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Full Length Research Paper

Response of nitrogen and foliar spray of nutrient mixture on yield attributes and yield of wheat (*Triticum aestivum* L.)

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A field experiment was conducted to study the effect of nitrogen and foliar spray of nutrient mixture on growth and yield of wheat (*Triticum aestivum L*). The obtained data showed that both grain and straw yield, and different yield attributing characters *viz.,* number of spikes plant^{-1}, spike weight and grain spike^{-1} were significantly maximum with application of 120 kg Nha^{-1} and the least with application of 30 kg Nha^{-1}. Foliar spray of 2% DAP + 1% KCl + nutrient mixture (F_2) significantly increased the periodic plant height , dry weight plant^{-1} and number of tillers plant^{-1} over 2% DAP + 1% KCl + 100 ppm maleic hydrazide (F_4). Foliar spray of 2% DAP + 1% KCl + 100 ppm salicylic acid 100 ppm (F_3) and 2% DAP + 1% KCl (F_1) also recorded significantly higher values of these growth characters over F_4 treatments. Both grain and straw yield and different yield contributing characters *viz.,* spikes plant^{-1}, spike weight, grains spike^{-1} and test weight were significantly higher with foliar spray of 2% DAP + 1% KCl + 100 ppm nutrient mixture (F_2) and significantly least with foliar spray of 2% DAP + 1% KCl + 100 ppm maleic hydrazide (F_4).

Key words: Nitrogen, nutrient mixture, foliar spray, yield, yield attributes

INTRODUCTION

Wheat is the second most important food grain of India next only to rice and it is a staple diet of people. It contributes 35% of the total food grain production of the country. In India, wheat is cultivated over an area of 28.17 million hectares with a production and productivity of 73.70 million tones and 26.17 qha^{-1}, respectively (Anonymous, 2007). India alone produces 13% of world's wheat. Green revolution has enabled India to make about four fold increase in food production during last 50 years, whereas before green revolution annual wheat imported touched 10 million tones and India was a beggar bowl. Uttar Pradesh, an important wheat growing state of India, has an area of 9 million hectares under wheat cultivation with a production of22.51 million tones and productivity of 25.02 qha^{-1} (Anonymous, 2005). The lower productivity could be attributed to the fact that under intense cereal-cereal cropping system and immense use of inorganic fertilizers, especially nitrogen, there has been great depletion of soil fertility.

Nitrogen driven agriculture has caused mining of phosphorous, potassium, sulphur and micronutrients. This is evident from the fact that U.P soils have shown to be deficient in micronutrients *viz;* zinc, copper, iron, manganese and boron by 64.0, 9.0, 6.0 and 24.0%, respectively (Takkar et al., 1997). The rice-wheat-jawar rotation having an economic produce of 6.0 tones /ha/ year removes from the soil zinc, copper, iron and manganese to the tune of 606, 282, 4603 and 1238 grams/ha/year, respectively (Rattan et al., 1999). Urea is generally being applied as basal and as top dressing at critical growth stages of the crop and under ideal

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conditions, the percent recovery of nitrogen is not more than 40%, meaning a loss of 60% of applied nitrogen in the form of urea. However, the foliar application of urea on the crop can substantially improve its recovery due to elimination of losses of nitrogen in the soil.

A favorable balance of macro and micronutrients is required for optimum crop production. However, the nutrient imbalances can occur due to non judicious and liberal use of major nutrient and presence of low levels of micronutrients. Zinc is known to be involved in the synthesis of Indole-3-acetic acid thereby indirectly involved in elongation of stems, whereas manganese plays an active role in the photolysis of water in the light reaction of photosynthesis. Boron functions in cell wall formation; transport of sugars, flower retention and pollen formation thereby improving grain production (Henry and Cathey, 2009). Maleic hydrazide, a known growth inhibitor, has been found to be involved in the improvement of growth at very low concentrations (Henry and Cathey, 2009). Similarly salicylic acid improves the transport and uptake of ions, induces changes in chloroplast structure and is involved in growth and development, photosynthesis and respiration (Hayat et al., 2005). Since the deficiency of micronutrients *viz.,* zinc boron and manganese is widely noticed in wheat so their foliar spray in a mixture can improve the wheat yields.

