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INTERCEPTION OF PHOTOSYNTHETICALLY ACTIVE RADIATION AND ITS EFFICIENCY FOR BIOMASS PRODUCTION AND YIELD IN WHEAT UNDER DIFFERENT ENVIRONMENTS

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A study was conducted for two years to evaluate the radiation interception and its efficiency for dry matter production in wheat under various nitrozen and moisture environments. The crop under non-stress conditions of moisture and nitrogen intercepted more light and converted into more biomass as compared to stress condition crop. Radiation use efficiency was more (2.88 g/MJ) in normal sown wheat as compared to early and late sown wheat.

Keywords : Environments; Radiation interception; Radiation use efficiency; Stress condition.

Introduction

The production of dry matter depends on mainly two processes i.e. interception of radiation by crop and storage of this energy as plant material. Crop depends on the incident energy that is intercepted on crop development. Solar radiation is the main source of energy for the process of photosynthesis. The photosynthetically active radiation is the radiation in 0.4 to 0.7 μm waveband that excites chlorophyll molecules and other pigments and thus initiates the flow of energy required in photosynthesis. The canopy architecture influences the distribution of light energy for dry matter accumulation which affects the efficiency of radiation energy use in photosynthetic way.

Stress conditions, due to varying date of sowing, fertilizer and moisture levels are found to influence the radiation interception and its conversion to biomass and crop yield. In this study an attempt was made to develop the relationship between intercepted light and dry matter production in wheat under different environments and to quantify the radiation use efficiency.

Materials and Methods

A field experiment was conducted during the *Rabi* season of 1996-97 and 1997-98 at Research Farm of Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar (Lat. 29° 10'N; Long. 75°46'E and 215.2 m MSL). The experiment was planned under three dates of sowing : D_1 - early (28th October), D_2 - normal (22nd November) and D_3 - late (17th December); two moisture levels : I_1 - (one irrigation at crown root initiation stage), I_2 - (four irrigation at crown root initiation, jointing, anthesis and dough stages) and four nitrogen levels : N_0 - (Control), N_1 - (50 percent of recommended), N_2 - (100 Percent of recommended), N_3 - (150 percent of recommended levels). The recommended dose of fertilizer is 120kg Nitrogen, 60 kg each of phosphorous and potash for WH542 variety of wheat.

The experiment was laid out in split plot design with net plot size of 5.0 x 3.5 m^2. Recommended package and practices were followed for management of crop. The observation on leaf area, dry matter and photosynthetically active radiation were taken on same day at different phenological stages. The leaf area was measured with using leaf area meter. The plant samples were dried in oven till constant weight to determine dry matter. Photosynthetically active radiation (PAR) was measured with the help of Line Quantum sensor (Model LI-190 SB) in the range of 400 - 700 nm at 2 meter above canopy level. The reflected PAR was measured by inverting the sensor above canopy and transmitted radiation at ground. The daily intercepted photosynthetically active radiation was

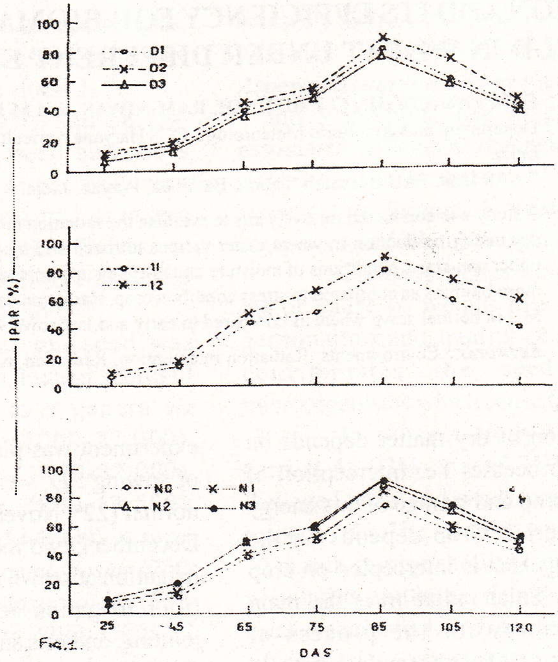

Fig. 1. Variation of IPAR (%) under different treatments during 1996-97

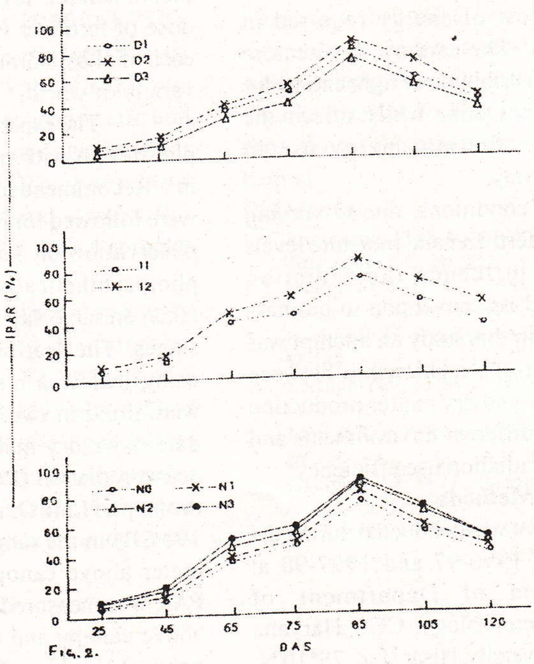

Fig. 2. Variation of IPAR (%) under different treatments during 1997-98

Table 1. Intercepted photosynthetically active radiation (IPAR), radiation use efficiency (RUE) maximum leaf area index (LAI), biomass production (DM) and yield in wheat crop under various environments during crop season of 1996-97 and 1997-98.

