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Short Comminucation

Effect of tillage, residue and nitrogen management on radiation interception and radiation use efficiency of wheat in a semi-arid environment

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Tillage practices involve physical manipulation of soil for crop establishment. Optimization of tillage practices under a particular environment enhances soil health. Conventional crop production technologies are not much cost effective, less water efficient and deteriorates soil health (Parihar *et al.,* 2016). Most of these impeding factors can be substantially mitigated by adopting conservation tillage practices in place of conventional tillage practices as conservation agriculture minimizes the soil disturbance, provide soil cover through crop residues, mulch or cover crops, and crop rotations for attaining higher productivity and minimizing adverse environmental impacts. Nitrogenous fertilizer is one of the most important inputs for wheat crop growth (Pradhan *et al.,* 2014a). Tillage, residue and N fertilization also affect nitrate-N concentration, water content, aeration and SOC (Rice and Smith, 1982; McKenny *et al.,* 1993). Tillage practices modifies soil environment, which influences root and shoot growth and crop yield. The above ground shoot growth is governed by radiation interception and radiation use efficiency. Radiation interception is influenced by leaf area index and leaf angle. Many workers have reported the effects of tillage, residue and nitrogen on soil physical, chemical and biological properties *vis-a-vis* crop growth (Parihar *et al.,* 2016). However, studies on the effect of tillage, residue and nitrogen on radiation interception and radiation use efficiency of wheat is very limited. Keeping these in view, the objectives of this study were to determine the interactive effect of tillage, residue and nitrogen on (a) temporal variation in LAI and (b) total IPAR, biomass yield, extinction coefficient (k) and radiation use efficiency of wheat in a semi-arid location of India.

A field experiment was conducted during the winter (*Rabi*) season of 2014-15 at the research farm of ICAR-Indian Agricultural Research Institute (78°89'E, 28°37'N and 228.7 m above sea level), New Delhi, India to study the effect of tillage, residue and nitrogen management on radiation interception and radiation use efficiency of wheat. The area comes under semi-arid subtropical climatic belt. The mean annual rainfall is about 774 mm, of which 84 per cent is received during monsoon periods of June to September. The soil is sandy loam (TypicHaplustept) with medium to angular blocky structure, non-calcareous and slightly alkaline in reaction.

The treatments comprised of two levels of tillage as main plot factor [conventional tillage (CT) and no tillage (NT)], two levels of residue as sub plot factor [maize residue @ 5tha^{-1} (M1) and without residue (M0)], and three levels of nitrogen as sub-sub plot factors [60, 120 and 180 kg ha^{-1}, representing 50 per cent (N60), 100 per cent (N120) and 150 per cent (N180) of the recommended dose of nitrogen for wheat, respectively] were evaluated in a split-split plot design with three replications. The sub sub-plot size was 4.5 m × 5 m. Wheat crop (cv. HD 2967) was sown on 16th November in 2014 by a tractor drawn no-till seed drill at a depth of 5 cm with a row spacing of 22.5 cm and seed rate of 100 kg ha^{-1}. The wheat crop was harvested on 17thApril 2015. Maize residue was applied manually at the rate of 5 t ha^{-1}in M1 treatment after CRI stage. Nitrogen was supplied as urea in three splits i.e., 50 per cent at sowing, 25 per cent at CRI stage and rest 25 per cent at flowering stage. All the plots received a uniform dose of 60 kg P_2O_5 ha^{-1} as single super phosphate and 60 kg K_2O ha^{-1} as muriate of potash applied as basal dose at sowing. All the plots received five irrigations at critical growth stages *i.e.*, CRI, tillering, jointing, flowering and milk stage.