MATERIAL AND METHODS

The experiment was conduct at Crop Research Farm, Department of Agronomy, Allahabad Agricultural Institute-Deemed University Allahabad- India during *rabi* 2007 to 2008 and 2008 to 2009. The soil of the experimental field was sandy loam in texture, low in available nitrogen 221 kg ha^{-1}, medium in available phosphorous 14.4 kg ha^{-1} and potassium 253.0 kg ha^{-1} with pH 7.9 (Alkaline) and 0.27% organic carbon. The experiment was conducted on Variety PBW-443, comprising of two factors (four nitrogen levels *viz.* N_1:30kg/ha N_2:60kg ha^{-1} N_3:90kg ha^{-1} N_4:120kg ha^{-1} and four foliar spray of nutrient mixture *viz* F_1: 2% DAP + 1% KCl. F_2: 2% DAP + 1% KCl + nutrient mixture F_3: 2% DAP + 1% KCl + 100 ppm salicylic acid F_4: 2% DAP + 1% KCl + 100 ppm maliec hydrazide) was laid out in 4^2 factorial randomized block design replicated thrice. (NB: Nutrient mixture = 0.5% $MgSO_4$, 0.2% $ZnSO_4$, 0.2% $MnSO_4$ and 0.1% Borax, DAP = Di-ammonium phosphate and MOP= Murate of potash). A uniform dose of phosphorous and potassium at the rate of 60 and 40 kg P_2O_5 and K_20/ha, respectively and half dose of nitrogen as per treatments was applied as basal at the time of sowing. Remaining half dose of nitrogen was applied in two equal splits, one each at 30 DAS and tillering stage as per treatment. Nitrogen, phosphorous and potassium was applied through urea, DAP and MOP. Foliar application of different nutrient mixtures was applied at full vegetative growth to each plot as per treatment.

RESULTS AND DISCUSSION

Yield attributes

Results over two consecutive years shows that spikes $plant^{-1}$ were significantly more over application of 30 kg Nha^{-1} due to application of 120 kg Nha^{-1} but the spikes $plant^{-1}$ did not vary significantly among 120, 90 and 60 kg Nha^{-1} application. Among different nitrogen levels, maximum number of spikes $plant^{-1}$ (3.42) were recorded with application of 120 kg Nha^{-1}, followed by application of 90 kg Nha^{-1} (3.24), 60 kg Nha^{-1} (3.21) and the least number of spikes $plant^{-1}$ was observed with application of 30 kg Nha^{-1} (Table 1). Singh et al. (1995) reported significant improvement in the effective tillers $plant^{-1}$ with nitrogen application up to 120 $kgha^{-1}$. Pooled data of two years shows that spikes $plant^{-1}$ were significantly higher with application of foliar spray of 2% DAP + 1% KCl + nutrient mixture (F_2) over 2% DAP + 1% KCl + 100 ppm maleic hydrazide (F_4) but the spikes per plant did not vary significantly amongst F_2, F_3 (2% DAP + 1% KCl + 100 ppm salicylic acid) and F_1 (2% DAP + 1% KCl) treatments. Maximum number of spikes (3.41) were recorded with F_2 treatment followed by F_3 (3.29) and F_1 (3.25) and the least number of spikes $plant^{-1}$ (3.15) was found in F_4 treatment. The significant increase in the spikes $plant^{-1}$ recorded by F_2 treatment could be attributed to better growth and development attained by the crop due to additional application of micronutrients, known to be involved in photosynthesis, protein metabolism and energy transfer reactions. Mohammad (1994) reported improvement in the number of spikes in wheat with foliar spray of zinc, iron and other micronutrients.

