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PLANT TYPE—SOME STRUCTURAL CONSIDERATIONS FOR HIGHER YIELD POTENTIAL IN RICE

B. VENKATESWARLU AND T. L. ACHARYULU
All India Coordinated Rice Improvement Project
Rajendranager, Hyderabad-500 030, A. P.

SUMMARY

The physical lengths, dry matter distribution among the parts of phytomers and diameter of internodes of Jaya variety were compared. The leaf blade was 18-20 times longer and the sheath length 2-6 times than the respective internode (s) in the main shoot which amounts to greater drain of biological energy. The lengths of peduncle and panicle formed 50% of the total height. The translocation of the assimilates take a long course to reach panicle as they pass through sheaths and stem from the blades. Appropriate dimensions were projected to avoid imbalanced organ growth, energy drain and to strengthen stem and shorten the route of assimilates.

INTRODUCTION

In recent times tailoring of morphological architecture with an appropriate blend of profuse tillering and short culm served as a route for increased yield potential. Further, short and erectofile orientation of leaves facilitated greater interception of solar radiation. However, it was only a shift from lousy tallness to active short stature resulting in increased harvest index from 20-26 to 50%, but the phytomer dimensions and the distribution of the photosynthetic products among different organs did not receive adequate attention. This paper discusses the recent efforts made on the phytomer analysis and their dry matter distribution with a focus on the ideal combinations for furthering the yield potential.

MATERIALS AND METHODS

Jaya, a short statured variety representing medium duration group and possessing high yield potential, was grown under field conditions with a density of 50 hills/sq. m. and maintaining at 80 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha. The crop was managed by adopting appropriate plant protection measures. Observations were recorded on the length and weights of all the internodes and the respective sheaths and blades of the main shoots by dissecting the plants at flowering. The diameters of all the internodes including the peduncle were recorded. Based on the observations, conceptual models for sheaths, internodes and their respective proportions including required sizes of panicle and peduncle were projected diagramatically.

RESULTS AND DISCUSSION

In general, 12-14 leaves were formed on the main shoots of rice from the time of germination and the earlier formed leaves, i. e., 4-6 at planting gradually dried up and were not considered in these studies. Rice plant is an assemblage of phytomers of different ages. A phytomer consists of a node (internode) with its respective sheath and the blade. The leaf blade length (Figs. 1 and 2) gradually increased reaching maximum at 6th node (50 cm) and decreased while the length of the sheath did not alter much irrespective of the position. However, relatively the sheath is 12 times more than the 2nd internode and as the internode's length was increasing, the proportion of the respective length of sheaths ranged 2.5 to 6.0 times, and the 7th and 8th nodes showed only an increase of 44 and 45%, respectively. Thus, the sheath at one node clasps or extends 2 to 6 times its respective internode and as a result the stem is wrapped alternately with sheaths till the peduncle and dominate the stem.

The leaf blade was also several times longer than internodes exhibiting a range of 18 to 20 times and at peduncle (flag leaf) the blade was shorter by 12% of its sheath. However, the length of sheaths and blades was constant. This situation suggests that the length of sheath and the blade individually showed several times more than the respective internode inferring lot of drain of biological energy in their formation. Out of a total length of 90 cm of the main shoot, the peduncle

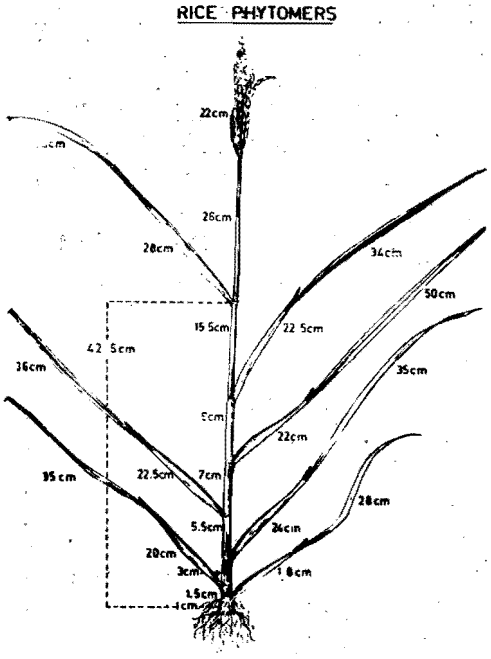

Fig. 1. Dimensions of rice phytomers (main shoot of Jaya).

