https://doi.org/10.29321/MAJ.10.A04067

Tiller and Main Shoot Relationship in *Setaria Italica* Beauv., (Tenai or the Italian Millet)

By

CHARLES RATNASWAMY

Introduction: The economic importance of the tillering habit in cereals is not new to the plant breeder and studies on the inter-relationship between the tillers and the main culms of cereals have received some attention in the past. In *Setaria italica* Beauv., (the Italian Millet) three high yielding strains Co. 1 and Co. 3 with free tillering and Co. 2 with stray-tillering habits have been evolved by pure line selection at the Millets and Pulses Breeding Station, Coimbatore. Work done on the inheritance of this habit has indicated that it is not only heriditary but also influenced by evironment to certain extent (Charles Ratnaswamy 1956–'57). The tillers not only develop from the base of the main culm but also from the nodes higher up on the main culm and the tillers. In the early stages of growth whenever the basal nodes come in contact with the soil, the roots from this region are induced to grow and function as normal ones and the axillary buds from the basal nodes develop into tillers. The tillers which develop from the base have direct contact with the soil through the adventitious roots developed later from their basal nodes, whereas those which develop from nodes a few inches above, do not contact the soil through roots. In a free-tillering variety the total number of tillers produced may be upto fifteen and varieties which do not tiller are also common. Interest in the possibilities of improving the productive capacity of a crop has increased during the recent years and the primary object of the plant breeder being to exploit the resources of yield potential of a particular crop, a study on the fundamental aspect of the tillering habit in *Setaria italica* Beauv., was taken up to find out information which can be focussed on the improvement of this crop.

Review of Literature: Engledow and Wadham (1924), in their investigations of yield in barley, surmised from more or less circumstantial evidence that tillers may be indcpendant units after the early stages of growth. Godbole (1928) in his studies on the Bajri crop had recorded the possibility of a greater portion of axillary shoots among tillered plants than among those without tillers. He observed that the environment which favoured tillering may also favour branching, or it may be that plants which tended to produce tillers also tended to produce the axillary shoots. Dungan (1931) had found that tillers or 'suckers' of corn under some conditions contributed to grain production of the main stem. Further, he had shown that suckers can contribute to the nourishment of the main stem when the latter had been stripped of its leaves. Smith (1933) had studied the physiological relationship between the tillers and the main stem of wheat plant and had come to the conclusions that translocation between the culms after the flowering period was possible, but was probably unimportant in the normal plant. Water from the roots was distributed evenly between all tillers irrespective of individual tillers to which roots were directly attached. Leaf blades, stem and ear of a culm each contributed about equally to the dry matter in the grain. Bartel *et al* (1935) found evidence that plant juices in Dwarf Hegari move from the main stalk to the tillers or from the tillers to the main stalk, depending upon where the nutritional deficiency occurred. Rosenquist (1941) had recorded in corn that tillers depended upon the main stalk for their very subsistence and as a consequence dry weights of both main stalks and tillers were greatly reduced when tillers of plants were covered to exclude light and prevent photosynthesis. Labanauskas *et al* (1956) have studied the inter-relationship of the tillers and the main stems in oats and concluded that the undisturbed main stem of oats was not affected materially by tillers, although translocation of nutrients can take place under certain conditions, viz., when blades were removed from the main stem or tillers, and when panicles were removed and blades remained intact. Defoliated tillers benefited from an undisturbed main stem in order of their age. Further they have observed that the performance of any stem appeared to be influenced by the favourable conditions surrounding other stems of the same plant.

Although literature on the inter-relationship of tillers and main culm is available, no work seems to have been done on the variation between the different types of tillers and the relationship of the tillers which do not have direct contact with soil through roots with regard to yield, to the main culm and tillers on which they develop, in any of the cereals and this is the first instance wherein a report on such an investigation in *Setaria italica* Beauv., (the Italian millet) is presented.

Materials and Methods: The details of origin and habit of growth of strains chosen for this study are given in Table I.