Grain weight $spike^{-1}$ was significantly influenced by different nitrogen levels and foliar spray of nutrient mixture during both years and in pooled data over two years. Pooled data of two years shows that the grain weight per spike was significantly higher over 30 kg Nha^{-1} due to application of 120 , 90 and 60 kg Nha^{-1} but the grain weight $spike^{-1}$ did not differ significantly amongst 120, 90 and 60 kg Nha^{-1} application. The higher nitrogen nutrition to the crop increased the vegetative growth by better photosynthesis through higher leaf area thereby resulting in better translocation of photosynthesis from source to sink (Table 2). Among different nitrogen levels, maximum grain weight $spike^{-1}$ (1.96 g) was observed with application of 120 kg Nha^{-1} followed by application of 90 kg Nha^{-1} (1.95 g), 60 kg Nha^{-1} (1.93 g) and the least grain weight $spike^{-1}$ (1.87 g) was observed with application of 30 kg Nha^{-1}. Singh et al. (1995) reported significant improvement in the grain weight $spike^{-1}$ with increasing nitrogen doses.

Pooled data of two years shows that grain weight $spike^{-1}$ improved significantly with foliar spray of 2% DAP + 1% KCl + nutrient mixture (F_2) over 2% DAP + 1% KCl + 100 ppm (F_4). This could be attributed to the better growth and development attained by the crop due to additional application of micronutrients known to be involved in photosynthesis and other energy transfer reactions. Besides, the lowest grain weight $spike^{-1}$ recorded with F_4 treatment could be due to growth inhibitory effect of maleic hydrazide application even at lower concentration.

Table 1. Effect of different levels of nitrogen and foliar spray of nutrient mixture on number of spikes $plant^{-1}$.

Nitrogen levels (kg ha^{-1})	Foliar spray of nutrient mixture														
	2007-08					2008-09					Pooled				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_{30}	3.14	3.32	3.16	3.02	3.16	3.07	3.32	3.19	3.05	3.16	3.10	3.32	3.17	3.02	3.15
N_{60}	3.18	3.36	3.20	3.07	3.20	3.22	3.37	3.24	3.10	3.23	3.20	3.36	3.22	3.08	3.21
N_{90}	3.32	3.50	3.34	3.21	3.34	3.33	3.49	3.36	3.22	3.35	3.32	3.49	3.35	3.21	3.34
N_{120}	3.39	3.55	3.41	3.28	3.41	3.42	3.55	3.44	3.30	3.43	3.40	3.55	3.42	3.29	3.42
Mean	3.26	3.44	3.28	3.14		3.26	3.44	3.31	3.17		3.25	3.41	3.29	3.15	
		F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)	
Nitrogen levels		S	0.132	0.27			S	0.127	0.26			S	0.127	0.26	
Foliar spray of nutrient mixture		S	0.132	0.27			S	0.127	0.26			S	0.127	0.26	
Interaction effect		NS	0.264	-			NS	0.254	-			NS	0.254	-	

F1 = 2% DAP + 1% KCl ; N1 = 30 Kg ha^{-1}, F2 = 2% DAP + 1% KCl + Nutrient mixture *; N2 = 60 Kg ha^{-1} , F3 = 2% DAP + 1% KCl + 100 ppm Salicylic acid , N3 = 90 Kg ha^{-1}, F4 = 2% DAP + 1% KCl + 100 ppm Maleic hydrazide; N4 = 120 Kg ha-1, * Nutrient mixture prepared by 0.5% MgSO4, 0.25% MnSO4, 0.25% ZnSO4 and 0.1 % Boric acid.

Table 2. Effect of different levels of nitrogen and foliar spray of nutrient mixture on spike length (cm).