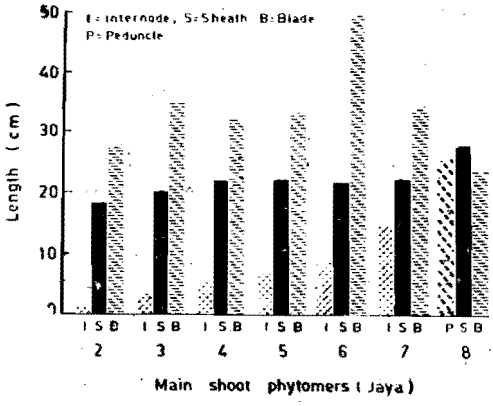

Fig. 2

and the panicle formed around 50% of the height. Peduncle is the longest structure (26 cm) followed by the panicle (22 cm).

Primordial initiation occurs around 4th to 6th node after planting and there would be serious competition for the assimilates due to the synchronous development of the panicle, stem, sheaths, leaves and roots. Hence, directed and balanced sharing of the photosynthetic products would condition or determine the respective levels of growth and productivity.

Observations on dry matter distribution among the three different organs indicated that internodal weight increased upto fifth and started decreasing recording lower value at peduncle (Table I). This shows although peduncle was several times longer (2 to 8 times) than the internodes, the weight was equal to 3rd internode and lower (158 mg) to 4th internode. The sheath weight also showed the same trend while the blade weight showed a fall from sixth node onwards. In general, the mean values indicated (Fig. 3) that the dry matter

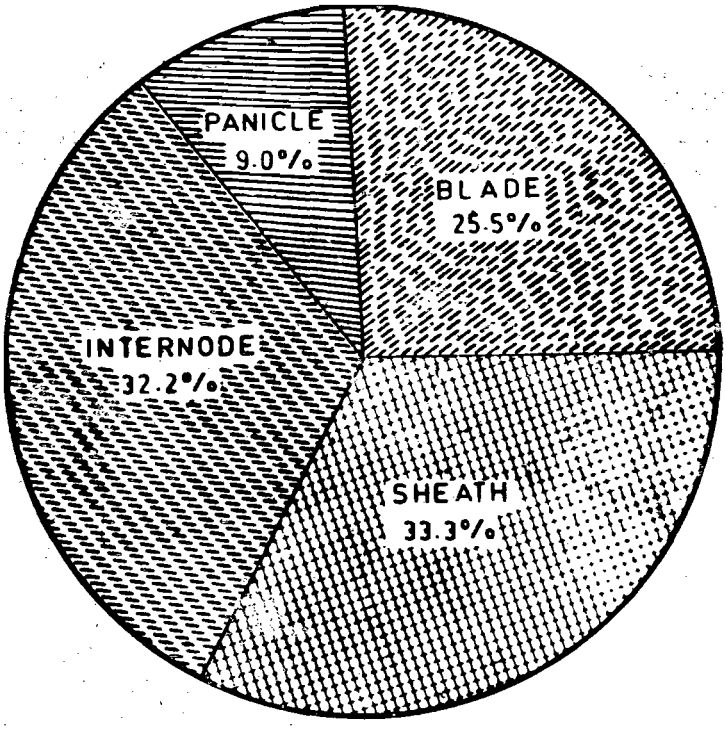

Fig. 3. DISTRIBUTION OF DRY MATTER IN MAIN SHOOT AT FLOWERING
(JAYA)

TABLE I. Dry matter distribution (mg) in different organs of the main shoot and diameter of internodes (mm)—Variety : Jaya

Leaf no. from base	Blade	Sheath	Internode	Blade weight as % of internode weight	Sheath weight as % of internode weight	Internode diameter (mm)
1	—	—	91	—	—	7.0
2	85	86	140	61	61	5.3
3	130	129	157	83	82	4.9
4	172	263	242	71	109	4.5
5	193	308	261	74	118	4.1
6	225	280	226	113	124	3.7
7	206	219	218	94	100	3.2
8	140	260	158*	89	164	2.3
Mean	168.7	220.7	186.6	83.6	108.0	4.38

*Peduncle

accumulation was greater in sheath (1545 mg) followed by the internode (1493 mg), the blade (1181 mg) and lowest in panicle (420 mg). Greater size and weight of sheaths and blades amount to greater expenditure of the assimilates in the structural formation. Hence, balanced development oriented for favoured panicle growth is essential for higher productivity.

