EFFECT OF SOWING ENVIRONMENT AND NITROGEN LEVELS ON LIGHT INTERCEPTION AND ITS EFFICIENCY IN DRY MATTER PRODUCTION IN WHEAT CULTIVARS

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ABSTRACT

The field experiments were conducted at research farm of the Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar. Five wheat cultivars: WH 542, PBW 343, UP 2338 Raj 3765 and Sonak were sown on 25th November, 10th and 25th December with four nitrogen levels viz., no nitrogen, 50, 100 and 150 per cent of recommended dose. Leaf area index, dry matter at anthesis and final dry biomass were measured at different growth stages. Photosynthetically active radiation was measured with line quantum sensor at different growth stages in all the treatments. Transmitted, reflected and absorbed photosynthetical active radiations were computed. Absorbed PAR in wheat decreased with delay in sowing. Wheat fertilized with 180 kg nitrogen/ha absorbed maximum photosynthetical active radiations. Delay in sowing adversely affected the radiation use efficiency of wheat crop. The cultivar PBW 343 was more efficient in radiation utilization in comparison with WH 542, UP 2338, Raj 3765 and Sonak. The maximum value of radiation use efficiency varied between 2.55 to 2.80 (1998-99) and 2.92 to 3.14 g/MJ (1999-2000). Radiation use efficiency explained around 65 per cent variability in leaf area index and dry biomass of wheat crop.

Key words: Photosynthetically active radiation, radiation use efficiency, wheat, sowing environments, transmitted, reflected, absorbed, nitrogen.

Solar radiation is the main source of energy for photosynthesis, the initial process that green plants use to convert carbon dioxide and water into simple sugars. Other plant processes convert these initial products of photosynthesis into dry matter. Photosynthetically active radiation (PAR) is the radiation in the particular waveband which excites chlorophyll molecules and other pigments and thus initiates the flow of energy required in photosynthesis. The ratio of PAR to total solar energy received at the surface is generally reported to be about 0.49 (Kailasnathan and Sinha, 1984). When a helathy crop receives adequate water and nutrients, dry matter production is mainly governed by solar energy available for photosynthesis.

Radiation use efficiency refers to the efficiency with which intercepted radiation energy is used for the production of biomass. Radiation interception depends mainly on the leaf area index (LAI) and canopy architecture. Patel et al. (1997) found that absorption of PAR was at peak during 50 per cent podding in pigeonpea. Nehra et al. (1996) reported that delay in sowing of toria (Brassica campestris) from first week of September to first week of October significantly increased the radiation use efficiency. Hall et al. (1995) studied radiation use efficiency of sunflower crops under different nitrogen levels and population densities. Higher light interception was reported by Kler et al. (1983) in bi-directional sowing of gram crop. Therefore, an attempt was made to study the PAR interception and its efficiency in dry matter production in wheat genotypes under different nitrogen levels and sowing environments.

MATERIALS AND METHODS

The field experiment was conducted during rabi seasons of 1998-99 and 1999-2000 at the research area of the Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar (latitude : 29º10’N, longitude 75º46’ E and altitude 215.2 m). The five wheat
genotypes WH 542 (V1), PBW 343 (V2), UP 2338 (V3), Raj 3765 (V4) and Sonak (V5) were sown on 25th November (D1), 10th December (D2) and 25th December (D3) with four nitrogen levels: No nitrogen (N0) 50 (N1), 100 (N2) and 150 per cent (N3) of the recommended dose of 180 kg N/ha. The experiment was laid out in a split plot design with three replications. All other agronomic practices were followed as per package of practices recommended for wheat crop by the University. The leaf area was measured with leaf area meter (Licor-3100) at an interval of 15 days starting from 30 days after sowing onwards to physiological maturity. The plant samples taken for leaf area measurement were dried in oven at 65±5ºC temperature till constant weight and weighed on an electric balance. The final seed yield was recorded after threshing the samples from all plots.

