International Journal of Agricultural Sciences
Volume 13 | Issue 2 | June, 2017 | 222-227 ■ e ISSN-0976-5670
DOI:10.15740/HAS/IJAS/13.2/222-227
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RESEARCH PAPER

Realization of wheat (*Triticum aestivum* L.) productivity, profitability and nutrient balance sheet through improved nutrient management

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Abstract : A field experiment was conducted during *Rabi* seasons of 2007-08 and 2008-09 to study the realization of wheat (*Triticum aestivum* L.) productivity, profitability and nutrient balance sheet through improved nutrient management. Sixteen fertility treatment combinations of NPK and $ZnSO_4$ were examined in Randomized Block Design with three replications. Application of NPK $ZnSO_4$ @ 150 : 75 : 60 : 20 kg/ha produced highest grain yield of 51.0 q/ha being significantly higher by 71.7, 57.9, 42.5, 49.9 and 9.5 per cent over control, NPK $ZnSO_4$ levels of 90 : 45 : 45 : 00, 90 : 45 : 45 : 20, 90 : 45 : 45 : 40 and 120 : 60 : 45 : 00 kg / ha, respectively. Further, increase in fertility levels beyond 150 : 75 : 60 : 20 kg NPK $ZnSO_4$/ha did not show any significant improvement in grain yield. However, the yield attributes *viz*., spikes/m^2, grains/spike, test weight and spike fertility ratio increased significantly upto 120 : 60 : 45 : 20 kg NPK $ZnSO_4$/ha over control, 90 : 45 : 45, (with and with out $ZnSO_4$) and 120 : 60: 45 kg NPK / ha but remained at a par with other levels of fertility tested in the experimentation. Most of the growth and developmental parameters in the study significantly increased upto the highest level of fertility management *i.e.* 150 : 75 : 75 : 40 kg/ha. Comparison of available NPK and Zn in soil after harvest of crop with the initial status under different treatments indicated the reduction in residual soil available nutrients at their lower level of application. However, an increase in available NPK in soil were noticed with the application of 150 : 75 : 60 and 150 : 75 : 75 kg NPK/ha with and without Zn level, while the status of Zn in soil was found positive with other primary nutrient under treatment 150 : 75 : 75: 20 and 150 : 75 : 75: 40 kg NPK $ZnSO_4$/ha only. Wheat crop grown under the fertility treatment 150 : 75 : 60 : 20 kg NPK $ZnSO_4$/ha recorded maximum net monetary return of Rs. 36,331/ha which was on an average just the double of all those treatments where nitrogen was applied @ 90 kg/ha.

Key Words : Balance sheet, Growth, N P K Zn uptake, Productivity, Profitability, Wheat

View Point Article : Kumar, Vipin, Kumar, Sandeep, Singh, Ombir and Kumar, Avesh (2017). Realization of wheat (*Triticum aestivum* L.) productivity, profitability and nutrient balance sheet through improved nutrient management. *Internat. J. agric. Sci.*, **13** (2) : 222-227, **DOI:10.15740/HAS/IJAS/13.2/222-227.**

Article History : Received : 23.01.2017**; Revised :** 08.04.2017**; Accepted :** 22.04.2017

INTRODUCTION

Wheat is the second important food crop being next to rice and contribute the total food production of the country to the extent of about 85 per cent with total production of 95.9 Mt and a productivity of 3.08 t/ha

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(DES, 2014). But still, there is a wide disparity among the productivity among the wheat growing states. The production of Uttar - Pradesh is 25.6 million tonnes and continues to be the highest producer of wheat followed by 14.5 MT of Punjab and 9.1 MT of Haryana (Anonymous, 2010).

With the development of newly Mexican dwarf wheat varieties, an entirely new era in crop management has been ushered. Among the various input essential for sustaining continued maximum crop production, judicious and optimum dose of chemical fertilizers has been considered as the key factor. A report said that since the last 25 years, the Indian soils are experiencing on an average, a net negative balance of 8-10 metric tonne of nutrients per annum which seems to be the fact that chemical fertilizer is still dominating factor (Nagarajan, 2005).