Although rice plant depends on current photosynthetic products for yield (Yoshida and Ahn, 1968; Cock and Yoshida, 1972; Venkateswarlu *et al.*, 1977) considerable proportions of accumulated reserves also contribute to yield. Varietal differences in the utilization of accumulated reserves were also reported by Yoshida and Ahn (1968) and Venkateswarlu *et al.* (1977) even among the same duration groups. It was felt that reserves buffer in stress situations paying premium over those cultivars that do not maintain them. This means that for productivity purposes the photosynthetic products are to be translocated from the leaves to the panicle via sheaths and stems. This is a long route. Further, as the contribution of the panicle to grain yield was very limited (8-23 %) Enyi (1962) and (13.1 to 19.7%) Venkateswarlu (1976), the panicle depends heavily on the products from the shoot system. Therefore, a shorter translocation path would have apparent advantages for effective utilization of the assimilates. Moreover, in these observations stem emerged to be weak and depends heavily on the sheaths for its strength. This means that the sheath is a primary reservoir of assimilates and the stem only secondary. Considering the disease and pest complex, it is also always advantageous to have stronger stems irrespective of the size of the sheaths. However, development of a balanced phytomer is ideal. The diameter of the internodes showed that it gradually decreased from the base (7.0 mm) towards the panicle (2.3 mm). The diameter dimensions of the internodes infer the thinness of the culm.

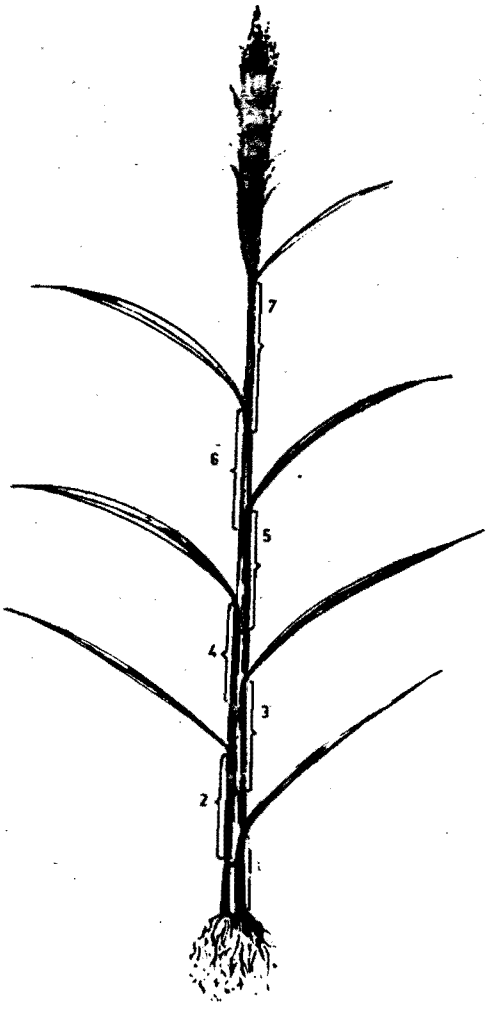

Fig. 4. Conceptual projection of the length of sheaths in relation to internodes.

