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Cultivation and Ecophysiology of Rice Plants in the Tropics*

V. Yield and yield components of several rice cultivars of India, grown under usual cultural methods

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Abstract : The grain yield and the yield components of Indian rice cultivars grown in 1985 wet season were studied. The results revealed that the yield was largely dependent on the number of spikelets per panicle and percentage of ripened grains. The number of spikelets per panicle was not correlated with the number of panicles per hill. One thousand-grain weight, length of panicle and leaf area of the four uppermost leaves seemed to have no significant effect on grain yield. The highest grain yield of 'Vijayamahsuri' among cultivars tested attributed to the greatest number of panicles per hill, a relatively great number of spikelets per panicle and a high percentage of ripened grains. The second highest yield was obtained with 'Sonamahsuri'. Both cultivars showed the same length of panicle as well as the first internode and the lower the internode, the shorter the length with similar tendency. Between two scented cultivars, 'HR 59' produced a higher yield than 'Basmati' at normal planting depth of 8-9 cm. 'Basmati', however, produced higher grain yields when transplanted at a shallow depth (2-3 cm). Although the number of panicles were nearly the same in both scented cultivars, the leaf area was larger in 'HR 59' than in 'Basmati'. Lodging in 'Mahsuri' and 'HR 59' were observed due to the elongation of lower internodes.

Key words : Internode, Lodging, *Oryza sativa* L., Planting depth, Varietal characteristics, Yield component.

熱帯地域における稲作およびその生態生理学的研究　第5報　インドにおける数種栽培稲の収量および収量構成要素：谷山鉄郎・池田勝彦・S.V. スバイヤ*・M.L. ナラシマ・ラオ*・S.K. シャルマ*(三重大学生物資源学部・*インド国立稲作総合研究所)

要　旨：収量調査には Vijayamahsuri, Sonamahsuri, Mahsuri, Basmati, HR 59 の5品種を用いた．Mahsuri は東南アジアで比較的広く栽培されていると共に，Vijayamahsuri や Sonamahsuri の交配母本でありすぐれた品種でもある．一株当り穂数は Vijayamahsuri と Basmati の浅植えで多く，他の品種は少なく7本程度であった．一穂当り籾数は Mahsuri が多く，ついで Vijayamahsuri であった．香り米の Basmati は最も少なかった．千粒重は一般的に日本型水稲に比較して著しく低かった．収量は Vijayamahsuri がすぐれ，ついで Sonamahsuri であった．HR 59 と Basmati は低かった．浅植えした Basmati は穂数と登熟歩合の増大で深植え（慣行植え）に比較して増収した．Mahsuri は肥沃土または多肥栽培では倒伏しやすく，本調査水田地域においても，大部分が登熟後期に倒伏した．倒伏は大別して3種類の型があり，上位第1または第2節間の挫折が最も多かった．倒伏の主因はこれら上位の節間が日本型水稲に比較して長いことによるものといえよう．Vijayamahsuri と Sonamahsuri は日本型水稲に類似した節間伸長を示した．インドの稲作は施肥量の増大につれて増収していることから，今後，肥培および水管理技術の向上につれて増収していくものと思われる．

キーワード：植付けの深さ，栽培稲，収量構成要素，節間，倒伏，品種特性．

The introduction of modern high-yielding cultivars to rice cultivation of India, significantly increased grain production. However, the long-culmed cultivars are still grown in some locations of the country. In general, long-culmed varieties with droopy leaves are poor yielders compared with modern cultivars. Mostly, those of fine quality types are long-culmed cultivars with poor yield, while high-yielding varieties are of coarse type. The traditional rice cultivars which differentiated through a long history of adaptation to various environment, are now facing extinction due to the recent introduction of improved modern varieties. Collection and conservation of useful germplasms would be of immense value for future plant breeding programs. Germplasm

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would be of use only after proper evaluation for their characteristics. Hence, in the present study, several rice cultivars with almost similar 1000-grain weight were studied especially on the varietal difference in plant characters related to the process of yield contribution. As far as varieties with similar 1000-grain weight are concerned, the 1000-grain weight slightly influences the grain yield and thus can be disregarded[6]. One important trait limiting the yield seemed to be lodging. Hence, the grain yield of fine type of rice variety mostly depends on the following parameters; (1) number of panicles per hill; (2) number of spikelets per panicle; (3) percentage of ripened grains and (4) lodging characteristic. An observation and classification of lodging were made with 'Mahsuri'. Furthermore, yield and yield components of 'Basmati' transplanted at different depth were examined.

