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STUDY ON THE DIFFERENTIAL CONTRIBUTION OF MOTHER SHOOT AND TILLERS FOR ROOT GROWTH OF WHEAT GENOTYPES

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SUMMARY

To understand the contribution of mother shoot and tillers for root growth, the effect of defoliation of mother shoot/tillers on the seminal and nodal roots of four wheat varieties, namely, C 306, HD 1553, HD 1593 and NP 846, was analysed. Roots were removed by washing technique and observations on number, length and weight of seminal and nodal roots were recorded at various intervals. In an another experiment, the translocation of photosynthates to seminal and nodal root was studied by $^{14}CO_2$ feeding of basal leaves of the mother shoot and the first tiller and in the wheat variety HD 1593. The defoliation experiment revealed that the contribution of the mother shoot to root growth was significantly higher than the tillers contribution. This was further confirmed by ^{14}C feeding study, which indicated that when mother shoot leaf was fed translocation of ^{14}C to root zone was higher than that of tiller leaf feeding. It was, thus, seen that root growth was mainly dependent on the photosynthates from mother shoot and contribution of photosynthates from tillers was very little. It was also contended from both the experiments that the dependence of nodal root growth was more on photosynthates while seminal root growth was related with the size of seeds substantively.

INTRODUCTION

Previous studies from this laboratory showed the differential growth behaviour of seminal and nodal roots of wheat varieties and their significance to drought resistance in plants (Sirohi *et al.*, 1976; Uprety *et al.*, 1980). They have also observed that the initial growth of seminal roots is related to the size of seeds, however, nodal root growth considerably affects the response of wheat varieties under water stress conditions (Uprety *et al.*, 1981). In a further analysis of root growth on the basis of the dynamic pattern of partitioning which balances root and shoot functions, Loomis *et al.* (1979) explained that the growth of root is more dependent on the assimilate status (shoot supply functions) than shoot growth, and shoot growth was more affected by water and nutrient status (root supply functions). Humphries and Thorne (1964) showed that roots may act as sinks for carbohydrates in various degrees without necessitating accompanying variations in shoot growth. According to Jordan *et al.* (1979) the availability of additional photosynthates could probably account for changes in root length and changes in root diameter is likely a reflection of alterations in the hormonal balance.

To understand the contribution of photosynthates for root growth in the present study, the differential effect of photosynthates from mother shoot and tillers for the growth of seminal and nodal roots of wheat varieties was studied.

MATERIALS AND METHODS

Four wheat varieties, namely, C 306, HD 1553, NP 846 and HD 1593 were grown in pot culture. Necessary required fertilizers (NPK) were given in 2 : 1 : 1 ratio twice (i) as basal dose and (ii) at 30 days after sowing. At 30 to 40 days after sowing, the following treatments were given to plants :

1. Mother shoot was defoliated completely (Defoliation started at 30 days after sowing).
2. Tillers were defoliated completely (Defoliation started at 35 days after sowing).
3. Control (No defoliation treatment).

Defoliation was repeated regularly at 10 days interval till anthesis. Roots were removed by careful washing and nodal and seminal roots were separated. Their length and number was noted at three stages, i. e., 36 (1st), 46 (2nd) and 56 (3rd) days after sowing. Dry weight of nodal and seminal roots was measured at four stages, i. e., 36, 46, 56 and 66 days after sowing. At the last sampling, the length and number of roots could not be measured correctly as they were very much intermingled. All the data were analysed statistically following the analysis of variance method (Snedecor and Cochran, 1956).

In order to understand the contribution of photosynthates from mother shoot and tillers for root growth, another experiment was done using the ^{14}C tracer technique. The fully expanded base leaf of the mother shoot or tiller was fed with $^{14}CO_2$ for 20 min in a perplexed glass airtight chamber. Translocation of ^{14}C to nodal and seminal roots was examined after 24 h. Samples of roots as well as above ground parts were taken and counting was recorded by a Paccard's Liquid Scintillation Counter after processing. CPM values were recorded. Percentage distribution of ^{14}C in different organs in relation to total count was tabulated. This translocation study with labelled carbon was done in one wheat variety, i. e., HD 1593 at 35 and 45 days after sowing.