Nitrogen is directly concerned with the physiological process occurring within plant and plays a vital role in wheat nutrition. Adequate P is essential for N uptake and if 'P' becomes limiting, plant do not grow normally and yields are consequently depressed. Like phosphorus, an adequate supply of K improves the photosynthetic efficiency of plants and synthesis of protein. Continuous growing of wheat crop with NPK fertilizer application alone has no doubt increased yield remarkably but simultaneously put forth a lot of problems related to micronutrient deficiencies, particularly Zn in soil. Thus, the capacity of soil to produce usable biomass (soil fertility) depends upon the supply of adequate and balance amount of all the essential nutrients (NPK) including micronutrient like Zn because the basic reason hidden behind the zinc deficiency might be an account of imbalance use of fertilizers. Moreover, farmers are also reluctant to apply organic manures due to its non - availability, thus, a proper nutrient management in wheat crop is warranted to achieve high and sustainable productivity in the current changed agro-ecological conditions of western Uttar Pradesh. Therefore, keeping in view the above facts, a field experiment on realization of wheat productivity, profitability and nutrient balance sheet through improved nutrient management" was carried out.

MATERIAL AND METHODS

The experiment was carried out at Agricultural Research Farm of Chaudhary Chhotu Ram Post-Graduate College, Muzaffarnagar (U.P.) during winter seasons of two consecutive years of 2007-08 and 2008-09. The soil of the experimental plot was calcareous and medium to moderately coarse textural material (67.7% sand, 18.1% slit and 14.7% clay) under predominant influence of tall grass vegetation and moderately well drained conditions having alkaline in reaction (pH 7.48), low in organic carbon (0.48%) and available nitrogen (220 kg/ha), medium in available phosphorus (16.2 kg/ha), available potassium (250.74 kg/ha) and available zinc (212 g/ha).Sixteen treatments consisting of possible combinations of NPK level with zinc sulphate *viz.*, control (T_1), 90 :45 : 45 kg NPK/ha (T_2), 90:45:45:20 kg NPK $ZnSO_4$ /ha (T_3), 90: 45 : 45 :40 kg NPK $ZnSO_4$/ha (T_4), 120 : 60 : 45 kg NPK / ha (T_5), 120 : 60 : 45 : 20 kg NPK $ZnSO_4$/ ha (T_6), 120 : 60 : 45 : 40 kg NPK $ZnSO_4$/ ha (T_7), 120 : 60 : 60 kg NPK / ha (T_8), 120 : 60 : 60 : 20 kg NPK $ZnSO_4$ / ha (T_9), 120 : 60 : 60 : 40 kg NPK $ZnSO_4$/ha (T_{10}), 150 : 75 : 60 kg NPK / ha (T_{11}), 150 : 75 : 60 : 20 kg NPK $ZnSO_4$ / ha (T_{12}), 150 : 75 : 60 : 40 kg NPK $ZnSO_4$ / ha (T_{13}), 150 : 75 : 75 kg NPK / ha (T_{14}), 150 : 75 : 75 : 20 kg NPK $ZnSO_4$ (T_{15}) and 150 : 75 : 75 : 40 kg NPK $ZnSO_4$ / ha (T_{16}) were laid out in Randomized Block Design replicated with three times. As per the fertility treatments, nitrogen, phosphorus and potassium were supplied through urea, single super phosphate and muriate of potash, respectively. Half of N, total quantity of P, K and $ZnSO_4$ were applied at the time of sowing. Remaining half of the nitrogen was applied in two splits applied at first and second irrigation. The wheat cultivar 'PBW – 343' was sown on November 25 and 22 of 2007 and 2008 as per standard package of practices and harvested on April 15 and 14 of 2008 and 2009, respectively. The grain and straw samples collected during the course of investigation were analyzed for N, P, K and Zn content and their total removal (uptake) from soil. Whereas, all the yield parameters, grain and biological yields were recorded at harvest of the crop. Harvest index was workout by dividing the grain yield with biological yield. The soil sample, taken from 0-15 cm soil layer after harvest of crop during each season, were analyzed for available N, P and K as method described by Subbiah and Asija (1956); Olsen *et al*. (1954) and Merwin and Peech (1950), respectively. The Zn content from soil sample was determined from 1:2 soil extractant ratio using DTPA - TEA buffer (0.005 M DTPA + 0.001 M $CaCl_2$ + 0.1 M TEA, pH 7.3) as per Lindsay and Norvell (1978). Nutrient balance of soil was worked out by subtracting the initial value from the soil available nutrient status after crop harvest adopting the method suggested by Palanniappan (1985).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Yield and yield attributes :