Line quantum sensor (LI-190 SB) was used to measure the photosynthetically active radiation (PAR) in the range of 400 to 700 nm at canopy level. The level. The reflected radiation was obtained by keeping the sensor inverted above the canopy and the sensor was also kept on ground across the rows diagonally to get transmitted radiation to the ground. The observations were recorded at different growth stages during 11:30-13:00 hours on clear days. The fraction of PAR intercepted (IPAR) by the crop was calculated as:

\[
IPAR = (1-r) \text{PAR}
\]

The fraction of PAR absorbed (APAR) is computed as:

\[
APAR = (1-r-t) \text{PAR}
\]

Where,

\[r \text{ & } t = \text{Reflected and transmitted PAR}\]

The attenuation coefficient 'k' was calculated as per the method adopted by Monsi and Saeki (1953).

Daily solar radiation was computed by the expression:

\[
Rs = RA (l-r) (a-b n/N)
\]

Where,

\[
Rs = \text{Solar radiation received at the earth surface}
\]

\[
RA = \text{Solar radiation received out the atmosphere}
\]

\[r = \text{Reflection coefficient (0.25)}
\]

\[a = 0.256; b = 0.56 \text{ (For Hisar, Bishnoi et al., 1995)}
\]

\[n = \text{Bright sunshine hours/day}
\]

\[N = \text{Maximum possible hours of sunshine (List, 1964)}
\]

The daily PAR was calculated by multiplying RS values by 0.49 (Kailsnathan and Sinha, 1984) and converted into MJ/m². The daily IPAR was calculated as per the procedure adopted by Rosenthal and Gerik (1991).

The radiation use efficiency (RUE) was calculated as:

\[
\text{RUE (g/MJ)} = \frac{\Sigma \text{DM (g/m²)}}{\Sigma \text{IPAR (MJ/m²)}}
\]

Where,

\[
\text{EDM} = \text{Cumulative dry matter for a growth period.}
\]

\[
\text{EIPAR} = \text{Cumulative intercepted phosynthetically active radiations for the same growth period.}
\]

The correlation and regression analysis were carried out to study the relationship of growth and yield with radiation use efficiency.

RESULTS AND DISCUSSION

Intercepted PAR by different wheat genotypes was cumulated over different phenophases and depicted in Fig. 1 & 2, during 1998-99 and 1999-2000, respectively. Interception of PAR increased rapidly up to 75 DAS (days...
Effect of sowing environment on wheat after sowing) and afterward it increased rapidly up to harvest in all the treatments. Wheat crop sown on 25th November intercepted more PAR in comparison with wheat sown on other dates. This might be due to higher leaf area index of wheat sown on this date. The application of nitrogen had also influenced the interception of PAR at all the growth stages. Sastri et al. (2000) reported that nitrogen fertilization significantly affected light interception. The wheat cultivar PBW 343 intercepted maximum PAR followed by UP 2338, WH 542, Raj 3765 and Sonak during whole growth period. This might be attributed to highest leaf area index produced by these cultivars. These results are in confirmation with the findings of Patel et al. (1997) in pigeonpea and Ram Niwas et al. (1999) in pearl millet.

The per cent values of transmitted, reflected and absorbed PAR at maximum leaf area index stage are presented in Table 1 during 1998-99 and absorbed PAR at maximum LAI stage were 81.7, 78.8 and 75.4 per cent in 25th November, 10th and 25th December, respectively during 1998-99 and 1999-2000. The corresponding values of absorbed PAR for second season were 80.4 (D1), 73.6 (D2) and 71.4 (D3) per cent. The absorbed PAR increased with increase in nitrogen application due to direct effect of nitrogen application on UP 2338 WH-542, Raj 3765 and Sonak, respectively.

