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Physiological indices and biomass accumulation of wheat as influenced by nitrogen scheduling under rice residue retained situation

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ABSTRACT
An experiment was conducted to study the influence of nitrogen scheduling on physiological indices and biomass accumulation of wheat during rabi season 2014-15 and 2015-16 at farmer`s field of village Akalgarh, Yamunanagar, Haryana under rice residue retained situation. The experiment was laid out in split plot design keeping four nitrogen levels in main plots and four different time of nitrogen application in sub plots with three replications under zero tillage sown wheat with residues retention. Crop growth rate up to 90 days after sowing (DAS), relative growth rate up to 30 DAS and net assimilation rate at 60-90 DAS were recorded significantly higher under 125% of recommended dose with uncoated urea (UU) than 75% of recommended dose with UU which resulted into superior biomass yield, however, statistically at par with 100% of recommended dose with UU as well as neem coated urea (NCU) in both the years. Among time of nitrogen application, these physiological indices were maximum with three splits doses viz. 1/3 as basal, 1/3 after 1st irrigation and 1/3 after 2nd irrigation. Application of nitrogen in three splits also resulted in significantly higher biomass accumulation as compared to other split applications.
Key words: *Biomass, Nitrogen scheduling, Physiological indices, Residue retention, Wheat*

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major cereal crop, which plays an significant role in food and nutritional security. It shares upto 40 percent of total food grain production in India. The global area of the wheat is 220.4 mha with production of 729.0 mt. Currently, India stands first in area and second in production next to China in the world. The India's share in world wheat area is about 12.40 per cent, whereas it occupies 11.77 per cent share in the total world wheat production [8]. In India, total area under wheat is 31.0 mha, with production of 86.53 mt and the productivity of 2.8 t/ha [14]. In India, the highest area under wheat cultivation is in Uttar Pradesh. Uttar Pradesh also ranks first in terms of production while Haryana ranks first in productivity. In Haryana, area under wheat is 2.6 mha, with production of 10.35 mt and the productivity of 4.0 t/ha [7]. In India, major breakthrough in wheat production started in 1967-68 with the overture of the dwarf Mexican wheat genotypes. The growth rate of production was highest during 1960's which led green revolution. The area under wheat has reached near saturation and there is hardly any scope for expansion of area. Our main prominence would be on increasing the efficiency of prevailing resources by appropriate management. If available resources are used suitably and weeds are managed properly, the wheat outcome can be auxiliary enhanced. Crop management practices like rice residue retention and nitrogen management have great bearing on physiological indices and finally on biomass accumulation.

Many soils under rice-wheat system (RWS) in the IGP are poor in organic matter and nutrient availability. The future increases in the productivity of RWS will greatly depend upon improvements in soil environment by proper management of resources with utilization of crop residues and other agricultural inputs. There are currently few uses for rice straw because of its poor quality as forage, bioconversion, and engineering applications. Rice straw is thus considered as waste and is generally burnt in the field as the loose residue interferes with tillage and seeding operations for the succeeding wheat crop. Burning of residues will result in loss of soil organic matter and plant nutrients, particularly N and S, besides causing environmental footprint [17]. To overcome the problems of burning residues or late sowing of wheat, a machine called the 'Happy Seeder' that cuts and spreads rice stubble on the soil surface as mulch while simultaneously sowing wheat with zero or strip tillage [15]. The incorporation or surface retention of rice residues in wheat crop would prevent these nutrient losses and cycle enormous amounts of nutrients to succeeding crops. It also moderates soil temperature and reduces evaporation that increases soil water content.

Among essential plant nutrients, nitrogen is one of the most important nutrient for wheat crop as it occupies prominent role in plant metabolism but its availability is limited in soils. It is one of the key factors in determining the yield of crop. Its application in optimum quantity is very essential, particularly in high yielding varieties of wheat for optimum growth and higher biomass accumulation. It increase physiological indices by improving leaf production and expansion rate that ultimately achieve more interception of photosynthetically active radiation and consequently more total biomass accumulation. The use of optimum dose of fertilizer at appropriate time are essential for improving growth and finally the biomass accumulation. Crop N demand and its synergy with N supply in a residue retained system may be altered, relative to a conventional system, such that N fertilizer rate, time of application to the wheat crop may have to be rescheduled [10] in order to obtain similar or higher wheat biomass accumulation. Information exists on the influence of N fertilization on physiological indices and biomass accumulation for conventional till wheat, the combined effects of zero tillage and residue retention with nitrogen management and other available nutrients are poorly documented in the irrigated rice-wheat system of IGP. All these threats with N fertilizer management in zero tillage systems realized the need for more research for improved and efficient utilization of fertilizer N. keeping this in view, present research was carried out to assess the physiological indices and biomass accumulation of wheat as influenced by nitrogen scheduling under rice residue retained situation.