Nitrogen levels (kg ha^{-1})	Foliar spray of nutrient mixture														
	2007-08					2008-09					Pooled				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_{30}	15.16	15.23	15.17	15.09	15.16	15.18	15.23	15.18	15.1	15.17	15.17	15.23	15.17	15.09	15.16
N_{60}	15.22	15.29	15.23	15.10	15.21	15.22	15.28	15.23	15.15	15.22	15.22	15.28	15.23	15.12	15.21
N_{90}	15.27	15.34	15.28	15.20	15.27	15.28	15.34	15.28	15.21	15.28	15.27	15.34	15.28	15.20	15.27
N_{120}	15.27	15.34	15.28	15.20	15.27	15.29	15.35	15.30	15.22	15.29	15.28	15.34	15.29	15.21	15.28
Mean	15.23	15.3	15.26	15.15		15.24	15.3	15.25	15.17		15.23	15.3	15.24	15.15	
		F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)	
Nitrogen levels		NS	0.156				NS	0.196				NS	0.176		
Foliar spray of nutrient mixture		NS	0.156				NS	0.196				NS	0.176	-	
Interaction effect		NS	0.312				NS	0.392				NS	0.352	-	

F1 = 2% DAP + 1% KCl; N1 = 30 Kg ha^{-1}, F2 = 2% DAP + 1% KCl + Nutrient mixture *; N2 = 60 Kg ha^{-1}, F3 = 2% DAP + 1% KCl + 100 ppm Salicylic acid; N3 = 90 kg ha^{-1} F4 = 2% DAP + 1% KCl + 100 ppm Maleic hydrazide; N4 = 120 Kg ha^{-1}, *Nutrient mixture prepared by 0.5% MgSO4, 0.25% MnSO4, 0.25% ZnSO4 and 0.1 % Boric acid.

Mohamed (1994) reported improvement in the grain weight $spike^{-1}$ of wheat with micronutrient application. Maximum grain weight $spike^{-1}$ (1.96 g) was recorded with F_2 treatment followed by F_3 (1.92 g), F_1 (1.92 g) and the lowest grain weight $spike^{-1}$ (1.90 g) was observed with F_4 treatment (Table 3). However, the grain weight $spike^{-1}$ recorded with F_2 did not differ statistically with F_3 and F_1 as well as the grain weight $spike^{-1}$ recorded with F_3, F_1 and F_4 was also statistically similar.

Grain number $spike^{-1}$ increased significantly and consistently with increase in nitrogen application up to 90 kg Nha^{-1}. However, further increase in nitrogen dose upto 120 kg Nha^{-1} didn't differ statistically with 90 kg Nha^{-1} dose. This could be

Table 3. Effect of different levels of nitrogen and foliar spray of nutrient mixture on grain weight $spike^{-1}$ (g).

Nitrogen level ($kg\ ha^{-1}$)	Foliar spray of nutrient mixture														
	2007-08					2008-09					Pooled				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_{30}	1.86	1.9	1.87	1.85	1.87	1.86	1.91	1.86	1.86	1.87	1.86	1.9	1.86	1.85	1.87
N_{60}	1.92	1.96	1.93	1.91	1.93	1.92	1.97	1.92	1.91	1.93	1.92	1.96	1.92	1.91	1.93
N_{90}	1.95	1.99	1.96	1.94	1.96	1.94	1.99	1.94	1.94	1.95	1.94	1.99	1.95	1.94	1.95
N_{120}	1.96	2.0	1.97	1.95	1.97	1.95	2.0	1.95	1.95	1.96	1.95	2.0	1.96	1.95	1.96
Mean	1.92	1.96	1.93	1.91		1.92	1.97	1.92	1.91		1.92	1.96	1.92	1.91	
		F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)	
Nitrogen levels		S	0.024	0.05			S	0.024	0.05			S	0.029	0.06	
Foliar spray of nutrient mixture		S	0.024	0.05			S	0.024	0.05			S	0.029	0.06	
Interaction effect		NS	0.048	-			NS	0.048	-			NS	0.058	-	

F_1 = 2% DAP + 1% KCl ;N_1 = 30 Kg ha^{-1}, F_2 = 2% DAP + 1% KCl + Nutrient mixture * ;N_2 = 60 Kg ha^{-1}, F_3 = 2% DAP + 1% KCl + 100ppm Salicylic acid; N_3 = 90 Kg ha^{-1} F_4 = 2% DAP + 1% KCl + 100ppm Maleic hydrazide; N_4 = 120 Kg ha^{-1}, * Nutrient mixture prepared by 0.5% $MgSO_4$, 0.25% MnSO4, 0.25% $ZnSO_4$ and 0.1 % Boric acid.