Materials and Methods

An experiment was carried out to survey yield and yield components of several rice cultivars growing in the experimental farm of Agricultural Research Institute (ARI), Rajendranagar, during the wet season (Kharif) of 1985. The cultivars examined were: 'Vijayamahsuri', 'Sonamahsuri', 'Mahsuri', 'HR 59' (Kakirekkalu) and 'Basmati'. The latter two are a scented type. Since the ususal cultural methods applied in the surveyed districts differed with cultivar, the growing conditions were not always the same[4]. The dates of sowing and transplanting and the planting density were the same as those reported previously[5]. The harvesting time and the amounts of fertilizer applied are also given in Table 1. At maturity, 20 hills were randomly sampled from each field for yield and its component determination. A standard method of yield analysis[2] was employed wherein; the number of panicles per hill, the number of spikelets per panicle, the percentage of ripened grains and 1000-grain weight both in the husk and in the brown rices were determined. The percentage of husks to grains was computed from the difference in weight between unhulled and brown rice. Although salt solution with a specific gravity of 1.10 -1.12 are tentatively suggested to estimate the ripened grains of indica rices[3], the specific gravity of 1.06 was used in the study.

The pattern of lodging in 'Mahsuri' at the ripening stage was visually examined and was classified into three types, according to breaking or bending position of the culm at which the lodging occurred. The appearance of lodging is presented in Fig. 1. The type I is the lodging caused by breaking of the culm at the 5th or 6th internode counted from the top. Bending or breaking of the culms at the 2nd or 3rd internode from the top is type II, and when the topmost or the 2nd internode was broken, it is type III.

The length and area of four uppermost leaf-blades were measured at heading. Leaf area was estimated by the use of the punching method. Panicle and internode lengths were likewise measured at harvest.

Results and Discussion

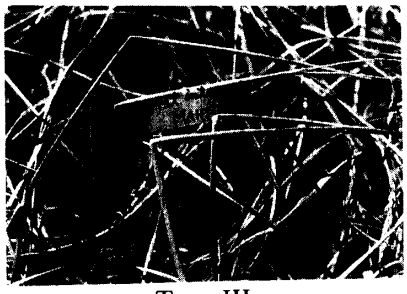
The yield and the yield components of five rice cultivars used, including those of 'Basmati' at shallow-depth planting, are shown in Table 2. The paddy rice yields varied with cultivar, ranging from 1.16 for 'Basmati' to 3.02t/ha for 'Vijayamahsuri'. Generally, the yields of 'Vijayamahsuri' and 'Sonamahsuri', both having similar panicle- and culm-length, were higher than the cultivars with tall and weak straw[1]. It was apparent that the relative importance of each yield component for contributing to the grain yield varied with cultivar. In 'Vijayamahsuri' the number of panicles per hill was the greatest among the test cultivars, resulting in the highest grain yield. On the other hand, 'Sonamahsuri' showed the greatest value in the percentage of ripened grains and the 1000-grain weight, whilst 'Mahsuri' showed the greatest number of spikelets per panicle among cultivars. Although 'Sonamahsuri' exceeded 'Vijayamahsuri' in terms of percentage of ripened grains and 1000-grain weight, a higher grain yield attained with 'Vijayamahsuri' was chiefly attributed to a greater number of panicles per hill than that of 'Sonamahsuri'. The grain yield of 'Mahsuri' was not comparable with those of 'Vijayamahsuri' and 'Sonamahsuri', in spite of having the greatest number of spikelets per panicle among the cultivars. The low yield of 'Mahsuri' might be attributed to a relatively small number of panicles per hill and light weight of 1000-grains as well. Furthermore, 'Mahsuri' was the most suscep-

Table 1. Times of sowing, transplanting and harvesting and the amounts of N-fertilizer applied (Kharif, 1985).