Leaf area index (LAI) was measured at regular intervals using a plant canopy analyzer (LAI-2000, LI- COR, Lincoln, NE, USA). Both incoming and transmitted photosynthetically active radiation (PAR) values were measured periodically at the top and bottom of the wheat canopy throughout the season using line quantum sensor LI-191SA (LICOR Inc., Lincoln, NE, USA). The fraction intercepted PAR (fIPAR) was calculated as (Monteith, 1981):

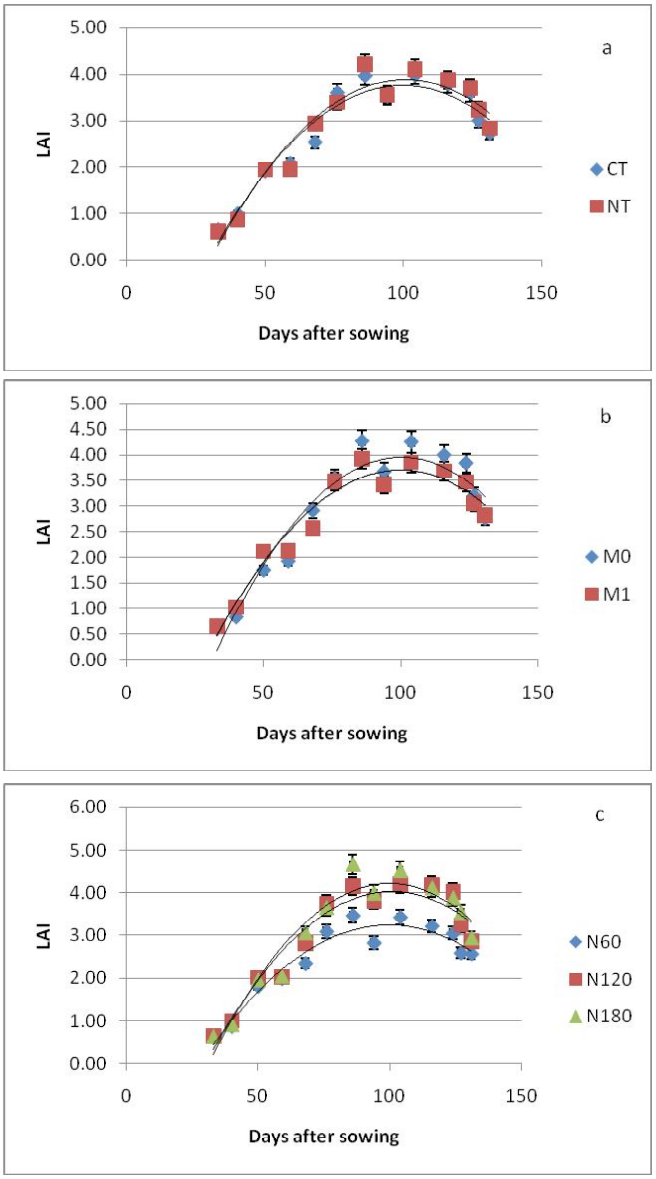

Fig. 1: Temporal variation in LAI of wheat under tillage (a), crop residue mulch (b) and nitrogen (c) treatments

fIPAR = $(I_o - I)/I_o$. The I_o is incident PAR at the top of canopy and I is the transmitted PAR at the bottom of the canopy. The canopy fIPAR and LAI were related by the relationship: $f\text{IPAR} = 1\text{-}e^{(-\kappa \times \text{LAI})}$ where, k is the canopy radiation extinction coefficient and LAI is the leaf area index. The k was determined with least-square regression by calculating the slope of the relationship between ln (1-fIPAR) and LAI with intercept set to zero (Robertson *et al.,* 2001). The total IPAR (TIPAR) and RUE was calculated as the procedure outlined Pradhan *et al.* (2014b, 2018).The grain and above ground biomass yield was recorded as per the standard procedure.The data were statistically analyzed using analysis of variance (ANOVA) as applicable to split-plot design (Gomez and Gomez, 1984). Regression analyses were performed using the data analysis tool pack of MS Excel (2007).