attributed to the fact that nitrogen helped to produce better vegetative growth as a result of which photosynthetic area increased thereby more food material synthesized contributed to the improvement in grains $spike^{-1}$. Chander and Pandey (1996) also observed that spikes per square meter and filled grains $spike^{-1}$ increased significantly with nitrogen application up to120kg ha^{-1}. Amongst different nitrogen levels, maximum number of grains $spike^{-1}$(50.2) were recorded with application of 120 kg Nha^{-1}, followed by 90 kg Nha-[1] (49.6), 60 kg Nha^{-1} (48.6) and the least number of grains $spike^{-1}$ (47.1) was observed with application of 30 kg Nha^{-1}. Number of grains $spike^{-1}$ was significantly higher with foliar spray of2% DAP + 1% KCl + nutrient mixture (F_2) over 2% DAP + 1% KCl + 100 ppm salicylic acid (F_3), 2% DAP + 1% KCl (F_1) and 2% DAP + 1% KCl + 100 ppm maleic hydrazide (F_4). This could be attributed to the fact that application of micronutrients in combination with macronutrients may have improved the photosynthetic ability of crop thereby more food material synthesized contributed to the improvement in number of grains $spike^{-1}$. The lowest grains $spike^{-1}$ recorded with F_4 treatment may be the result of growth inhibitory effect of maleic hydrazide.

Amongst different foliar spray of nutrient mixtures maximum grains $spike^{-1}$ (50.0) were observed with F_2 treatment followed by 49.1 with F_3 treatment, 49.0 with F_1 treatment and the least number of grains $spike^{-1}$ (47.4) with F_4 treatment (Table 4). Both F_3 and F_2 treatment, at par with one another, recorded significantly more grains $spike^{-1}$ than F_4 treatment. Significantly higher grains $spike^{-1}$ recorded with F_3 over F_4 treatment may be due better growth and development, photosynthesis, ion uptake and transport attained by the crop due to application of salicylic acid. Data over two years indicated that 1000-grain weight increased significantly with nitrogen application at 120 kg ha^{-1} over 60 and 30 kg Nha^{-1}. The nitrogen levels of 120 and 90 kg Nha^{-1} did not differ significantly with one another and application of nitrogen beyond 90 kg Nha^{-1} didn't affect the 1000-grain weight. This increase in the 1000-grain weight could be attributed to the fact that nitrogen helped to produce better vegetative growth as a result of which photosynthetic area increased and thus more food material synthesized contributed to the improvement in the grain weight. Amongst different nitrogen levels applied, significantly maximum 1000-grain weight (40.8 g) was recorded with 120 Kg Nha^{-1}, followed by 40.7 g with 90 kg Nha^{-1} and 40.5 g with 60 kg Nha^{-1}. Least 1000-grain weight (40.08) was recorded with nitrogen application at 30 kg Nha^{-1} (Table 5).

Significantly, highest 1000-grain weight was recorded with foliar spray of 2% DAP + 1% KCl + nutrient mixture (F_2). The significant increase in 1000-grain weight as recorded with F_2 treatment could be attributed to the fact that application of micronutrients in combination with macronutrients may have improved the photosynthesis thus, more food material synthesized contributed to the improvement in 1000-grain weight compared to

Table 4. Effect of different levels of nitrogen and foliar spray of nutrient mixture on grains spike^{-1}.