Cultivars	Date of				Total nitrogen fertilizer applied (kg/ha)
	sowing	transplanting		harvesting	
Vijayamahsuri	13 June	11 July	(16.7×13.4)*	14 Nov.	40 (25)**
Sonamahsuri	13 June	16 July	(13.9×11.2)	14 Nov.	80 (25)
Mahsuri	29 May	28 June	(14.0×13.0)	5 Nov.	60 (30)
HR 59	29 May	27 June	(19.8×14.4)	30 Nov.	40 (15)
Basmati	14 June	13 July	(13.3×11.3)	24 Nov.	40 (30)

*Spacing in parenthesis, row × hill in cm.
**Basal amount of N-fertilizer in parenthesis and the remainder was topdressed at the panicle initiation stage.

Type I.



Type III.

Type II.

Fig. 1. Looks of lodging of cv. Mahasuri.
Type I Breaking at the 5th or 6th internode.
Type II Bending at the 2nd or 3rd internode.
Type III Breaking at the 1st or 2nd internode.

Table 2. Yield and its components of five cultivars of India (Kharif, 1985).

Cultivars	Number of panicles per hill	Number of spikelets per panicle	Percentage of ripened grains* (%)	Weight of 1000 kernels		Yield (kg/10a)		Percentage of husks (%)
				Unhulled	Brown	Unhulled	Brown	
Vijayamahsuri	12.6	156.7	85.8	18.7	13.8	302.3	223.7	26.0
Sonamahsuri	7.6	145.2	88.8	20.6	15.3	233.3	173.8	25.5
Mahsuri	7.3	185.3	84.6	16.4	11.9	188.9	137.5	27.2
HR 59	7.4	111.9	82.0	18.5	13.7	126.6	93.9	25.8
Basmati	7.9	64.4	79.1	20.7	14.5	115.8	83.4	28.0
Basmati**	10.9	60.4	85.9	20.9	14.3	141.6	96.9	31.6

*Sunken grains in salt water with a specific gravity of 1.06.
**Shallowly transplanted at a depth of 2-3 cm, though usual depth was 6-9 cm.

tible to lodging and a poor yield of this cultivar might be also ascribable to lodging. Various types of lodging were observed in 'Mahsuri' under the field conditions as shown in Fig. 1. Although the lodging of type I and II was observed, the lodging of most plants was the type III, i.e., breakage at the 1st or 2nd internode. Moreover, the breakage at the 1st internode more frequently occurred than at the 2nd internode, amounting to about 81% of

this type. Thus, the cause of an extreme lightweight of grains can be partially due to lodging.

'HR 59' and 'Basmati', being long-culmed and liable to lodge and bearing longer leaves and panicles, could not produce higher yield. The results of the yield component analysis of 'HR 59' and 'Basmati' showed that these cultivars were characterized by less number both in panicles per hill and in spikelets per panicle and low percentage of ripened grains. The most influential cause of low percentage of ripened grains, in spite of the decrease in the number of grains per hill, can be mainly ascribed to the lack of grain filling due to lodging. Comparing both scented cultivars having almost equal number of panicles, 'HR 59' seems to be more advantageous than 'Basmati', because the four uppermost leaves are more favourable in terms of length and leaf area for light utilization (Fig. 2). In comparison between improved and traditional cultivars, although no essential differences in length of upper leaves were recorded, erect leaves of the former as against long-droopy ones of the latter were observed.

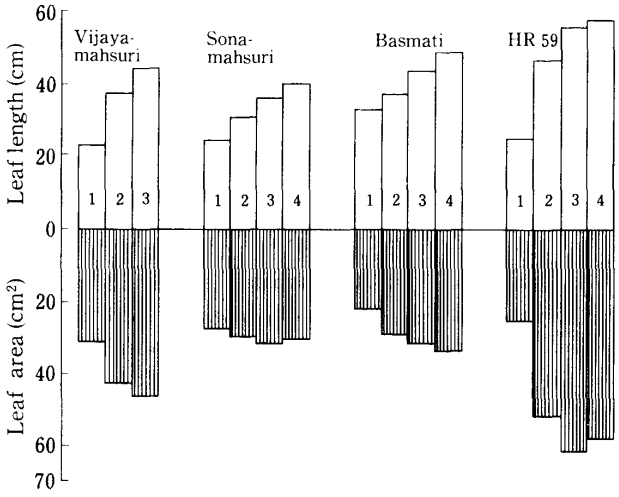


Fig. 2. Length and area of leaf-blade in four cultivars at the heading stage (Kharif 1985).
1,2,3, and 4 in the figure denote the flag, 2nd, 3rd and 4th leaf, respectively.