Yield is the manifestation of various yield components. Grain yield increased significantly with increasing NPK and $ZnSO_4$ levels upto the dose of 150: 75 : 60 : 20 kg /ha (T_{12}) over control (T_1), NPK applied alone (T_2), and with 20 and 40 kg $ZnSO_4$ (T_3 and T_4) as well as 120 : 60 : 45 : 00 kg/ ha NPK $ZnSO_4$ (T_5). Further, increase in fertility levels did not show any significant improvement in grain yield (Table 2). Increase in yield of wheat due to higher fertility levels can be related to improvement in yield attributing characters. Ghulam *et al.* (2009) and Sepat *et al.* (2010) have also been reported an increase in grain yield and yield attributes with increasing NPK and $ZnSO_4$ levels. Application of NPK $ZnSO_4$ dose @ 150: 75: 60: 20 kg/ ha (T_{12}) produced maximum grain yield of 51.0 q/ha being significantly higher by 71.7, 57.9, 42.5, 49.9 and 9.5 per cent over control, NPK $ZnSO_4$ levels of 90 : 45 : 45 : 00, 90 : 45 : 45 : 20, 90 : 45 : 45 : 40 and 120 : 60 : 45 : 00 kg/ ha, respectively.

Various yield attributes of wheat like number of spike/m^2, spikelet fertility ratio, grains/spike and test weight was also increased significantly due to different fertility management. A fertility level of NPK $ZnSO_4$ @ 120: 60 : 45 : 20 kg/ha (T_6) showed its significantly superiority over control (T_1), NPK @ 90 : 45 : 45 kg / ha (T_2) with or without $ZnSO_4$ levels (20 - T_3 and 40 kg/ ha - T_4) with regards to number of spike / m^2. However, spikelet fertility ratio, grains /spike and test weight were recorded maximum with the highest dose of NPK $ZnSO_4$ *i.e.* 150 : 75 : 75 : 20 kg/ ha (T_{15}) and significant higher than that of control (T_1) but remained at a par, above the 90 : 45 : 45 : 40 NPK kg / ha (T_4) levels. Improved nitrogen and phosphorus nutrition is known to enhance the formation of new cells, promotes root and shoot growth. It is also associated with vital oxidation-reduction reaction of various physiological processes determining the supply of photosynthates to proliferating shoots and other parts. Besides, potassium and zinc is also play a vital role in maintenance of ionic balance, cell turgor, stomatal regulation and protein synthesis. Thus, NPK Zn might have helped in production of large number of tillers and finally their conversion into different yield attributes and ultimately the yield. None of the fertility levels could attain the level of significance with regard to harvest index. However, maximum value of harvest

Table 1: Growth and developmental parameters of wheat as influenced by improved fertility management (pooled data of 2 years)

Treatments	Symbol	Plant height (cm)	Dry matter accumulation (g/plant)	Tillers/plant	LAI	Mortality (%)	Days taken to 75% maturity
00:00:00:00	T_1	90.2	2.85	1.95	2.70	44.7	123
90:45:45:00	T_2	91.2	3.29	2.6	3.74	33.8	130
90:45:45:20	T_3	91.7	3.34	2.55	3.88	28.1	132
90:45:45:40	T_4	94.8	3.36	2.55	3.89	27.3	132
120:60:45:00	T_5	96.3	4.08	2.60	4.06	26.9	133
120:60:45:20	T_6	100.5	4.17	2.60	4.13	24.8	133
120:60:45 :40	T_7	103.1	4.31	2.60	4.11	26.2	133
120:60:60:00	T_8	100.0	4.27	2.60	4.26	26.9	136
120:60:60:20	T_9	105.0	4.76	2.60	4.27	26.8	134
120:60:60:40	T_{10}	103.1	4.86	2.60	4.28	26.6	135
150:75:60:00	T_{11}	100.2	4.21	2.60	4.57	26.6	137
150:75:60:20	T_{12}	103.7	4.40	2.70	4.56	26.9	135
150:75:60:40	T_{13}	103.3	4.60	2.60	4.56	26.8	135
150:75:75:00	T_{14}	102.5	4.54	2.55	4.62	28.3	136
150:75:75:20	T_{15}	104.1	4.95	2.60	4.59	27.8	136
150:75:75:40	T_{16}	104.4	5.11	2.65	4.62	27.3	136
S.E. $\pm$		3.6	0.33	0.16	0.22	1.32	0.88
C.D. (P=0.05)		10.5	0.98	0.47	0.59	3.78	2.56