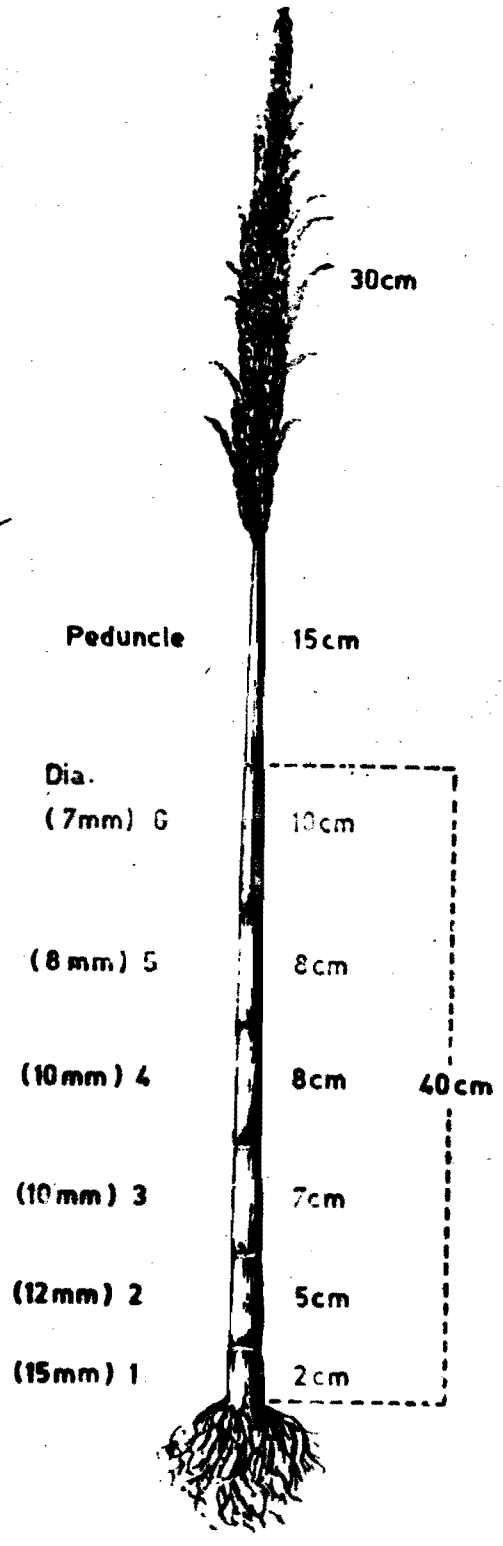

Fig. 5. Desired diameters and lengths of internodes including peduncle and panicle. →

In view of these observations, it was felt desirable to reduce the length of the sheaths to the size of 25% more than its own internodal length. This retains the clasping margins covering nearly 25% of the succeeding internode. It is likely that such arrangement will cater to the requirements of strength of the plant (Fig. 4). Again diameter of the internodes could be more observing the pattern of the natural trend but preferring 15 mm at base and ending with 7 mm at the peduncle. Experience shows that there were some varieties in the germplasm bank with varied sizes of stems which calls for proper identification and utilisation in the plant improvement programmes. The peduncle size could be less or reduced to around 15 cm and the panicle size increased proportionately. This means for the same height of the plant, the peduncle and the panicle sizes could be altered giving preference to panicle as shown in Fig. 5. It is well known that panicle development depends on the assimilates gathered by the leaves 4, 5 and 6 after planting as reported by Tanaka (1961a). Therefore, reduction in the size of the sheaths and increase in the diameter and weight of the internodes would be more advantageous for the production of larger panicle and greater number of spikelets. This also shortens the path of assimilates to the panicle and promotes stem as a major reservoir. The present projection of the size of the panicle works out to 25% of the total length of the stem. Thus, a closer examination and analysis at the organ level may lead to the identification of ideal combinations to minimise drain of energy from imbalanced growth of organs and direct the assimilate supply for enhanced sink size raising the yield potential. Studies are in progress on the relevant organ-organ relationships, optima and dimensions with different plant types.

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REFERENCES

Rnyi, B. A. C. (1962). The contribution of different organs to grain weight in upland and swamp rice. *Ann. Bot.* N. S., **26** : 529-31.

Cock, J. H. and Yoshida, S. (1972). Accumulates of C^{14} labelled carbohydrates before flowering and subsequent redistribution and respiration in the rice plant. *Proc. of the Crop Sci. Society of* Japan, **41** : 226-34.

Tanaka, A. (1961a). Studies on the nutrio-physiology of leaves of rice plant. *J. Fac. Agric., Hokkaido Univ.*, **51** : 449-550.

Venkateswarlu, B., (1976). Source-sink interrelationships in lowland rice. *Plant and Soil*, **44** : 575-86.

Venkateswarlu, B., Suryaprakasha Rao, J. and Rao, A. V. (1977). Relationship between growth duration and yield parameters in irrigated rice (*Oryza sativa* L.). *Indian J. Plant Physiol.*, **20** : 69-76.

Yoshida, S. and Ahn, S. B. (1968). The accumulation process of carbohydrates in rice varieties in relation to their response to nitrogen in the tropics. *Soil Sci. Plant Nutr.*, **14** : 153-62.