Growth and yield of 'Basmati' planted at shallow depth (2-3 cm) surpassed those planted at a normal depth of 8-9 cm, giving about 22% increase in grain yield (Table 2). It can be assumed that, since the lower nodes of the main shoot of shallow-planted seedlings are close to the soil surface, tillers that develop from the nodes come out successively with more ease than the tillers of deep-planted seedlings, resulting in a higher production of panicles per hill. Moreover, roots growing at the early stage, i.e., just after transplanting, are distributed mostly in the shallow layer of the soil, hence giving more favourable effect

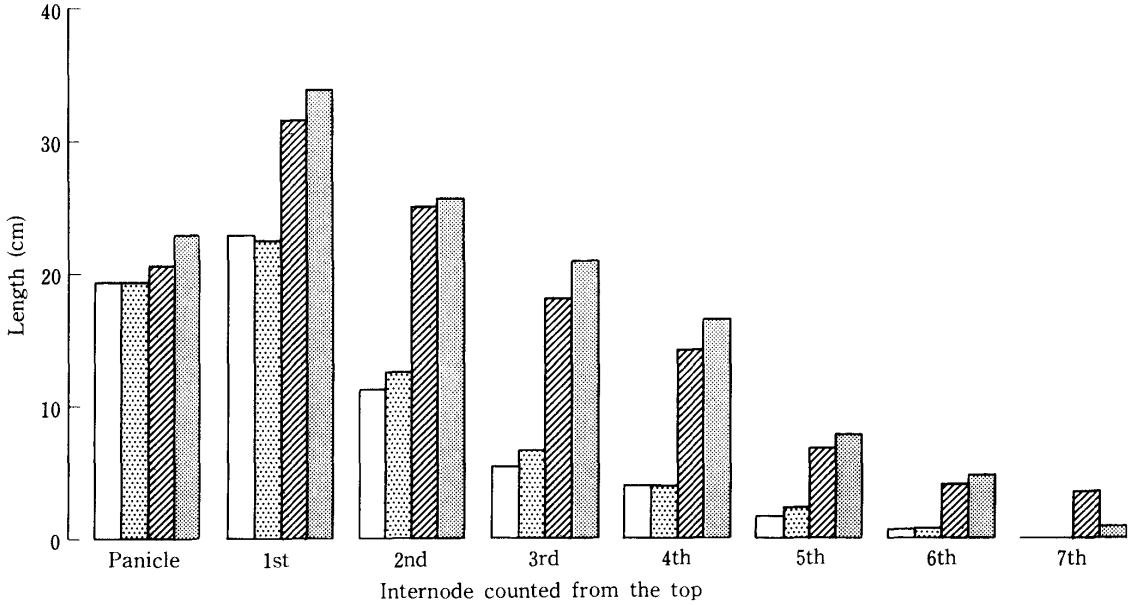


Fig. 3. Lengths of panicle and internodes in four cultivars (Kharif 1985). Open bars, cv. Vijayamahsuri; dotted bars, cv. Sonamahsuri: hatched bars, cv. Mahsuri: Solid bars, cv. HR 59.

on nutrient absorption.

The length of panicle and internodes of four cultivars, 'Vijayamahsuri', 'Sonamahsuri', 'Mahsuri' and 'HR 59', were measured (Fig. 3). The first internode was the longest and the successive internodes were gradually shortened with lowering the position in all cultivars. In 'Vijayamahsuri' and 'Sonamahsuri', the panicle and the first internode were almost identical in length, giving 19 cm in the former and 23 cm in the latter. The difference between the first and second internode lengths was considerably great in these cultivars, comparing with those between any other two successive internode, and a sharp decrease in length was observed as the position of internode lowered. In contrast, although successive internodal length of 'HR 59' and 'Mahsuri' decreased by 4-5 cm with lowering from the 2nd to 5th internode, the 6th one was still longer than 4 cm. Since the increased resistance to lodging is supposed to be most responsible for high yield, the liability to lodge caused by the increase in length as well as in number of lower internodes of 'Mahsuri' and 'HR 59' is disadvantageous in attaining high yields.

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