RESULTS

Data relating to defoliation effect on the root growth are tabulated in Tables I and II and described below :

Mother shoot defoliation significantly reduced the number of seminal roots in the varieties HD 1553, NP 846 and HD 1593 at all the stages, however, the reduction was not significant in variety C 306 at stage I. Defoliation of tillers also brought about a substantive reduction in seminal root number in HD 1553 and

TABLE I. Effect of defoliation treatment on the seminal root characters of wheat varieties (per plant data)

Variety	Treatment	Seminal root number Stage			Seminal root length (cm) Stage			Seminal root weight (g) Stage			
		I	II	III	I	II	III	I	II	III	IV
C 306	Control	7.00	13.00	13.33	15.10	36.80	42.70	0.082	1.52	2.55	7.52
	Mother shoot defoliated (MSD)	6.33	11.00	11.00	13.43	29.00	29.23	0.060	0.85	1.88	4.69
	Tiller defoliated (TD)	—	12.00	12.33	—	35.06	37.33	—	1.37	2.22	7.17
HD 1553	Control	10.00	11.33	14.66	16.50	42.06	53.50	0.067	1.36	1.98	6.27
	MSD	7.00	8.33	8.33	11.00	24.00	30.20	0.052	0.63	1.71	4.43
	TD	—	9.66	11.00	—	32.83	37.40	—	1.20	1.90	6.01
NP 846	Control	11.30	12.00	14.00	13.16	36.33	51.66	0.052	0.89	2.88	4.74
	MSD	6.33	7.00	7.20	11.83	29.03	38.50	0.042	0.44	1.87	3.83
	TD	—	7.00	10.66	—	35.26	39.56	—	0.84	2.79	4.56
HD 1593	Control	10.66	13.66	13.50	15.33	31.10	39.66	0.090	1.51	2.54	6.30
	MSD	7.66	9.00	9.52	10.33	22.60	29.73	0.064	0.77	1.92	3.92
	TD	—	10.00	11.60	—	28.93	36.50	—	1.16	2.12	6.05
	CD at 5%	2.83	1.48	2.97	4.11	7.74	8.31	0.014	0.217	0.557	0.944

TABLE II. Effect of defoliation treatment on the nodal root characters of wheat varieties (per plant data)

Variety	Treatment	Nodal root number Stage			Nodal root length (cm) Stage			Nodal root weight (g) Stage			
		I	II	III	I	II	III	I	II	III	IV
C 306	Control	3.65	6.33	12.33	6.33	22.30	23.80	0.035	0.91	2.22	8.52
	Mother shoot defoliated (MSD)	3.33	3.66	6.33	4.13	12.46	15.86	0.025	0.45	1.35	2.67
	Tiller defoliated (TD)	—	6.33	7.00	—	17.33	17.36	—	0.72	1.92	5.68
HD 1553	Control	3.00	6.00	11.33	4.13	17.50	26.33	0.016	0.59	1.76	4.68
	MSD	1.66	4.00	6.66	2.16	10.93	16.30	0.019	0.26	1.59	3.36
	TD	—	5.33	9.33	—	11.83	21.06	—	0.33	1.50	3.73
NP 846	Control	3.33	8.00	10.66	3.33	15.23	22.06	0.015	0.27	1.04	3.18
	MSD	2.00	4.66	8.33	2.63	10.06	14.16	0.012	0.18	0.83	2.19
	TD	—	6.66	10.00	—	10.73	17.56	—	0.27	0.93	2.73
HD 1593	Control	4.00	7.66	15.00	7.50	14.43	22.60	0.066	0.88	2.26	5.29
	MSD	3.33	6.00	8.00	3.86	10.80	13.60	0.021	0.38	1.25	2.82
	TD	—	7.33	12.66	—	13.03	18.03	—	0.75	1.84	4.34
	CD at 5%	1.988	1.817	2.65	2.25	4.58	4.46	0.016	0.306	0.33	1.19

NP 846 but the effect in variety C 306 was not significant at any stage. It was also observed that the reduction by mother shoot defoliation was considerably more than that with tillers defoliation (Table I).

Nodal root production was significantly lowered by the mother shoot defoliation at 2nd and 3rd stages in varieties C 306, HD 1553 and NP 846. The reduction was not significant at 1st stage in all the varieties and at 2nd stage to HD 1593. The defoliation of tillers did not bring any significant effect on nodal root number in varieties HD 1553, NP 846 and HD 1553 at 2nd and 3rd stage and in C 306 at 2nd stage, however, the adverse effect was noted in C 306 at 3rd stage (Table II).