index *i.e.* 45.61 was registered with application of NPK $ZnSO_4$ @ 120 : 60 : 60 : 40 kg/ ha (T_{10}). These results are in accordance with the findings of Dahiya *et al.* (2008); Verma *et al.* (2014) and Khan *et al.* (2008).

Growth and development :

The growth parameters like plant height and dry matter accumulation (Table 1) increased significantly with NPK and zinc fertilization as compared to control. Significantly increase in plant height and dry matter due to NPK $ZnSO_4$ applied @ 150:75:75:40 kg/ha over control, 90: 45: 45 kg NPK /ha with or without Zn levels might be due to the fact that higher nutrients supply rapidly converted the carbohydrates into protein which in turn elaborated into protoplasm and increase the proportion of protoplasm to have cell wall materials and increase in size of cell and ultimately expressed in form of plant height. Auti *et al.* (1999) have also similar opinion in this regard.

Wheat crop fertilized with 150 : 75 : 60 : 20 kg/ha of NPK and $ZnSO_4$ (Table 1) recorded significantly higher number of tillers/ plant over control, NPK applied @ 90 : 45 : 45 and 120 : 60 : 45 with or without Zn levels. Further increase in fertility levels did not show any significant changes. It might be attributed to increased availability of nutrients upto certain level have produced new meristematic tissue. The data further revealed that the significantly higher rate of tillers mortality was observed under control (44.7%) and 90 : 45 : 45 kg NPK/ ha (33.8%) treatment as compared to rest of the fertility combinations. This resulted into mortality of late formed tillers which could not compete with strong shoots for space, light and nutrients. The results were corroborate with the findings of Ghulam *et al.* (2009).

Leaf area index in general is a measure of photosynthetic capacity of the crop. Increasing application of fertilizer had beneficial effect on LAI and days taken to maturity as compared to control. Higher LAI may be due to more tillers per unit area and more numbers of functional leaves per shoots. Adequate supply of NPK Zn promotes cell elongation and apical meristem which resulted into vigorous growth. The results are in the conformity with the findings of Khan *et al.* (2008). Wheat crop fertilized with NPK and Zn fertilizers took significantly more number of days to maturity as compared to control (Table 1), might be the effect of nitrogen nutrition. Under inadequate level of nitrogen, the life cycle of plant was shortened and plant matured earlier due to depression in cytokinin synthesis.

Table 2: Yield, yield attributes and economics of wheat as influenced by improved fertility management (pooled data of 2 years)

