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SHORT COMMUNICATION

RELATIVE CONTRIBUTION OF LAMINAE TO TOTAL CARBON DIOXIDE FIXATION IN WHEAT IN RESPONSE TO NITROGEN

VANITA JAIN* AND SANGEETA KHETARPAL

Division of Plant Physiology, Indian Agricultural Research Institute, New Delhi 110012

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Relative contribution of the main shoot laminae towards the total carbon dioxide fixed by the main shoot was examined in wheat cultivars Uniculm Gigas (V_1) and Kalyansona (V_2). These cultivars were grown in pots at two levels of nitrogen, viz. 30 (N_1, sub-optimal) and 120 (N_2, optimal) kg ha^{-1}. Photosynthetic rates (Pn) and lamina area at each insertion level were measured at weekly interval throughout the ontogeny. Sub-optimal level of nitrogen significantly reduced the area of the upper laminae, particularly penultimate and flag lamina, in both the cultivars. Pn rate of these two laminae was also reduced under sub-optimal N in the cv Kalyansona. These reductions were reflected in the grain yield. At optimal N level, the upper laminae make significant contribution to the total carbon dioxide fixed by the plant.

Key words: **Carbon dioxide, laminae, nitrogen, wheat**

Wide variations have been reported in the relative contribution by different plant parts to the total carbon dioxide fixed by the wheat plant. These variations are dependent upon the cultivar and cultural conditions (Asana and Mani 1950, Evans 1975, 1993). Earlier studies relating to the estimation of contribution by the different plant parts are based on shading, defoliation and feeding labelled carbon dioxide to the leaf discs (Stoy 1963, Lucas and Asana 1968, Rawson and Hofstra 1969). Among the different plant parts, laminae constitute the major source, though, the ear photosynthesis in some cases, has been reported to make significant contribution to the total grain requirement during the early grain growth stage (Evans 1975). Changes in leaf photosynthesis during ontogeny and its relationship to yield in wheat was reported by Rawson *et al*. (1983). Wheat cultivars have been shown to differ in their response to applied nitrogen (Sivasankar *et al.* 1998 a, b). In the present study, total carbon dioxide fixed by each lamina on the main shoot of wheat cultivars differing in their response to applied nitrogen has been examined

Two wheat cultivars, Uniculm (V_1) and Kalyansona (V_2), were grown in 35 cm diameter earthen pots filled with sandy loam soil. Nitrogen was applied in the form of urea equivalent to 30 (N_1) and 120 (N_2) kg N ha^{-1}. Half of the nitrogen was applied as basal dose and the rest in two equal splits at 30 and 45 days after sowing (DAS). P and K were applied @ 60 and 40 kg ha^{-1}, in the form of single super phosphate and muriate of potash, respectively. Only a single culm was maintained in both the cultivars. Tillers were removed as and when they appeared. Treatments were replicated four times in a completely randomized design. Thirty pots, each containing six plants, were maintained per treatment.

Laminae at different insertion levels were sampled at weekly interval from emergence till senescence. Three pots were sampled at each sampling. The lamina area at each sampling was measured using a green leaf area meter (ΔT Devices, England). The lamina area duration (LAD) was calculated by integrating the lamina area over the entire duration of each lamina. Photosynthetic rate

* Corresponding author.

was measured by an infra red gas analyzer (model LI 6200, Licor, USA). Total CO_2 fixed by each lamina was calculated by integrating the per day values of Pn rate over the entire duration of the lamina. Corrections were made for the diurnal fluctuations taking into account values obtained under similar conditions (Uprety and Tomar 1990) and the sunshine hours. The experiment was laid in a completely randomized design and the replicated data obtained in the experiment were statistically analyzed following Gomez and Gomez (1984).

