Thousand kernel weight ranged from 34.58 to 38.55g among different wheat varieties. Significantly the highest 1000-kernel weight was observed in PBW-343 and the lowest in HW-2425. The application of phosphorus and zinc in increasing doses led to significant increase in the 1000-seed weight during both the years of the field experiment. Maximum 1000- seed weight was recorded with the application of 90kgP/ha and 10kgZn/ha and it was statistically significant over all the other treatments. Statistically significant differences were recorded due to interaction between the phosphorus and zinc doses and phosphorus application @ 90 kg/ha in combination with zinc @ 10 kg/ha recorded significantly higher 1000-seed weight in both the years over all the treatments except phosphorus application @ 60 kg/ha along with zinc @ 10 kg/ha (Table 2). The significant differences observed in 1000-kernel weight among wheat varieties may be due to the differences in the genetic make up of the varieties. However, these differences may be partly attributed due to different growing and environmental conditions prevailed during growing periods. The results are comparable with early findings of Finney *et al.* (1973); Slaughter *et al.* (1992), and Butt *et al.* (2001). The increase in 1000-seed weight due to increase in the doses of phosphorus may be due increase in the amount of available phosphorus during initial stage of growth when it is most needed. Thus, increasing doses of phosphorus ensure that it is available in adequate amount and plays the significant role in the carbohydrate synthesis more efficiently. The findings are in agreement with the results obtained by Sharma and Bhardwaj (1998). Wagdi *et al.* (2012) reported that the increases in N, P, K and Zn uptake appears to be driven by P application and is more conspicuous in the sandy and calcareous soils. This may result in more efficient growth which is manifested as much bolder seeds of wheat.

Table 1: 1000-Seed weight of wheat as influenced by various treatments

Treatments	Test weight (in 'g') 2002-03	2003-04
Variety		
V_1 (NW-1014)	37.38*	37.18*
V_2 (HW-2425)	34.78	34.58
V_3 (PBW-343)	38.55*	38.35*
CD (P = 0.05)	(1.53)	(1.52)
*- (S) Statistically Significant over HW-2425		
Phosphorus levels		
P_0 (0 kg/ha)	33.72	33.52
P_1 (60 kg/ha)	36.52*	36.32*
P_2 (90 kg/ha)	40.48*	40.28*
CD (P = 0.05)	(1.54)	(1.54)
Zinc levels		
Z_0 (0 kg/ha)	34.15	33.95
Z_1 (5 kg/ha)	37.67*	37.47*
Z_2 (10 kg/ha)	38.84*	38.69*
CD (P = 0.05)	(1.54)	(1.54)

*- (S) Statistically Significant over control; **- (NS) Statistically Non Significant over control

The increasing trend in test weight due to increase in zinc doses during both the years of experiment may be due to the fact that application of zinc led to increase availability of zinc for plant growth in the zinc deficient local soil. Zinc is an important substrate involved in photo system-II of

Table 2: 1000-Seed weight of wheat as influenced by interaction between phosphorus and zinc levels

Zinc levels	Phosphorus levels 2002-03 P_0 (control)	P_1 (60 kg/ha)	P_2 (90 kg/ha)	2003-04 P_0 (control)	P_1 (60 kg/ha)	P_2 (90 kg/ha)
Z_0 (Control)	31.45	33.50**	37.49*	31.25	33.30**	37.29*
Z_1 (5 kg/ha)	34.14*	37.16*	41.72*	33.94*	36.96*	41.52*
Z_2 (10 kg/ha)	35.56*	38.89*	42.23*	35.36*	38.69*	42.03*
CD (p = 0.05)	2.677	2.677				

*- (S) Statistically Significant over control; **- (NS) Statistically Non Significant over control

Table 3: Protein content in wheat as influenced by various treatments

Treatments	Protein content (in per cent) 2002-03	2003-04
Variety		
V_1 (NW-1014)	11.19*	11.30*
V_2 (HW-2425)	11.53*	11.65*
V_3 (PBW-343)	10.08	10.79
CD (p = 0.05)	(0.54)	(0.17)
*- (S) Statistically Significant over PBW-343		
Phosphorus levels		
P_0 (0 kg/ha)	10.81	10.92
P_1 (60 kg/ha)	11.16**	11.27**
P_2 (90 kg/ha)	11.44*	11.55*
CD (p = 0.05)	(0.44)	(0.44)
Zinc levels		
Z_0 (0 kg/ha)	10.39	10.49
Z_1 (5 kg/ha)	11.41**	11.52**
Z_2 (10 kg/ha)	11.61*	11.73*
CD (p = 0.05)	(0.44)	(0.44)