Treatments	1996-97					1997-98				
	IPAR (MJ/m^2)	RUE (g/MJ)	LAI	DM (g/m^2)	Yield (q/ha)	IPAR (MJ/m^2)	RUE (g/MJ)	LAI	DM (g/m^2)	Yield (q/ha)
Date of sowing										
D_1	648.6	2.5	3.25	1620.6	39.2	629.4	2.2	3.0	1396.0	33.1
D_2	703.2	2.8	4.64	1968.9	45.7	683.4	2.5	4.2	1696.3	40.1
D_3	640.2	2.4	3.00	1503.8	34.2	620.7	2.1	2.75	1290.3	32.2
CD (5%)	51.2	0.2	0.25	120.3	4.5	49.5	0.2	0.2	105.2	3.8
Moisture levels										
I_1	641.6	2.5	3.35	1620.0	36.5	626.3	2.2	3.03	1359.8	33.1
I_2	686.4	2.7	4.50	1856.2	42.8	662.7	2.4	3.8	1562.0	37.2
CD (5%)	40.5	0.2	0.20	148.5	5.0	38.4	0.2	0.15	124.5	4.5
Nitrogen levels										
N_0	642.1	2.2	3.39	1400.5	36.8	601.5	2.2	3.0	1247.5	32.5
N_1	654.5	2.6	3.50	1682.4	39.1	642.6	2.2	3.35	1381.4	34.8
N_2	670.3	2.7	4.00	1801.8	42.7	661.3	2.4	3.6	1555.8	38.1
N_3	687.3	2.8	4.25	1908.7	40.2	672.5	2.5	4.0	1659.0	35.0
CD (5%)	38.5	0.18	0.15	130.5	3.5	55.4	0.15	0.12	150.4	5.0

calculated as per the procedure adopted by Rosenthal and Geric[1] and converted into MJ/m^2 :

PAR = Rs x 0.49

Where Rs is solar radiation received at the surface of the earth, Cal/cm^2

IPAR = PAR ($1-e^{-kf}$) MJ/m^2/day

Where K is extinction coefficient and f is leaf area index K was calculated by the slope expression

$K = \ln (I/I_0)/f$

Where I_0 is radiation energy at the top of the canopy and I is radiation energy at the bottom of crop canopy

Radiation use efficiency (RUE) was calculated as

$$\text{RUE (g/MJ)} = \frac{\Sigma\text{dry matter (g/m}^2)}{\Sigma\text{IPAR (MJ/m}^2)}$$

Results and Discussion

Intercepted photosynthetically active radiation (IPAR) under different nitrogen and moisture levels is shown in Fig. 1 and Fig. 2 for the year 1996-97 and 1997-98, respectively. IPAR initially increased slowly upto first 40 days then at faster rate to attain maxima at 85 days after sowing (DAS) and declined thereafter upto harvest. This was due to rise and decay of green foliage. It indicates that a maximum leaf area index is proportionate to with maximum radiation interception. The best crop health in terms of higher values of IPAR was observed in 22nd November sown crop (D_2) where it attained above 80 per cent level. It shows that D_2 treatment had experienced over all conductive environmental conditions for growth followed by 28th October (D_1) and

17th December (D_3) sown crop treatments. Moisture and nitrogen levels also influenced the interception of PAR. The crop under the non-stress condition of moisture and nitrogen levels was observed to intercept more PAR in comparison with their corresponding stress treatments. Similar trend was observed during the growiing season of 1997-98. Table 1 presents the radiation use efficiency (RUE) of wheat for both years, which varied from 2.2 to 2.8 g/MJ under non-stressed conditons of moisture and nutrients, whereas RUE values were lower under stress conditions varying from 2.2 to 2.5 g/MJ. RUE was higher 2.8 and 2.5 g/MJ in D_2 and decreased in D_1 and D_2 during 1996-97 and 1997-98, respectively. The decreasing trend in RUE with delayed sowing was also reported by Squire *et al*[2]. and Ghallagher and Biscoe[3]. The percentage of IPAR is directly proportional to the accumulated LAI and this concept has been exploited into the determination of total biomass.

Biomass production was maximum 1968.9 and 1696.3 g/m² in D_2 treatment during 1996-97 and 1997-98, respectively and followed by D_1 and D_3 treatments in both seasons. More biomass and grain yield was produced in I_2 treatment as compared to I_1 in both growing seasons. Table 1 clearly show that D_2 treatment attained more cumulated IPAR 703.2 and 683.4 MJ/m² and produced maximum dry matter 1968.9 and 1696.3 g/m² as compared to other treatments D_1 and D_3. Under different nitrogen levels N_3 produced maximum dry matter than N_0, N_1 and N_2 treatments, whereas grain yield was produced maximum by N_2 (Table 1). These results presented a very close relationship between biomass productions and intercepted photosynthetically active radiation in conformity with the finding of Monteith[4] and Biscoe and Gallaghar[5].

Therefore, the normal sown wheat crop under four irrigation and 120 kg/ha Nitrogen fertilizer dose intercepted the maximum light energy and converted into higher biomass attaining maximum yield in wheat under semi-arid agro-climatic condition.

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