MATERIALS AND METHODS

The experiment was conducted during rabi season, 2014-15 and 2015-16 at farmer field of village Akalgarh, Yamunanagar, Haryana (India) situated in semi-arid, sub-tropics at an elevation of 255 meters above mean sea level with latitude of 30°07' in the North and longitude of 77° 17' in the East. The texture of the surface soil of the experimental field was loam containing 25.0 per cent sand, 49.5 per cent silt and 25.5 per cent clay, respectively . The electrical conductivity was 0.21 dS/m. The bulk density of the experiment soil was 1.42 g/cm^3. The soil was slightly alkaline (pH 8.0) in nature. The organic carbon content was 0.75 per cent in the upper layer. Soil was low in available N (196.7 kg/ha), medium in available P (30.0 kg/ha) and medium in available K (192.6 kg/ha). During the crop period 2014-15 and 2015-16, the 8th and 1st standard weeks recorded the highest (102.8 mm) and lowest (2.20 mm) rainfall while the 10th and 45th standard weeks recorded the highest (36.6 mm) and lowest (0.30 mm) rainfall, respectively. Experiment was carried out in split plot design keeping four nitrogen levels in main plots and four different time of nitrogen application in sub-plots with three replications. Seed treatment was done with tebuconazole (100 ml /100 kg seed) before sowing of crop. The wheat variety HD 2967 was sown with happy seeder under rice residue retained situation. Crop was received uniform application of 60:60 kg/ha of P_2O_5 and K_2O. Full dose of P_2O_5 and K_2O were applied under all treatments at the time of sowing of wheat. Nitrogen was applied with different levels based on treatment taken in main plots and time of nitrogen application based on different splits kept in sub plots as per decided protocol during both the years. Based on crop water requisite and gap in rainfall, irrigation was scheduled. To supplement the rainfall three irrigations were applied during first year, while four irrigations were applied during second year.

RESULTS AND DISCUSSION

Physiological indices

Crop growth rate (CGR)

Crop growth rate (CGR) of wheat with residue retention increased with advancement of crop age and reached peak at 60-90 DAS, thereafter, it declined among all the treatments in both the years (Table 1).

This was due to the maximum production of dry matter at early stages of plant growth. Among the nitrogen levels, 125% of recommended dose as uncoated urea recorded significantly higher CGR than 75% of recommended dose as uncoated urea but it was statistically at par with 100% of recommended dose (UU/NCU) at all crop growth period except 90 to 120 DAS (all at par) during both the years. CGR represents the net result of photosynthesis, respiration and canopy area interception. Appropriate leaf area available for utilizing full photosynthesis potential under optimum fertilization leads to more CGR. These results corroborate with the finding of Alam [1], Qamar *et al.* [12], Asif *et al.* [3] and Warraich *et al.* [21] who reported increasing trend of CGR with increasing nitrogen levels. CGR was significantly affected by time of nitrogen application at 30 DAS till 90 DAS. Three splits doses *viz.* 1/3 as basal, 1/3 after 1st irrigation and 1/3 after 2nd irrigation had significantly higher CGR than the rest of treatments, but it was statistically at par with 2 split doses *viz.* ½ as basal and ½ after 1st irrigation at 30 DAS in both the years. This might be due to higher dry matter production and more leaf area available for better photosynthesis activity.

Table 1. Crop growth rate (CGR) of wheat as influenced by nitrogen scheduling under rice residue retained situation