Nitrogen levels (kg ha^{-1})	Foliar spray of nutrient mixture														
	2007-08					2008-09					Pooled				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_{30}	47.2	48.1	47.8	45.6	47.2	47.3	48.3	47.4	45.7	47.2	47.2	48.2	47.6	45.6	47.1
N_{60}	48.6	49.6	48.7	47.0	48.5	48.8	49.8	48.9	47.3	48.7	48.7	49.7	48.8	47.1	48.6
N_{90}	49.6	50.6	49.7	48.0	49.5	49.8	50.8	49.9	48.3	49.7	49.7	50.7	49.8	48.1	49.6
N_{120}	50.3	51.3	50.4	48.7	50.2	50.3	51.3	50.4	48.8	50.2	50.3	51.3	50.4	48.7	50.2
Mean	48.9	49.9	49.1	47.3		49	50	49.1	47.8		49	50	49.1	47.4	
		F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)	
Nitrogen levels		S	0.411	0.84			S	0.441	0.9			S	0.426	0.87	
Foliar spray of nutrient mixture		S	0.411	0.84			S	0.441	0.9			S	0.426	0.87	
Interaction effect		NS	0.822	-			NS	0.882	-			NS	0.852	-	

F_1 = 2% DAP + 1% KCl; N_1 = 30 kg ha^{-1}, F_2 = 2% DAP + 1% KCl + Nutrient mixture * ; N_2 = 60 kg ha^{-1}, F_3 = 2% DAP + 1% KCl + 100 ppm Salicylic acid; N_3 = 90 kg ha^{-1}, F_4 = 2% DAP + 1% KCl + 100ppm Maleic hydrazide ;N_4 = 120 kg ha^{-1}, *Nutrient mixture prepared by 0.5% MgSO4, 0.25% MnSO4, 0.25% ZnSO4 and 0.1 % Boric acid.

Table 5. Effect of different levels of nitrogen and foliar spray of nutrient mixture on 1000 grain weight (g).

Nitrogen levels# (kg ha^{-1})	Foliar spray of nutrient mixture														
	2007-08					2008-09					Pooled				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_{30}	39.9	40.3	39.9	39.6	39.9	39.9	40.5	40	39.8	40.0	39.9	40.4	39.9	39.7	40.0
N_{60}	40.4	40.9	40.9	40.2	40.6	40.4	41.0	40.6	40.3	40.6	40.4	40.9	40.6	40.2	40.5
N_{90}	40.6	41.1	40.6	40.4	40.7	40.7	40.8	40.8	40.6	40.7	40.6	40.9	40.7	40.5	40.7
N_{120}	40.8	41.2	40.8	40.5	40.8	40.8	40.9	40.9	40.7	40.8	40.8	41.0	40.8	40.6	40.8
Mean	40.4	40.9	40.5	40.2		40.4	40.8	40.6	40.3		40.4	40.8	40.5	40.2	
		F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)	
Nitrogen levels		S	0.318	0.65			S	0.245	0.5			S	0.294	0.6	
Foliar spray of nutrient mixture		S	0.318	0.65			S	0.245	0.5			S	0.294	0.6	
Interaction effect		S	0.636	1.3			S	0.49	1			S	0.588	1.2	

F_1 = 2% DAP + 1% KCl; N_1 = 30 kg ha^{-1}, F_2 = 2% DAP + 1% KCl + Nutrient mixture*;N_2 = 60 kg ha^{-1}, F_3 = 2% DAP + 1% KCl + 100 ppm Salicylic acid; N_3 = 90 Kg ha^{-1}, F_4 = 2% DAP + 1% KCl + 100 ppm Maleic hydrazide; N_4 = 120 Kg ha^{-1},* Nutrient mixture prepared by 0.5% $MgSO_4$, 0.25% MnSO4, 0.25% $ZnSO_4$ and 0.1 % Boric acid.

F3, F1 and F4 treatments. Significantly,1000-grain weight recorded with F_4 (2% DAP + 1% KCl + 100 ppm maleic hydrazide) treatment may be as a result of the growth inhibitory effect of maleic hydrazide.Amongst different foliar spray of nutrient mixture, significantly maximum 1000-grain weight (40.8 g) was observed by F_2 treatment followed by 40.5 g with F_3 (2% DAP + 1% KCl + 100 ppm salicylic acid) treatment, 40.4 g with

Table 6. Effect of different levels of nitrogen and foliar spray of nutrient mixture on grain yield (qha^{-1}).