Treatments	Symbol	Spikelet fertility ratio	Grains (spike^{-1})	Test weight (g)	Spikes (m^{-2})	Grain yield (q/ha)	Harvest index (%)	Cost of cultivation (Rs./ha)	Net return (Rs./ha)	B : C
00:00:00:00	T_1	79.93	31	37.42	267.7	29.70	43.45	24,800	13,971	0.56
90:45:45:00	T_2	82.42	35	39.91	356.3	32.35	43.71	27,559	14,555	0.53
90:45:45:20	T_3	82.59	43	40.97	352.3	35.80	43.26	28,159	18,661	0.66
90:45:45:40	T_4	83.28	40	41.06	354.3	34.40	44.32	28,759	15,500	0.54
120:60:45:00	T_5	84.61	46	41.86	362.7	46.60	44.06	28,353	32,096	1.13
120:60:45:20	T_6	84.44	48	42.28	362.3	48.85	44.44	28,953	34,180	1.18
120:60:45:40	T_7	84.05	47	42.16	364.9	48.85	44.38	29,553	33,509	1.13
120:60:60:00	T_8	84.42	47	42.17	365.3	48.70	45.17	28,478	33,141	1.16
120:60:60:20	T_9	84.98	49	42.68	360.9	47.50	41.61	29,078	36,067	1.24
120:60:60:40	T_{10}	85.04	48	43.59	363.5	50.15	45.61	29,678	33,503	1.13
150:75:60:00	T_{11}	83.20	47	43.71	364.7	50.00	43.89	29,272	33,708	1.22
150:75:60:20	T_{12}	82.84	48	44.76	378.7	51.00	44.04	29,872	36,331	1.22
150:75:60:40	T_{13}	84.18	48	43.59	369.3	50.65	44.08	30,472	35,230	1.16
150:75:75:00	T_{14}	83.40	47	43.21	358.6	48.65	44.16	29,398	33,652	1.14
150:75:75:20	T_{15}	86.39	49	43.38	361.8	50.60	44.25	29,998	35,521	1.18
150:75:75:40	T_{16}	85.85	49	44.14	363.8	50.60	44.11	30,598	35,009	1.14
S.E. $\pm$		1.78	2.01	1.60	4.3	1.27	0.86			
C.D. (P=0.05)		5.15	5.62	4.77	12.4	3.59	NS			

NS= Non-significant

Soil fertility status :

Comparison of available nitrogen, phosphorus, potassium and zinc status of soil to initial stage and after harvest of wheat crop under different treatments indicated the reduction in residual soil available nutrients at lower doses of fertilizer applications. However, an increase in available NPK in soil were noticed with the application of 150 : 75 : 60 and 150 : 75 : 75 kg NPK/ha with and without Zn levels, while the status of Zn in soil was found positive with the application of 150 : 75 : 75: 20 and 150 : 75 : 75: 40 kg NPK $ZnSO_4$/ha only. The application of the lowest dose of 90 : 45 : 45 kg NPK/ha without Zn showed a marginal decline in nitrogen and phosphorus level while, slight improvement in potassium level of soil. The higher availability of NPK and Zn in plots received higher doses of fertilizers might have been accounted to direct quantitative effect of fertilizers and also to imbalance uptake of other nutrients.

The wheat crop grown without any of nutrients (control) showed a large amount loss of N PK and Zn after 2 years of study (Table 3). The crop supplied with less than 150 kg N/ha *i.e.* 120 kg or 90 kg/ha registered more loss with regards to actual nitrogen content in soil. However, the supply of 150 kg N/ha proved to be beneficial with respect to gain in its content. Whereas, actual positive gain in soil 'P' content was noticed at 60 and 75 kg P /ha, below that crop showed clear negative sign in this regard. Similar to N and P content, K status in soil after 2 years of investigation indicated that application of K @ 40kg/ha was sufficient to produce net gain in its content, however in few treatments gradual negative balance in this regard was also recorded, which was probably due to luxury consumption of K by crop plants. The application of $ZnSO_4$ with combination of NPK was also able to produce a positive balance of Zn content in soil. In most of the treatments where $ZnSO_4$ was not applied to crop showed high amount of loss in soil Zn content. Moreover, this loss was maximum in the plots where none of the nutrient were applied to crop. This indicated that higher levels of nitrogen, phosphorus, potassium and zinc fertilization met the requirement of crops and to a great extent help in maintaining the soil fertility. The similar opinion have also been reported by Ravankar *et al.* (2004) and Neeru *et al.* (2010).