TABLE I

Strain No.	Origin.	Habit of growth.
1. Co. 1	Mosu Tenai of Coimbatore	Tillering.
2. Co. 3	Perum Tenai of Coimbatore	Tillering.

Both Co. 1 and Co. 3 take about 50 days to flower. The tillering varieties begin to tiller from 18 to 20 days after the seed germinates.

The studies reported in this paper were conducted in 1956 (summer season) at the Millets and Pulses Breeding Station, Coimbatore. The seeds were sown in the field during the first week of April and the crop was harvested towards the end of July. Detachment of the tillers from the main culms was done by cutting with a scissor. Defoliation was done with the scissor, cutting the leaf blades close to the sheath. The flowering dates for each plant were recorded and as the crop matured, the maximum height, length of the main panicle and length of the fourth internode and leaf in centimeters and the weight of the main panicle in grams were recorded. The grain from each panicle was stripped separately and the weight of the dry grain in grams was recorded.

Experimental data: *Experiment I.* To investigate the relationship of the rooting tillers to the main culm, the following experiment was laid out. Early in the tillering stage of the crop a total of 100 plants with three such tillars which have root contact with the soil were chosen in both the strains Co. 1 and Co. 3. The tillers were detached in a group of fifty plants leaving the rest for comparison. Whenever fresh shoots developed from the treated plants, they were cut and removed. After the crop matured, the quantitative characters were measured to find out the variation in growth between the normal and the treated plants. Table I and II present the data taken in this regard.

TABLE I

Treatment I. Variation between the treated and the control plants of Co. 1 (Mean of 50 plants)

Characters of main culm.	Control	Treated.
1. Maximum height in cms.	90·14 ± 1·21	105·23 ± 1·36
2. Length of the main panicle in cms.	9·67 ± 0·41	11·12 ± 0·52
3. Weight of the main panicle in cms.	3·02 ± 0·08	2·31 ± 0·07
4. Weight of the grain from main panicle in gms.	1·20 ± 0·10	1·40 ± 0·06
5. Length of the fourth internode in cms.	6·91 ± 0·57	8·01 ± 0·52
6. Length of the fourth leaf in cms.	35·23 ± 0·72	38·91 ± 0·81
7. Days to flower.	64·50 ± 0·15	66·20 ± 0.12

TABLE II

Treatment I Variation between the treated and the control plants of Co. 3. (Mean of 50 plants)

Characters of main culm	Control	Treated
1. Maximum height in cms.	97·65 ± 1·33	11·27 ± 1·65
2. Length of the main panicle in cms.	13·95 ± 0·40	14·96 ± 0·50
3. Weight of the main panicle in gms.	257· ± 0·09	3·32 ± 0·10
4. Weight of the grain from main panicles in gms.	1·72 ± 0·06	2·21 ± 0·07
5. Length of the fourth internode in cms.	7·45 ± 0·59	8·70 ± 0·50
6. Length of the fourth leaf in cms.	39·45 ± 0·82	43·29 ± 0·80
7. Days to flower	62·39 ± 0·16	64·00 ± 0·12

Experiment II: To investigate the relationship of the tillers which have no contact with the soil through roots to the main culm, the following experiment was laid out. Early in the tillering stage of the crop a total of 150 plants with two such tillers alone was chosen in both the strains Co. 1 and Co. 3. These tillers were detached in the first group of fifty plants and the leaf blades of these tillers were detached in the second group of fifty plants leaving the rest for comparison. After the crop matured the quantitative characters were measured to find out the variation in the growth between the normal and the treated plants. Tables III and IV present the data taken in this regard.