The lamina area duration (LAD) of the whole shoot of Uniculm (V_1) was 5213 cm^2 days (Table 1). Amongst the laminae, the penultimate lamina recorded a maximum LAD of 1280 cm^2 days. At sub-optimal N level (N_1), there was 15-20 per cent reduction in the LAD values of the lower six laminae. Flag lamina recorded the maximum reduction of 68.6% followed by the penultimate lamina (50.3%). In Kalyansona (V_2) all the laminae on the main shoot had an LAD of 4590 cm^2 days. Highest LAD was recorded in the flag lamina (1369 cm^2 days) followed by the penultimate lamina (1087 cm^2 days). While the lower laminae (1 to 4) maintained similar LAD values at both the nitrogen levels, the upper ones viz. 5-8 showed a reduction of 15-30 per cent in their LAD values at sub-optimal N, the maximum reduction being in the flag lamina. The contribution of the upper three laminae, which were metabolically active during the post-flowering phase, to the total LAD of the shoot varied between 70 to 75% (Table 1), thus made major contribution to the total CO_2 assimilation. Peoples *et al* (1980) have reported smilar observations on the contribution of the upper laminae.

The cumulative CO_2 fixed by the main shoot laminae of Uniculm (V_1) was 10,916 mg (Table 2). The penultimate lamina fixed the highest amount of CO_2 (2888 mg) followed by the flag lamina (2660 mg). At sub-optimal level of N, the amount of CO_2 fixed by the shoot was reduced to half of that at optimal level of N.

Table 1. Lamina area duration (LAD) of the main shoot laminae in wheat cultivars Uniculm (V_1) and Kalyansona (V_2) at two levels of nitrogen, viz. N_1 (30 kg ha^{-1}) and N_2 (120 kg ha^{-1}).

	Lamina area duration (cm^2 days)					
Lamina		**V_1**			**V_2**	
no.	**N_1**	**N_2**	**Mean**	**N_1**	**N_2**	**Mean**
1	40	41	41	35	35	35
2	76	98	87	59	59	59
3	171	169	170	141	144	143
4	278	333	306	217	236	227
5	911	1129	1020	645	773	709
6	1108	1319	1213	885	1036	961
7	823	1737	1280	903	1272	1087
8	524	1668	1096	1119	1619	1369
Total	3931	6495	5213	4004	5174	4590
LSD (5%)	L=37.88,	N=18.96	LxN=53.56	L=43.77,	N=21.88	LxN=61.86

Amongst the laminae, the maximum reduction (72%) was recorded in the flag lamina. In Kalyansona, the total CO_2 fixed by all the laminae was 6651 mg of which, the maximum amount was fixed by the flag lamina. When the N supply was sub-optimal, the CO_2 fixed by the individual lamina decreased. Maximum reduction (47-48%)was noted in both the penultimate and the flag laminae. Amongst the two genotypes, V_1 assimilated higher amount of CO_2 than V_2 at both the nitrogen levels. At N_2, the total CO_2 fixed by V_1 was much higher than that of V_2 (Table 2). In both the varieties, the lower laminae (1 to 4) fixed similar amounts of CO_2 at both the N levels whereas the upper laminae (5 to 8) fixed much higher CO_2 at N_2, almost two to three fold higher in penultimate laminae (PL) and flag laminae (FL).

Photosynthetic activity and area of the laminae is related to their nitrogen status (Lawlor *et al.* 1989, Groot and Spiertz 1989, Connor *et al.* 1993, Sivasankar *et al.* 1998b, Jain *et al.* 1999). In these two cultivars, area of both PL and FL were reduced at sub-optimal N levels. The decline in the total CO_2 fixed by these two laminae is related to drastic reductions in the lamina area in *cv* V_1 while in V_2, it was related to reductions in both area as well as Pn rate (Fig 1).