Nitrogen levels (Kg ha^{-1})	Foliar spray of nutrient mixture														
	2007-08					2008-09					Pooled				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_{30}	41.6	44.2	41.8	40.8	42.1	41.4	44.2	41.7	40.6	42.0	41.5	44.2	41.7	40.6	42.0
N_{60}	43.7	46.3	43.9	42.9	44.2	43.6	46.4	43.9	42.8	44.2	43.6	46.3	43.9	42.8	44.1
N_{90}	45.3	47.9	45.5	44.5	45.8	45.3	48.0	45.6	44.4	45.8	45.3	47.9	45.5	44.4	45.8
N_{120}	46.5	49.1	46.7	45.7	47.0	46.6	49.3	46.9	45.7	47.1	46.5	49.2	46.8	45.7	46.8
Mean	44.3	46.9	44.5	43.5		44.2	47	44.5	43.4		44.2	46.9	44.5	43.4	
		F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)	
Nitrogen levels		S	0.534	1.09			S	0.603	1.23			S	0.441	0.9	
Foliar spray of nutrient mixture		S	0.534	1.09			S	0.603	1.23			S	0.441	0.9	
Interaction effect		S	1.068	2.18			S	1.206	2.46			S	0.882	1.8	

F_1 = 2% DAP + 1% KCl; N_1 = 30 kg ha^{-1}, F_2 = 2% DAP + 1% KCl + Nutrient mixture *; N_2 = 60 kg ha^{-1},F_3 = 2% DAP + 1% KCl + 100 ppm Salicylic acid; N_3 = 90 Kg ha^{-1}, F_4 = 2% DAP + 1% KCl + 100ppm Maleic hydrazide; N_4 = 120 Kg ha^{-1}, * Nutrient mixture prepared by 0.5% $MgSO_4$, 0.25% MnSO4, 0.25% $ZnSO_4$ and 0.1 % Boric acid.

F_1(2%DAP + 1% KCl) treatment and least (40.2 g) with F_4 treatment.

Yield

Grain and straw yield increased significantly with nitrogen application at 120 $kgha^{-1}$ over 90, 60 and 30 kg Nha^{-1}. N120 level marked grain yield superiority of 2.18, 6.12 and 14.9% and straw yield superiority of 2.70, 6.13 and 10.93% over N_{90}, N_{60} and N_{30} kg levels, respectively (Tables 6 and 7). Different nitrogen levels increased the nutrient content in the plants that lead to increase in vegetative growth. Besides, nitrogen is an involved in cell division and cell elongation. The increase in vegetative growth is evident from the plant height, tiller production and dry matter accumulation and the increase in different yield contributing characters *viz.,* spikes/plant, spike length, grains/spike thereby consequently improving the straw and grain yield of crop. The increase in grain and straw yield with application of nitrogen has also been reported by Akthar (2001); Naeem (2001) and Jatoi (2003). Comparatively lower grain and straw yield obtained with 30 kg Nha^{-1} could be attributed to poor nutrition to the crop because of insufficient nitrogen uptake.

Grain and straw yield of 46.9 and 74.7 qha^{-1}, respectively was realized with application of F_2 treatment followed by F_3 treatment recording 44.5 and 72.7 qha^{-1} of grain and straw yield, respectively, whereas the lowest grain and straw yield of 43.4 and 70.1 qha^{-1}, respectively was recorded with F_4 treatment. F_2 treatment marked grain and straw yield superiority of 5.39, 6.10 and 8.06% and 2.75, 2.60 and 6.56% over F_3, F_1 and F_4 treatments, respectively (Tables 6 and 7). Comparatively higher grain yield recorded with F_3 treatment over F_1 and F_4 treatments could be due to the fact that salicylic acid plays a role in growth and development, photosynthesis, ion uptake and transport. Seed treatment / foliar spray of salicylic acid induces reduction in sodium absorption and toxicity which is further reflected in low membrane injury, high water content and high dry matter production (El-Tayeeb, 2005).