Treatments	Crop growth rate (g/m²/day)							
	2014-15				2015-16			
	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS
Nitrogen levels								
75% of recommended dose (Uncoated urea)	0.97	3.17	15.08	7.91	1.04	3.32	15.35	7.57
100% of recommended dose (Uncoated urea)	1.12	3.65	17.74	9.38	1.19	3.89	18.36	8.89
100% of recommended dose (Neem coated urea)	1.12	3.69	18.00	9.55	1.20	3.92	18.65	9.11
125% of recommended dose (Uncoated urea)	1.15	3.86	18.72	10.04	1.24	4.16	19.33	9.85
SEm ±	0.035	0.094	0.408	0.564	0.039	0.130	0.474	0.560
CD (0.05)	0.122	0.324	1.413	NS	0.133	0.449	1.641	NS
Time of application								
½ as basal + ½ after 1st irrigation	1.16	3.55	17.31	9.05	1.23	3.77	17.71	8.91
½ after 1st irrigation + ½ after 2nd irrigation	1.03	3.48	16.82	9.02	1.11	3.68	17.45	8.45
1/3 as basal + 1/3 after 1st irrigation + 1/3 after 2nd irrigation	1.14	3.85	18.67	9.96	1.22	4.17	19.33	9.71
1/3 before 1st irrigation + 1/3 after 1st irrigation + 1/3 after 2nd irrigation	1.04	3.49	16.73	8.83	1.11	3.67	17.19	8.36
SEm ±	0.033	0.085	0.368	0.458	0.036	0.132	0.460	0.589
CD (0.05)	0.095	0.248	1.074	NS	0.105	0.386	1.343	NS

Table 2. Relative growth rate (RGR) of wheat as influenced by nitrogen scheduling under rice residue retained situation

Treatments	Relative growth rate (mg/g/day)							
	2014-15				2015-16			
	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS
Nitrogen levels								
75% of recommended dose (Uncoated urea)	112.23	47.61	51.92	11.48	114.71	47.02	50.89	10.82
100% of recommended dose (Uncoated urea)	116.79	47.90	52.29	11.62	118.58	48.41	51.24	10.83
100% of recommended dose (Neem coated urea)	117.06	48.14	52.31	11.66	119.17	48.46	51.24	10.84
125% of recommended dose (Uncoated urea)	117.89	48.47	52.39	11.87	119.93	49.01	51.31	10.85
SEm ±	1.155	1.444	1.049	0.653	1.050	1.384	1.190	0.672
CD (0.05)	3.996	NS	NS	NS	3.635	NS	NS	NS
Time of application								
½ as basal + ½ after 1st irrigation	118.06	46.40	51.60	11.62	119.99	45.69	51.66	10.66
½ after 1st irrigation + ½ after 2nd irrigation	114.05	48.87	52.32	11.67	115.92	49.41	51.06	10.95
1/3 as basal + 1/3 after 1st irrigation + 1/3 after 2nd irrigation	117.47	49.05	52.21	11.74	119.95	49.41	50.64	10.97
1/3 before 1st irrigation + 1/3 after 1st irrigation + 1/3 after 2nd irrigation	114.40	47.81	52.78	11.61	116.51	48.38	51.22	10.77
SEm ±	0.965	0.940	0.812	0.546	1.030	1.421	1.164	0.760
CD (0.05)	2.816	NS	NS	NS	3.005	NS	NS	NS

Table 3. Net assimilation rate (NAR) and biomass accumulation of wheat as influenced by nitrogen scheduling under rice residue retained situation

Treatments	Net assimilation rate (mg/cm²/day)								Biomass accumulation (kg/ha)	
	2014-15				2015-16				2014-15	2015-16
	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS		
Nitrogen levels										
75% of recommended dose (Uncoated urea)	100.94	24.48	33.19	13.91	107.05	25.18	33.13	13.04	12136	12248
100% of recommended dose (Uncoated urea)	110.28	26.82	37.59	15.77	115.72	28.06	38.14	14.78	13303	13243
100% of recommended dose (Neem coated urea)	109.10	27.01	37.79	15.99	115.84	28.13	38.45	15.12	13530	13477
125% of recommended dose (Uncoated urea)	109.00	27.62	38.60	16.54	116.43	29.17	39.20	15.92	14007	13869
SEm ±	4.310	0.723	0.934	0.991	4.186	0.899	0.983	0.948	210	182
CD (0.05)	NS	NS	3.234	NS	NS	NS	3.403	NS	741	642
Time of application										
½ as basal + ½ after 1st irrigation	111.24	25.92	36.70	15.33	117.49	26.82	37.03	14.74	13178	13194
½ after 1st irrigation + ½ after 2nd irrigation	104.06	26.19	36.01	15.28	110.28	27.30	36.52	14.20	13091	13070
1/3 as basal + 1/3 after 1st irrigation + 1/3 after 2nd irrigation	110.26	27.90	38.64	16.50	116.91	29.55	39.28	15.74	13817	13777
1/3 before 1st irrigation + 1/3 after 1st irrigation + 1/3 after 2nd irrigatio	103.75	25.91	35.82	15.10	110.36	26.87	36.11	14.18	12890	12797
SEm ±	3.379	0.617	0.761	0.786	3.485	0.966	0.980	0.963	162	148
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	476	435