TABLE III

Treatment II Variation between the treated and the control plants of Co. 1 (Mean of 50 plants)

Characters of main culm	Control	Treated	
		Tillers detached	Leaves of tillers detached
1. Maximum height in cms.	91·12 ± 1·01	90·68 ± 1·10	85·34 ± 1·34
2. Length of the panicles in cms.	10·10 ± 0·36	9·81 ± 0·36	7·24 ± 0·33
3. Weight of the main panicle in gms.	2·10 ± 0·09	2·07 ± 0·07	1·60 ± 0·07
4. Weight of the grain from main panicle in gms.	1·24 ± 0·06	1·2I ± 0·07	0·98 ± 0·08
5. Length of the fourth internode in cms.	6·72 ± 0·49	6·82 ± 0·55	5·34 ± 0·51
6. Length of the fourth leaf in cms.	34·96 ± 0·76	35·25 ± 0·75	33·12 ± 0·73
7. Days to flower	64·40 ± 0·16	64·51 ± 0·14	66·12 ± 0·12

TABLE IV

Treatment II Variation between the treated and the control plants of Co. 3. (Mean of 50 plants)

Characters of main culm	Control	Treated	
		Tillers detached	Leaves of tillers detached
1. Maximum height in cms.	98·13 ± 1·26	99·01 ∓ 1·10	92·92 ± 1·22
2. Length of the main panicle in cms.	14·02 ± 0·38	14·51 ± 0·40	10·13 ∓ 0·42
3. Weight of the main panicle in gms.	2·59 ∓ 0·09	2·61 ∓ 0·08	2·01 ∓ 0·08
4. Weight of the grain from main panicle in gms.	1·55 ± 0·06	1·56 ∓ 0·09	1·19 ∓ 0·10
5. Length of the fourth internode in cms.	7·50 ± 0·61	7·48 ± 0·59	6·01 ± 0·46
6. Length of the fourth leaf in cms.	38·96 ∓ 0·82	38·26 ± 0·79	36·13 ∓ 3·83
7. Days to flower	62·50 ± 0·14	62·60 ± 0·16	63·45 ± 0·20

Discussion: Engledow and Wadham (1924) have used the term 'tiller' to describe all the side shoots from the main stem. The main stem was thus not regarded as a 'tiller'. Accepting this usage of the world 'tiller', the American word 'culm' has come into use to describe the ear-bearing stems, including the main stem. The two terms thus overlap, but the main stem was not classed as a 'tiller' and tillers which fail to bear ears were not classed as culms. Godbole (1924) in his studies on the bajri *(Pennisetum typhoides)* crop has termed the basal side shoots as the tillers, as differentiated from the main stem and other side shoots which develop above the soil surface as the axillary branches. *In Setaria italica* Beauv., the basal side shoots root and have direct contact with the soil whereas the side shoots which develop from the nodes above the ground level do not root and as such have no contact with the soil directly. From the present investigation it will be seen that there is definite difference between these shoots in the physiological behaviour. When the former were detached, the main culm showed an increased growth whereas in the case of the other types of shoots which have no contact with the soil separately when detached, the main culms showed neither increased nor decreased growth. But when the leaf blades of such shoots were detached, the growth of the main culm was reduced. Although both the types of shoots can be grouped as tillers, it would appear more reasonable as is seen from the physiological behaviour, to classify the former. i. e., the shoots which develop at the basal culm and have root contact with the soil, as the *primary tillers* and the latter i. e., those which develop from the nodes above the soil surface and which have no contact with the soil separately as the *secondary tillers* (Figure 2).

TABLE V

Proportionate development of secondary tillers with primary tillers in the strain Co. 3 (summer 1957)