Both F_3 and F_1 also recorded significantly higher straw yield over F_4 treatment. Significantly, lowest yield obtained with F_4 treatment even at lower concentration could be due to the fact that maleicessential constituent of plant tissue and thus is hydrazide may have limited the growth and development of the crop and due to its inhibitory effect (Henry and Cathey, 2009).

The interaction effect for grain and straw yield between nitrogen levels and foliar spray of nutrient mixture was found significant. The highest grain and straw yield of 49.2 and 78.1qha^{-1}, respectively was recorded with the treatment combination N_4F_2.

Conclusion

Both grain and straw yield and different yield attributing characters *viz.,* number of spikes $plant^{-1}$, spike weight and grain $spike^{-1}$ were significantly

Table 7. Effect of different levels of nitrogen and foliar spray of nutrient mixture on straw yield (qha^{-1}).

Nitrogen levels ($Kg\ ha^{-1}$)	Foliar spray of nutrient mixture														
	2007-08					2008-09					Pooled				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_{30}	68.3	70.3	68.5	65.8	68.2	69.3	70.9	69.3	66.5	69.0	68.8	70.6	68.9	66.1	68.6
N_{60}	71.4	73.4	71.6	68.9	71.3	72.6	74.2	72.6	69.3	72.2	72.0	73.8	72.1	69.1	71.7
N_{90}	73.3	75.8	73.9	71.2	73.6	75.0	76.6	75	72.2	74.7	74.3	76.2	74.4	71.7	74.1
N_{120}	75.9	77.9	76.1	73.6	75.9	76.7	78.3	76.8	73.9	76.4	76.3	78.1	76.4	73.7	76.1
Mean	72.5	74.3	72.5	70		73.4	75	73.4	70.5		72.8	74.7	72.7	70.1	
		F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)			F-test	SEd ±	CD (P=0.05)	
Nitrogen levels		S	1.029	2.1			S	0.809	1.65			S	0.906	1.85	
Foliar spray of nutrient mixture		S	1.029	2.1			S	0.809	1.65			S	0.906	1.85	
Interaction effect		NS	2.058	-			NS	1.618	-			NS	1.812	-	

F_1 = 2% DAP + 1% KCl; N_1 = 30 Kg ha^{-1}, F_2 = 2% DAP + 1% KCl + Nutrient mixture*; N_2 = 60 Kg ha^{-1}, F_3 = 2% DAP + 1% KCl + 100 ppm Salicylic acid; N_3 = 90 Kg ha^{-1}, F_4 = 2% DAP + 1% KCl + 100ppm Maleic hydrazide; N_4 = 120 Kg ha^{-1}, * Nutrient mixture prepared by 0.5% $MgSO_4$, 0.25% MnSO4, 0.25% $ZnSO_4$ and 0.1 % Boric acid.

maximum with application of 120 kg Nha^{-1} application and the least with application of 30 kg Nha^{-1}. Foliar spray of 2% DAP + 1% KCl + nutrient mixture (F_2) significantly increased the periodic plant height , dry weight $plant^{-1}$ and number of tillers $plant^{-1}$ over 2% DAP + 1% KCl + 100 ppm maleic hydrazide (F_4). Foliar spray of 2% DAP + 1% KCl + 100 ppm salicylic acid 100 ppm (F_3) and 2% DAP + 1% KCl (F_1) also recorded significantly higher values of these growth characters over F_4 treatments. Both grain and straw yield and different yield contributing characters *viz.,* spikes $plant^{-1}$, spike weight, grains $spike^{-1}$ and test weight were significantly higher with foliar spray of 2% DAP + 1% KCl + 100 ppm nutrient mixture (F_2) and significantly least with foliar spray of 2% DAP + 1% KCl + 100 ppm maleic hydrazide (F_4).

The interaction effects for various characters studied during the course of investigation were found mostly significant. The treatment combination N_{120} X 2% DAP + 1% KCl + 100 ppm nutrient mixture (F_2) produced the highest values for different characters.

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