*- (S) Statistically Significant over control; **- (NS) Statistically Non Significant over control

photosynthesis and plays vital role in energy metabolism process in plant. Thus, the increased availability and efficient absorption of zinc resulted in vibrant metabolism in wheat plant, which is an important reason for increase in test weight of the seeds. Similar results were obtained by Verma and Minhas (1987).

The significant response observed due to interaction between the phosphorus and zinc doses may be due to the synergistic action of phosphorus and zinc doses. The synergistic action was mainly promoted due to the fact that the local soil was deficient in zinc and thus its application at the rate of 10 kg/ha could not trigger any antagonistic reaction as is normally witnessed when both these nutrients are applied in combination. The results are in conformity with the findings of Gattani *et al.* (1976) and Nayak and Gupta (1995).

The chemical composition of whole wheat flour such as protein content were significantly affected by the wheat varieties, phosphorus doses, zinc doses and interaction between phosphorus and zinc doses (Table 3). The variation among the varieties with respect to the protein content may be attributed to the different genetic makeup of the varieties. The varieties having vigorous growth rates and efficient root systems could easily adapt to the prevailing agro-climatic conditions. Thus, they could absorb the micro and macronutrients at much efficient rate and thereby initiate vibrant metabolism, which ultimately led to increase in protein content and other nutritional characters of wheat plant. The results of this investigation are comparable with early findings of Davis *et al.* (1981), Tanija *et al.* (1983). The concomitant increase in the protein content of wheat with increase in dosage of phosphorus during both the years of cultivation might be due to the affect of increase in phosphorus concentration in soil and it is well known that phosphorus nutrition directly and indirectly influences wheat grain protein in many ways. The nutrient is required for absorption and assimilation of 'N' by wheat plants (Haper and Paulsen, 1969), for translocation of 'N' from vegetation to grain which might indirectly affect protein concentration. The results are in agreement with the findings of Mosolov and Volleidt (1962). The increase in the availability of zinc in zinc deficient soil led to increase in protein content of wheat. It is well known that zinc is actively involved in protein synthesis of plants. It is an important structural component of the protein synthesis machinery and is involved in the form of zinc mottifs in protein synthesis of plant. Similar, results have been reported by Jhaw (1991). The synergistic

Table 4: Protein content in wheat as influenced by interaction between phosphorus and zinc levels

Zinc levels	Phosphorus levels 2002-03			2003-04		
	P_0 (control)	P_1 (60 kg/ha)	P_2 (90 kg/ha)	P_0 (control)	P_1(60 kg/ha)	P_2 (90 kg/ha)
Z_0 (Control)	9.83	10.33**	11.00*	9.93	10.44**	11.11*
Z_1 (5 kg/ha)	11.11*	11.51*	11.60**	11.22*	11.63*	11.72**
Z_2 (10 kg/ha)	11.49*	11.63*	11.72**	11.60*	11.75*	11.84**
CD (p = 0.05)	0.775	0.767				

*- (S) Statistically Significant over control; **- (NS) Statistically Non Significant over control

Table 5: Amino acid composition in wheat as influenced by various treatments (in per cent)