The length of seminal root was significantly reduced by mother shoot defoliation treatment at 2nd and 3rd stage in varieties C 306, HD 1553, HD 1593, whereas in variety NP 846, the reduction was significant only at 3rd stage. The tiller defoliation did not affect the seminal root length at 2nd stage in C 306, HD 1593 and NP 846, however, the adverse effect of this treatment was significant in variety HD 1553 at 2nd and 3rd stage and in NP 846 at 3rd stage (Table I).

The elongation of nodal root was significantly lowered by mother shoot as well as the tiller defoliation in all the varieties at 2nd and 3rd stage. The mother shoot defoliation also reduced the nodal root length in varieties C 306 and HD 1593 at the 1st stage (Table II).

Mother shoot defoliation brought about a significant reduction in the dry weight of seminal roots in all the varieties, however, the reduction was not significant at 1st and 4th stage in NP 846 and at 3rd stage in HD 1553. The defoliation of tillers did not significantly affect the dry matter production of seminal roots in all the varieties except at 2nd stage in variety HD 1593.

Dry weight of nodal roots was significantly depressed by mother shoot defoliation in varieties C 306, HD 1553 and HD 1593. The reduction was not significant in variety NP 846 at any stage of growth. The tiller defoliation did not affect the dry weight of nodal roots significantly. It was also seen that the adverse effect of defoliation was more pronounced in the nodal root characters (length and weight) than in those of seminal roots (Table II).

The data on the percentage distribution of ^{14}C in roots and upper plant parts of variety HD 1593 are given in Table III. It was observed that the mother shoot leaf feeding treatment resulted in the accumulation of more ^{14}C in nodal and seminal roots as compared to the tiller leaf feeding treatment. It was also seen that the recovery of ^{14}C was more from roots at tillering stage (35 days) than those of earing stage (45 days). The accumulation of ^{14}C was more in nodal roots as compared to seminal roots in mother shoot leaf feeding treatment, whereas no such difference was found in tiller leaf feeding treatment.

TABLE III. Percentage distribution of ^{14}C photosynthate to roots and above ground parts at the nodal root growth and preanthesis stage in wheat variety HD 1593 (CPM values)

	35 days stage		45 days stage	
	Mother shoot leaf fed	Tiller leaf fed	Mother shoot leaf fed	Tiller leaf fed
Nodal root	6.89	3.39	3.47	2.96
Seminal root	5.41	3.80	2.53	2.61
Mother shoot	3.12	5.08	3.37	3.15
Tiller 1	3.50	4.53	2.37	1.77
Tiller 2	1.00	3.95	1.75	1.91
Tiller 3	0.57	1.40	1.03	2.24
Fed leaf	79.47	77.82	85.45	85.32

DISCUSSION

It is clear from the observations discussed in this study that the root growth in wheat varieties depends, to great extent, on the photosynthates translocated from the leaves. The contribution of mother shoot appeared to be quite substantive as compared to tillers. It can be noted here that tiller formation starts 25 to 30 days after sowing and the translocation flow pattern of photosynthates for root growth is being determined earlier (Broawer and De Witt, 1969) so that there should be no dearth of photosynthates at the tillering time when nodal roots start appearing. In the beginning, tillers depend for their own growth on the mother shoot which is the largest source not only for root growth but also for tiller development. However, in the later stage when tillers start playing their role as source another important and powerful sink (ear head) starts developing at the same time. This changes the course of translocation due to competition between two sinks, i. e., root and ear. The earlier dependence of tillers on mother shoot and the later changes in the flow of photosynthates might probably be the reason for the comparatively small effect of tiller defoliation for root growth.

Nodal root characters such as length and weight were more affected by defoliation treatment than those of seminal roots. It may be emphasized here that seminal roots initiate immediately after sowing and their growth most probably depend on the nature and size of seeds of wheat varieties (Uprety *et al.*, 1981). Jesco *et al.* (1971) explained that after the exhaustation of the endosperm, the growth of both existing seminal roots and newly developing nodal roots depends on the pool of photosynthates. The crown roots which are located in the nodes are nearer the source (leaves) as compared to seminal roots; supporting the 'near sink hypothesis' of Brouwer (1963) the present study also showed that crown root growth was more influenced by the photosynthates than that of far situated seminal roots. It appears that the mother shoot defoliation did not significantly affect