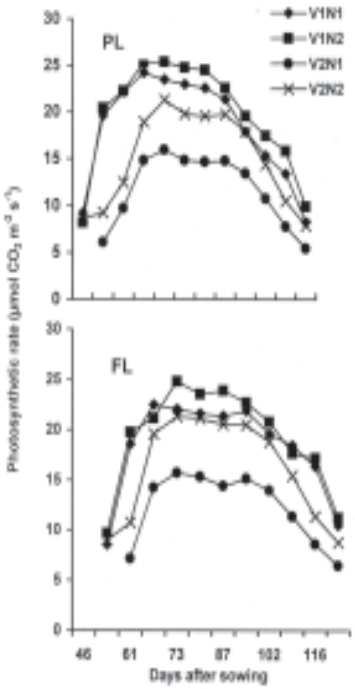

Fig. 1. Photosynthetic rate of the penultimate (PL) and flag (FL) laminae of wheat cultivars Uniculm 'Gigas' (V_1) and Kalyansona (V_2) at two levels of nitrogen, viz. 30 (N_1) and 120 (N_2) kg N ha^{-1}. CD at 5% between varieties and nitrogen levels 0.444 and between SxV, NxS and NxV is 1.541, 1.541 and 0 .629, respectively. (S refers to stage of sampling).

Table 2. Total CO_2 fixed by individual lamina on the main shoot in wheat cultivars Uniculm (V_1) and Kalyansona (V_2) at two levels of nitrogen, viz. N_1 (30 kg ha^{-1}) and N_2 (120 kg ha^{-1}).

	CO_2 fixed (mg lamina^{-1})					
Lamina	**V_1**			**V_2**		
no.	**N_1**	**N_2**	**Mean**	**N_1**	**N_2**	**Mean**
1	131	137	134	117	126	121
2	175	184	180	148	171	160
3	345	372	359	251	264	257
4	849	1060	955	452	554	503
5	1348	1813	1581	564	829	696
6	1720	2598	2159	797	1397	1097
7	1809	3967	2888	1137	2146	1642
8	1155	4165	2660	1479	2871	2175
Total	7532	14296	10916	4945	8358	6651
LSD (5%)	L=177, N=88	LxN=249		L=102, N=50	LxN=144	

The relative contribution, in terms of percentage, of individual lamina to the total CO_2 assimilation by main shoot laminae varied among the laminae and at different N levels (Table 3). In both the varieties, the lower laminae (1 to 4) contributed around 20 per cent of the total CO_2 assimilation at sub-optimal N supply that came down to 12 to 13 per cent at N_2 level. The upper laminae (5 to 8) contributed around 80 to 90 per cent of the total CO_2 assimilation at both the N levels. Differences, however, were observed between the varieties in the relative contribution of flag lamina. In the cv V_1, at N_1, the relative contribution of the flag lamina was reduced to half as compared to that of N_2 level. In V_2, the relative contribution of the flag lamina at N_1 was marginally reduced as compared to that in V_1 (Table 3). The estimate of relative contribution of individual laminae using infrared gas analyzer is an improvement over the earlier methods of shading and defoliation wherein compensatory mechanisms and alterations due to injury are involved (Long 1982).

Table 3. Per cent contribution of individual lamina to the total CO_2 assimilation by all the main shoot laminae in wheat cultivars Uniculm (V_1) and Kalyansona (V_2) at two levels of nitrogen, viz. N_1 (30 kg ha^{-1}) and N_2 (120 kg ha^{-1}).

	Per cent contribution			
Lamina	V_1		V_2	
no	N_1	N_2	N_1	N_2
1	1.7	0.9	2.4	1.5
2	2.3	1.3	3.0	2.1
3	4.6	2.6	5.1	3.2
4	11.3	7.4	9.1	6.6
5	17.9	12.7	11.4	9.9
6	22.8	18.2	16.1	16.7
7	24.0	27.8	23.0	25.7
8	15.3	29.1	29.4	34.4
LSD (5%)	L=0.99,N=0.49 LxN=1.40		L=0.42,N=0.60 LxN=0.59	

In the present study, a direct assessment of the contribution of individual lamina towards the final grain yield of the plant was not possible as Pn of the plant parts other than the laminae was not measured and also the losses due to respiration were not considered. However, magnitude of differences in carbon dioxide fixed by the flag and the penultimate laminae at sub-optimal and optimal N levels is revealed.

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