Treatments	Tryptophan (in per cent) 2002-03	2003-04	Methionine (in per cent) 2002-03	2003-04	Lysine (in per cent) 2002-03	2003-04
Variety						
V_1 (NW-1014)	2.24	2.22	1.44	1.43	2.20	2.22
V_2 (HW-2425)	2.30	2.27	1.99	1.97	2.08	2.02
V_3 (PBW-343)	2.26	2.24	1.82	1.80	2.40	2.42
CD (p = 0.05)	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)
Phosphorus levels						
P_0 (0 kg/ha)	1.79	1.78	1.66	1.64	2.14	2.16
P_1 (60 kg/ha)	2.44*	2.42*	1.77*	1.75*	2.23*	2.25*
P_2 (90 kg/ha)	2.56*	2.53*	1.82*	1.80*	2.31*	2.33*
CD (p = 0.05)	(0.09)	(0.09)	(0.07)	(0.06)	(0.08)	(0.04)
Zinc levels						
Z_0 (0 kg/ha)	1.96	1.94	1.50	1.49	2.16	2.18
Z_1 (5 kg/ha)	2.33	2.31	1.84	1.82	2.24**	2.26**
Z_2 (10 kg/ha)	2.50	2.48	1.90	1.88	2.27*	2.29*
CD (p = 0.05)	(NS)	(NS)	(NS)	(NS)	(0.08)	(0.09)

*- (S) Statistically Significant over control; **- (NS) Statistically Non Significant over control

action between phosphorus and zinc may be the reason behind the increasing trend of protein content (Table 4). The deficiency of zinc in soil also might have played indirect role in increasing the protein content in wheat. Application of zinc led to synergistic action with phosphorus in the zinc deficient soil. The results are in conformity with the findings of Webb and Loneragan (1990).

The amino acid composition of the whole wheat flour such as lysine, tryptophan and methionine content were significantly affected by phosphrus and zinc application during both the years of investigation (Table 5). The impact of varieties and interaction between the phosphorus and zinc doses was non significant. The increase in the amount of amino acids due the increase in the doses of phosphorus and zinc may be ascribed to the fact that both these minerals play a vital role in protein synthesis during the grain filling stages in the wheat crop and indirectly enhance the availability of nitrogen to the plants. Thus, increased efficiency of the protein synthesis is manifested in the increase in its structural components which include the amino acids such as lysine, tryptophan and methionine. Similar findings were reported by Lindsay (1972), Alessendroni *et al.* (1976) and Epperdorfer (1978).

The sedimentation value and water absorption capacity were also significantly affected by varieties, doses of phosphorus and zinc (Table 6). The sedimentation value ranged from 31.53 to 36.21 while water absorption capacity was in the range of 65.62 to 72.48. The varietal differences with respect to sedimentation value and water absorption capacity of wheat may be attributed to the fact that these varieties show significant variation among themselves in the context of gluten content. The sedimentation value and water absorption capacity of wheat is directly proportional to gluten content of wheat varieties. Therefore, it is natural that they have variation in their sedimentation values and water absorption capacity also. Similar results have also been reported by Islam *et al.* (1998).

The positive impact on sedimentation value and water absorption capacity due to increase in the doses of phosphorus and zinc may be due to the vital role played by these nutrients in increasing the gluten as well as the total protein content of the wheat. The findings of the present investigation are in conformity with the findings of Pratt (1971) and Jyurg *et al.* (1974).

Table 6: Sedimentation value and water absorption capacity of wheat as influenced by various treatments

Treatments	Sedimentation (in mL)		Water absorption capacity (in mL)	
	2002-03	2003-04	2003-04	2003-04
Variety				
V_1 (NW-1014)	31.53	31.84	65.62	66.27
V_2 (HW-2425)	35.85*	36.21*	71.76*	72.48*
V_3 (PBW-343)	34.11*	34.45*	66.93**	67.60*
CD (P = 0.05)	(1.67)	(1.06)	(2.67)	(1.21)
*- (S) Statistically Significant over NW-1014				
**- (NS) Statistically Non Significant over NW-1014				
Phosphorus levels				
P_0 (0 kg/ha)	32.86	33.19	66.28	66.95
P_1 (60 kg/ha)	33.77**	34.10**	67.90*	68.57**
P_2 (90 kg/ha)	34.86*	35.21*	70.13*	70.83*
CD (P = 0.05)	(1.33)	(1.34)	(0.92)	(2.66)
Zinc levels				
Z_0 (0 kg/ha)	33.62	33.95	67.72	68.39
Z_1 (5 kg/ha)	33.86**	34.20**	68.08**	68.76**
Z_2 (10 kg/ha)	34.01**	34.35**	68.51**	69.20**
CD (P = 0.05)	(1.33)	(1.34)	(0.92)	(2.66)

*- (S) Statistically Significant over control; **- (NS) Statistically Non Significant over control

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