The transmitted and reflected PAR values varied among different sowing dates, nitrogen level and cultivars. Irrespective of all the treatments the PAR transmission varied nitrogen level and cultivars. Irrespective of all the
Table 1. Effect of different treatments on transmitted, reflected and absorbed photosynthetically active radiations (%) at maximum leaf area stage in wheat

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transmitted</td>
<td>Reflected</td>
<td>Absorbed</td>
<td>Transmitted</td>
<td>Reflected</td>
<td>Absorbed</td>
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<tr>
<td>D₁</td>
<td>11.4</td>
<td>6.9</td>
<td>81.7</td>
<td>12.9</td>
<td>6.8</td>
<td>80.4</td>
</tr>
<tr>
<td>D₂</td>
<td>14.2</td>
<td>7.0</td>
<td>78.8</td>
<td>17.7</td>
<td>8.7</td>
<td>73.6</td>
</tr>
<tr>
<td>D₃</td>
<td>17.1</td>
<td>7.5</td>
<td>75.4</td>
<td>20.0</td>
<td>8.5</td>
<td>71.4</td>
</tr>
<tr>
<td>N₀</td>
<td>17.2</td>
<td>8.9</td>
<td>73.9</td>
<td>17.5</td>
<td>10.2</td>
<td>72.4</td>
</tr>
<tr>
<td>N₁</td>
<td>15.2</td>
<td>7.5</td>
<td>77.3</td>
<td>17.4</td>
<td>8.5</td>
<td>73.9</td>
</tr>
<tr>
<td>N₂</td>
<td>12.5</td>
<td>6.3</td>
<td>81.1</td>
<td>16.2</td>
<td>7.4</td>
<td>75.8</td>
</tr>
<tr>
<td>N₃</td>
<td>12.1</td>
<td>5.8</td>
<td>82.1</td>
<td>16.4</td>
<td>5.9</td>
<td>76.4</td>
</tr>
<tr>
<td>V₁</td>
<td>13.2</td>
<td>6.9</td>
<td>80.0</td>
<td>16.7</td>
<td>7.7</td>
<td>75.7</td>
</tr>
<tr>
<td>V₂</td>
<td>10.8</td>
<td>6.1</td>
<td>83.1</td>
<td>15.3</td>
<td>7.0</td>
<td>77.8</td>
</tr>
<tr>
<td>V₃</td>
<td>12.6</td>
<td>6.3</td>
<td>81.0</td>
<td>17.5</td>
<td>8.0</td>
<td>74.0</td>
</tr>
<tr>
<td>V₄</td>
<td>13.7</td>
<td>7.7</td>
<td>77.6</td>
<td>16.4</td>
<td>9.8</td>
<td>73.8</td>
</tr>
<tr>
<td>V₅</td>
<td>16.7</td>
<td>8.7</td>
<td>74.6</td>
<td>18.6</td>
<td>9.6</td>
<td>71.0</td>
</tr>
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</table>

The radiation use efficiency (RUE) of wheat cultivars under various treatments are presented in Table 2 during 1998-99 and 1999-2000. The radiation use efficiency of wheat cultivars increased with growing period and attained maximum at 90 DAS and afterward decreased till harvest in all the treatments and in both seasons. The first sown wheat crop was more efficient in radiation utilization over later sown wheat crops. This was attributed to maximum PAR interception by first wheat sown crop. The decrease in RUE with delay in sowing of pearl millet was reported by Squire et al. (1984). The values increased with increase in nitrogen application in wheat crop. The maximum values of RUE were 2.67, 2.80, 2.60 and 2.55 g/MJ in WH 542, PBW 343, UP 2338, Raj 3765 and Sonak, respectively during 1998-99. The corresponding value of RUE for the second season were 3.03, 3.14, 3.12, 2.93 and 2.92, respectively. Gallagher and Biscoe (1978) reported that the RUE of wheat and barley was 2.2 g/MJ.