	Plants with no. of secondary tillers															Total
0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Plants with no. of primary tillers 0	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20
1	22	2	...	...	...	...	...	...	...	...	...	...	...	...	...	24
2	44	14	5	...	...	...	...	...	...	...	...	...	...	...	...	63
3	76	2	1	...	2	...	...	...	...	...	...	...	...	...	...	81
4	90	20	12	2	...	2	...	...	...	...	...	...	...	...	...	126
5	94	18	9	9	...	1	...	...	...	...	...	...	...	...	...	131
6	98	18	3	3	7	1	2	...	...	...	1	...	...	...	...	133
7	56	12	14	8	3	...	...	...	2	...	...	...	...	...	1	96
8	36	16	7	2	4	...	1	...	...	...	1	...	...	...	1	68
9	34	6	11	6	5	1	1	...	...	...	...	...	...	1	...	65
10	16	6	2	1	2	1	...	...	...	...	...	...	...	...	...	28
11	16	8	12	5	2	3	...	...	...	...	...	...	...	1	...	47
12	6	4	1	2	4	1	...	...	...	...	...	...	...	...	...	18
13	4	4	9	3	2	1	...	...	...	...	...	...	...	...	...	23
14	6	4	1	1	1	...	...	...	...	...	...	...	...	...	...	13
15	6	2	5	2	1	...	...	...	...	...	...	...	...	...	...	16
16	...	2	...	1	1	...	...	...	...	...	...	...	...	...	...	4
17	...	...	1	1	1	...	2	...	...	...	...	...	...	...	...	5
18	...	2	1	3	...	...	...	...	...	...	...	...	...	...	...	6
19	...	...	1	1	1	...	...	...	...	...	...	...	...	...	...	3
20	...	...	1	1	1	...	...	...	...	...	...	...	...	...	...	3
21	...	2	...	1	...	2	...	...	...	...	...	...	...	...	...	5
22	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	1
23	...	2	1	1	...	1	2	...	...	...	...	...	...	...	...	7
24	...	...	1	1	1	1	...	1	...	...	...	...	...	...	...	5
25	...	...	1	...	1	...	...	1	...	...	...	...	...	...	...	3
26	...	...	...	1	...	...	...	...	...	1	...	...	...	...	...	2
27	...	...	...	1	...	...	...	...	...	1	...	...	...	...	...	2
28	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	1
29	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	1
Total	624	144	100	56	39	15	8	2	2	4	2	...	...	2	2	

Proportionate development of primary and secondary tillers : From the data presented in Table V it will be seen that the plants with greater number of primary tillers favour the production of secondary tillers. As Godbole (1928) has recorded in the case of Bajri, perhaps availability of more nutrition for proper development favour the production of both the types of tillers.

Primary and secondary tillers as related to the main culm: From a perusal of the data presented in Tables I and II it will be seen that the amounts of grain produced on the main culms with detached primary tillers were 16·7% and 28·5% more in Co. 1 and Co. 3 respectively than that produced on the main culms with tillers undisturbed. In the case of a normal plant, the evidence for the translocation of food materials from the tillers to the main culm and vice versa is difficult to determine under field conditions. However, the data from this experiment suggest that the main culm is able to utilise the food materials drawn from the soil by the roots of the primary tillers. When the secondary tillers were detached the main culm showed neither increased nor decreased growth. But when the blades were removed from these tillers the main culm showed decreased growth, as it was deprived of a part of its grain-forming materials required by its defoliated secondary tillers. The losses in grain weights by the main culm, due to the defoliation of the secondary tillers, were 21% and 20·8% in the case of Co. 1 and Co. 3 respectively. From this evidence it is reasoned that the secondary tillers develop from the nodes with the extra nutrients left unutilised by the main culm. About 45 to 50 days after the germination of the seed, the secondary tillers commence to develop. But the primary tillers develop earlier by about 18 to 20 days after the seed germinates. In the case of the primary tillers, immediately after the tillers develop from the basal culm the roots also develop simultanesously from the base of the respective tillers. Hence the primary tillers are able to utilise the nutrients drawn from the soil by their own roots.

Practical application of the finding: Early in the tillering stage of the crop, the primary tillers were detached with a few roots and transplanted to study the tillering behaviour. The production of primary tillers was much less, but each of the transplanted tiller developed more than four secondary tillers. It is concluded that with suitable environment, production of secondary tillers can be improved to increase the ultimate yield of a particular plant. Such increased availability of nutrients with favourable conditions of growth may correspondingly increase the productive capacity of the plant. Recent studies conducted on the subject of plant response to different types of soils of varying fertility have indicated the close relationship of root and shoot development to the soil fertility (Charles Ratnaswamy, 1956). The present study indicates the possibility of obtaining increased yield in the tillering varieties of Tenai by manuring the crop with readily available plant nutrients.