The temporal variation in LAI of wheat under different tillage, crop residue mulch and nitrogen treatments are presented in Fig. 1. The peak value of LAI coincides with the booting to flowering stage of wheat. The increase in LAI is attributed to foliage expansion because of development of new leaves and enlargement of existing leaves (Mandal *et al.,* 2005). The decrease in LAI during later part of crop growth is ascribed to leaf senescence (Pradhan *et al.,* 2013). The LAI of wheat was not significantly affected by tillage and crop residue mulch treatment. However, nitrogen treatment significantly affected LAI of wheat from 76 days after sowing (late tillering) till harvesting. There was increase in LAI with the increase in N dose but there was no significant difference between 120 and 180 kg N ha^{-1}.The temporal variation in fIPAR followed the trend similar to that of LAI (data not given).The variation in light extinction coefficients (k) of wheat among different tillage, crop residue mulch and nitrogen treatments are presented in Table 1. The k value ranged between 0.34 in NTM1N60 treatment to 0.57 in NTM0N180 treatment with a mean value of 0.44. Averaged over tillage and residue management, the k value of wheat due to CT and NT treatments were numerically same. However, the k value in no residue treatment (M0) was 6 per cent higher compared to crop residue mulch treatment (M1). The N180 treatment registered 17 and 27 per cent higher k value compared to N60 and N120 treatments, respectively. It indicated that with the decrease in nitrogen levels, the leaf becomes erect resulting in better penetration of PAR into the canopy and lower fIPAR and RUE (Bassu *et al.,* 2011).

The grain yield of wheat was not significantly affected by tillage and crop residue mulch treatment. However, the nitrogen treatment significantly influenced the grain yield of wheat (Table 1). N180 and N120 registered respectively, 26 and 19 per cent higher ($P<0.05$) grain yield compared to N60 treatment.However, the N180 and N120 treatments were statistically at par. Similar to grain yield, the biomass yield of wheat was not significantly affected by tillage and crop residue mulch treatment, but nitrogen levels significantly affected the biomass yield of wheat. The N180 and N120 treatments registered respectively, 38 and 33 per cent higher ($P<0.05$) biomass yield compared to N60 treatment.Increased grain and biomass yield of wheat with increased nitrogen rate might have resulted from increased LAI, green spikes area and crop duration with greenness (Pradhan *et al.,* 2014c). The non-significant effect of tillage

Table 1: Total intercepted photosynthetically active radiation (TIPAR), grain yield, above ground biomass and radiation use efficiency (RUE) of wheat for different tillage, residues and nitrogen levels

	TIPAR (MJm^{-1})	Grain yield (kg ha^{-1})	Above ground biomass (kg ha^{-1})	RUE (gMJ^{-1})	Light extinction coefficient (*k*)
CT	470	4439	11106	2.39	0.44
NT	467	4125	10633	2.32	0.44
CD (0.05)	NS	NS	NS	NS	-
M0	463	4319	10649	2.32	0.45
M1	474	4245	11090	2.39	0.43
CD (0.05)	NS	NS	NS	NS	-
N60	405	3727	8800	2.22	0.39
N120	476	4429	11672	2.50	0.43
N180	524	4691	12137	2.34	0.50
CD (0.05)	71	446	1517	NS	-

treatment (CT and NT) on grain and biomass yield of wheat can be ascribed to the similar hydrophysical environment in NT and CT in the initial years of imposition of tillage treatments (two years old).

Similar to grain and above ground biomass yield, the TIPAR was not affected by the tillage and crop residue mulch treatment. The N180 treatment registered 29 per cent higher ($P<0.05$) TIPAR compared to N60 treatment. However, N120 and N180, and N60 and N120 treatments were statistically at par with respect to TIPAR. The higher TIPAR with increased nitrogen levels is attributed to higher LAI resulting in higher interception of photosynthetically active radiation (Pradhan *et al.,* 2014a). The RUE was not-significantly ($P<0.05$) affected by tillage, residue and nitrogen treatments under this study. It could be attributed to the fact that increase in biomass was associated with the increase in TIPAR which is evident from the significant and positive correlation between TIPAR and above ground biomass ($r = 0.93^{**}$).

From this study it may be concluded that there was improvement in the LAI of wheat with the increase in nitrogen level but the effect of tillage and residue was not significant on the LAI. The total intercepted photosynthetically active radiation was not influenced by tillage and residue treatments but increased with N levels. Grain and biomass yield of wheat were not significantly affected by tillage and residue treatments but increased significantly with N levels. However, there was no significant difference between 120 and 180 kg Nha^{-1} with respect to grain and biomass yield of wheat. The radiation use efficiency of wheat was not significantly affected by tillage, residues and nitrogen treatments. So wheat may be grown with the recommended dose of N (120 kg Nha^{-1}) under No tillage with residue retention to obtain higher grain yield, radiation interception and radiation use efficiency under irrigated condition in the semiarid climate of the Indo-Gangetic plain region.

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