The IPAR and radiation use efficiency were correlated with leaf area index, dry matter and yield. The correlation coefficients ‘r’ were higher in case of RUE in comparison with intercepted PAR. The simple regression model for leaf area index and dry matter based on RUE during maximum leaf area stage are of the from:

\[
\text{LAI} = -0.275 + 1.39 \times \text{RUE}
\]

\[R^2 = 0.06\]

\[
\text{TDM} = 210.01 + 340.60 \times \text{RUE}
\]

\[R^2 = 0.65\]

Where, \(\text{LAI}\) = Leaf area index

\(\text{TDM}\) = Total dry matter (g/m²)

\(\text{RUE}\) = Radiation use efficiency (g/MJ)

The radiation use efficiency during maximum leaf area stage of wheat explained the variability up to 65 and 66 per cent in leaf area index and total dry matter production respectively.
Table 2. Effect of different treatments on radiation use efficiency (gMJ⁻¹) at various growth stages in wheat

<table>
<thead>
<tr>
<th>Treatment</th>
<th>30 DAS</th>
<th>45 DAS</th>
<th>60 DAS</th>
<th>75 DAS</th>
<th>90 DAS</th>
<th>105 DAS</th>
<th>120 DAS</th>
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<tr>
<td></td>
<td>98-99</td>
<td>99-00</td>
<td>98-99</td>
<td>99-00</td>
<td>98-99</td>
<td>99-00</td>
<td>98-99</td>
</tr>
<tr>
<td>D₁</td>
<td>0.92</td>
<td>1.17</td>
<td>1.45</td>
<td>1.78</td>
<td>2.14</td>
<td>2.31</td>
<td>2.75</td>
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<tr>
<td>D₂</td>
<td>0.80</td>
<td>1.07</td>
<td>1.30</td>
<td>1.38</td>
<td>1.92</td>
<td>2.15</td>
<td>2.32</td>
</tr>
<tr>
<td>D₃</td>
<td>0.74</td>
<td>0.83</td>
<td>1.21</td>
<td>1.03</td>
<td>1.83</td>
<td>1.99</td>
<td>2.03</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>0.07</td>
<td>0.08</td>
<td>0.09</td>
<td>0.36</td>
<td>0.13</td>
<td>0.26</td>
<td>0.28</td>
</tr>
<tr>
<td>N₅</td>
<td>0.64</td>
<td>0.90</td>
<td>1.13</td>
<td>1.35</td>
<td>1.82</td>
<td>1.96</td>
<td>1.98</td>
</tr>
<tr>
<td>N₁</td>
<td>0.77</td>
<td>1.05</td>
<td>1.25</td>
<td>1.53</td>
<td>1.88</td>
<td>2.14</td>
<td>2.27</td>
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<tr>
<td>N₂</td>
<td>0.91</td>
<td>1.15</td>
<td>1.42</td>
<td>1.60</td>
<td>2.04</td>
<td>2.29</td>
<td>2.53</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>0.05</td>
<td>0.05</td>
<td>0.06</td>
<td>0.22</td>
<td>0.08</td>
<td>0.19</td>
<td>0.16</td>
</tr>
<tr>
<td>V₁</td>
<td>0.82</td>
<td>1.05</td>
<td>1.32</td>
<td>1.47</td>
<td>1.97</td>
<td>2.20</td>
<td>2.4</td>
</tr>
<tr>
<td>V₂</td>
<td>0.86</td>
<td>1.05</td>
<td>1.32</td>
<td>1.47</td>
<td>1.97</td>
<td>2.20</td>
<td>2.4</td>
</tr>
<tr>
<td>V₃</td>
<td>0.83</td>
<td>1.09</td>
<td>1.36</td>
<td>1.50</td>
<td>2.02</td>
<td>2.16</td>
<td>2.49</td>
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<tr>
<td>V₄</td>
<td>0.81</td>
<td>1.03</td>
<td>1.28</td>
<td>1.42</td>
<td>1.91</td>
<td>2.13</td>
<td>2.25</td>
</tr>
<tr>
<td>V₅</td>
<td>0.77</td>
<td>1.03</td>
<td>1.26</td>
<td>1.41</td>
<td>1.87</td>
<td>2.10</td>
<td>2.20</td>
</tr>
<tr>
<td>C.D. at %</td>
<td>NS</td>
<td>0.02</td>
<td>NS</td>
<td>0.04</td>
<td>0.08</td>
<td>NS</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Note: NS indicates not significant.
REFERENCES


List, R.J. 1964. Smithsonian Methsonian Meteorological Table. *Smithsonian Institute, USA.*