Economics :

Wheat crop grown under improved fertility management of 150 : 75 : 60 : 20 kg NPK $ZnSO_4$/ha

Table 3: Nutrient balance sheet after harvest of wheat as influenced by improved nutrient management after two years of study (pooled data of 2 years)

Treatments	Sym-bol	Nutrient added (kg/ha)				Nutrient removed				Soil available nutrient				Actual gain/loss			
		N	P	K	Zn	N (kg/ha)	P (kg/ha)	K (kg/ha)	Zn (g/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Zn (g/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Zn (g/ha)
00:00:00:00	T_1	-	-	-	-	69.3	9.3	74.4	94.9	184.5	14.4	224.8	175	-33.5	-1.9	-30.9	-38.5
90:45:45:00	T_2	90	45	45	-	76.8	10.3	87.5	96.8	195.4	14.9	259.6	184	-22.6	-1.4	+3.9	-29.5
90:45:45:20	T_3	90	45	45	4.2	86.1	11.5	105.2	137.8	193.8	15.9	258.4	215	-24.2	-0.4	+2.7	+1.5
90:45:45:40	T_4	90	45	45	8.4	81.3	10.7	94.9	152.9	192.1	16.2	261.2	219	-25.9	-0.1	+5.5	+7.0
120:60:45:00	T_5	120	60	45	-	111.8	15.0	149.2	150.0	213.5	17.2	253.3	172	-4.5	+0.9	-2.4	-41.5
120:60:45:20	T_6	120	60	45	4.2	116.6	15.7	157.9	205.4	212.6	17.0	248.6	192	-5.4	+0.7	-7.1	-21.5
120:60:45: 40	T_7	120	60	45	8.4	116.2	14.8	157.3	235.3	207.8	18.5	250.5	216	-10.2	+2.2	-5.2	+2.5
120:60:60:00	T_8	120	60	60	-	113.8	15.3	154.3	147.6	211.3	19.0	257.5	180	-6.7	+2.7	+1.8	+33.5
120:60:60:20	T_9	120	60	60	4.2	120.3	16.1	166.4	225.5	214.4	19.1	262.5	205	-3.6	+2.8	+6.8	-8.5
120:60:60:40	T_{10}	120	60	60	8.4	118.3	15.9	159.2	247.2	213.6	19.2	261.3	207	-4.4	+2.9	+5.6	+3.5
150:75:60:00	T_{11}	150	75	60	-	120.4	17.4	167.6	157.6	230.4	19.7	266.3	191	+12.4	+3.4	+10.6	-22.5
150:75:60:20	T_{12}	150	75	60	4.2	123.6	17.8	171.2	201.1	231.8	19.9	264.3	205	+13.8	+3.6	+8.6	-8.5
150:75:60:40	T_{13}	150	75	60	8.4	122.8	16.6	171.7	216.0	232.8	20.1	261.4	212	+14.8	+3.8	+5.7	-1.5
150:75:75:00	T_{14}	150	75	75	-	116.9	16.9	159.9	149.5	232.2	20.7	282.0	199	+14.2	+4.4	+26.3	-14.5
150:75:75:20	T_{15}	150	75	75	4.2	121.6	17.7	170.1	193.2	236.2	21.3	272.8	214	+18.2	+5.0	+17.1	+0.5
150:75:75:40	T_{16}	150	75	75	8.4	121.3	17.0	170.3	228.4	238.3	21.5	276.8	218	+20.3	+5.2	+21.1	+4.5
S.E. $\pm$						3.7	1.4	6.6	6.8	4.9	1.42	4.5	3.03				
C.D. (P=0.05)						10.8	4.1	19.9	19.8	13.8	3.47	13.1	7.98				

*Initial status of soil: Available N,P, K and Zn 218:16.3:255.7:213.5 (NPK in kg/ha and Zn in g/ha)

(T_{12}) recorded maximum net monetary return of Rs. 36,331 which was approximately double to all those treatments where nitrogen was applied @ 90 kg/ha. The treatment (T_{12}) also proved its superiority over other combinations of nutrient management with 120 and 150 kg N/ha. However, maximum benefit : cost of 1.24 was noticed in treatment T_9 (120 : 60 : 60 : 20) followed by T_{12} (150 : 75 : 60 : 20) *i.e.* 1.22. This difference in benefit cost ratio between T_9 and T_{12} was mainly because of differences in the cost of cultivation.

Therefore, the application of 150: 75: 60: 20 kg NPK and $ZnSO_4$ (T_{12}) to wheat crop was found to be the most appropriate dose for higher productivity as well as profitability. This combination of fertility management also improved the fertility status of soil.

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