Relative growth rate (RGR) and net assimilation rate (NAR)

Relative growth rate (RGR) and net assimilation rate (NAR) of wheat being maximum between sowing to 30 DAS and fluctuated afterward among all treatments in both the years (Table 2 and 3). The reasons for higher RGR and NAR values at early stages of growth is possibly due to the juvenility of the plants and effects on dry matter accumulation. RGR and NAR values decreased steadily with the advancement of plant age due to relatively slow accumulation of dry matter. Among the nitrogen levels, 125% of recommended dose as uncoated urea was found to have significantly higher RGR (upto 30 DAS) and NAR (60 to 90 DAS) than 75% of recommended dose as uncoated urea but it was statistically at par with 100% of recommended dose (UU/NCU) during both the years. Our results are in agreement with the findings of many researchers [1-4, 13, 21] who observed increasing trend of growth with increasing nitrogen levels. Three splits doses *viz.* 1/3 as basal, 1/3 after 1st irrigation and 1/3 after 2nd irrigation produced significantly higher RGR (upto 30 DAS) and NAR (60 to 90 DAS) than the rest of treatments in both the years. But it was statistically at par with 2 split doses *viz.* ½ as basal and ½ after 1st irrigation with respect to RGR at 30 DAS in both the years. This was possibly due to higher dry matter production and more leaf area provide greater sink for optimum photosynthesis activity.

Biomass accumulation

Biomass accumulation of crop is a valid norm for comparing the efficiency of different inputs applied during growing period. The biomass accumulation of wheat increased with increasing nitrogen levels. The data on biomass accumulation of wheat revealed that among nitrogen levels, 125% of recommended dose as uncoated urea produced maximum biomass accumulation (14007 and 13869 kg/ha), which was significantly higher than 75% of recommended dose as uncoated urea but statistically at par with 100% of recommended dose (UU/NCU) during both the years of experimentation, respectively (Table 3). This increase can be due to increased plant height and dry matter accumulation with increasing nitrogen levels. Zero tillage with residue retention need higher rates of nitrogen fertilizer to sustain higher yield potential due to increased crop nitrogen uptake and also compensate for nitrogen sequestration under residue retention [9]. Similar results have been reported by Tripathi *et al.* [18] who reported increase in wheat yield by 21.3% at zero N, 8.3% at 150 kg N/ha whole as basal application, and by 5.4% at 150 kg N/ha with three splits under zero tillage with residue retention situation. However, Usman *et al.* [20] found highest yield with 200 kg/ha nitrogen with application in four splits at sowing, 20, 45 and 70 DAS.

Time of nitrogen application also influenced the biomass accumulation significantly. Nitrogen application in three splits doses *viz.* 1/3 as basal, 1/3 after 1st irrigation and 1/3 after 2nd irrigation produced maximum biomass accumulation (13817 and 13777 kg/ha) which was significantly higher than rest of treatments during 2014-15 and 2015-16, respectively (Table 3). It may be due to increased number of tillers and dry matter accumulations. These results are in conformity with results of Singh *et al.* [16], Usman and Rehman [19], Naresh *et al.* [11] and Bhardwaj *et al.* [5] who also observed positive effect of split application of nitrogen at appropriate time. In contrast, Coventry *et al.* [6] reported no significant difference in grain yield with different split timing of nitrogen application in rice-wheat cropping system.

CONCLUSION

The physiological indices were recorded maximum with 125% of recommended dose resulting into higher biomass accumulation than 75% of recommended dose as UU but it was statistically at par with 100% of recommended dose (UU/NCU) in both the years. Among time of nitrogen application, three splits doses *viz.* 1/3 as basal, 1/3 after 1st irrigation and 1/3 after 2nd irrigation were significantly superior with respect to physiological indices which resulted into higher biomass accumulation than the rest of treatments. The result accomplished that 100% of recommended dose of nitrogen with three way split application *viz.* 1/3 as basal, 1/3 after 1st irrigation and 1/3 after 2nd irrigation were optimal for better crop growth and biomass accumulation of wheat.

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