Summary: The tillering varieties of Tenai (*Setaria italica* Beauv.,) have been noted to produce two different types of tillers and the present studies have been made to determine the variations between them. The side shoots developing from the basal nodes of

the main culm and which have root contact with the soil separately are termed as the *primary tillers* while the shoots developing a little above the base and which remain without root contact with the soil separately are termed as the *secondary tillers.* Availability of more nutrition for proper development favours the production of both the type of tillers. The primary tillers, after the formation of their own adventitious roots, function independently. But the main culm gets the benefit of the plant nutrients absorbed by the roots of the primary tillers when it is not required by the latter. The secondary tillers develop from the nodes with the extra nutrients left unutilised by the main culm or the primary tillers from which they grow. It is suggested therefore, that more yield can be obtained from the tillering varieties of Tenai by manuring the crop with more of readily available nutrients.

REFERENCES.

Bartel, A. T. *et al* 1935 Effect of tillers on the development of grain sorghums. Jour. Amer. Soc. Agron. 27 : 707—714.

Charles Ratnaswamy, M. 1956 Root anatomy in Tenai (*Setaria italica* Beauv.,) with special reference to soil variation - A preliminary study. Read at the VI Scientific workers' conference, Coimbatore 1956.

Charles Ratnaswamy, M. *et al* 1957 Improvement of *Setaria italica* Beauv., (The Italian millet) Ind. J. Agron II. 5-11.

Dungan, G. H. 1931 An indication that corn tillers may nourish the main stalk under some conditions. Jour. Amer. Soc. Agron. 23 : 662—670.

Englodow, F. L. *et al* 1924 Investigations on yield in the cereals I, Appendix III - J. Agric. Sci., 14 : 80—85.

Godbole, S. V. 1928 Studies on the Bajri crop. 1. The Morphology of *Pennise um typhoideum.* Mem. Dept. of Agri. in India Bot. Ser. XIX : 247—268.

Labanauskas, C. K. *et al* 1956 Inter-relationship of tillers and main stems in oats. Agron. Jour. 48 : 265

Rosenquist, C. E. 1941 The effect of tillers in corn upon the development of the main stalk. Jour. Amer. Soc. Agron 33 : 915.

Smith, H. F. 1933 The Physiological relations between tillers of a wheat plant. Jour. Council Sci. and Indust. Res. Australia 6 : 32—42.

FIG. 1. Tenai plants showing variation in tillering.

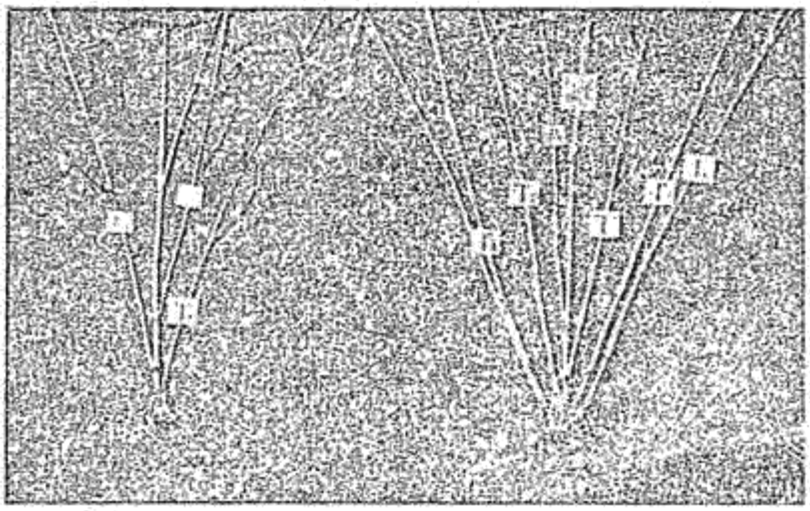

FIG. 2. Two Tenai plants spread out to show the different types of tillers.

M — Main Culm.

T1 to T6 — Primary tillers.

A1 to A3 — Secondary tillers.