Ratoon Cropping of Rice and Sorghum: Recent Advances

DONALD L. PLUCKNETT[1], RODOLFO G. ESCALADA[2] and RAMON S. de la PENA[3]

Ratoon cropping is an important practice in tropical agriculture, particularly in the sugarcane, banana and pineapple industries where it frequently provides a significant margin of profit for growers. Despite its importance, however, for many years ratooning could be considered as a neglected area of agricultural research, for even research organizations for ratooned crops such as sugarcane seldom devoted much effort or resources to the study of improved ratoon systems (Plucknett *et al.* 1970).

In recent years, however, considerable interest has developed in ratoon cropping of cereals, particularly in rice and sorghum. In part, this interest appears to be due to the growing concern about meeting increasing food needs through more intensive cropping systems.

This paper will concern itself mostly with recent research developments in rice and sorghum.

Why Practice Ratooning

Ratooning offers a number of advantages, notably:

(1) decreased cost of production through savings in land preparation and crop care during the seedling or early growth stages;

(2) shorter crop duration for the ratoon crops;

(3) better use of growing season, particularly in monsoon areas;

(4) higher yield per ha per unit of time, and

(5) ratoon crops often require less water and fertilizer than "plant" cross (Plucknett *et al*, 1970).

Despite the advantages, there can also be problems with ratooning. Foremost of these is buildup of pests and diseases, including problem weeds.

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1. Scientific Adviser, Consultative Group on International Agricultural Research, World Bank, Washington, D. C. (Formerly Professor of Agronomy and Soil Science, University of Hawaii, Honolulu, Hawaii, 96822, U. S. A.)

2. Associate Professor of Agronomy and Chairman, Department of Agronomy and Soils, Visayas State College of Agriculture, Baybay, Leyte, Philippines.

3. Associate Agronomist, Department of Agronomy and Soil Science, University of Hawaii, Honolulu, Hawaii, 96822, U. S. A.

Ratooning of Rice

Rice ratooning has been attempted in China, Colombia, Ecuador, India, Japan, the Philippines, Swaziland, Taiwan, Thailand, and the United States (Texas) (Plucknett, *et al*, 1970; Bahar and De Datta, 1977). Kung (1975) reported that ratooning is practiced in China in the Yangtze and Han River valleys (Hunan and Hupeh provinces) and the Tungting Lake Basin and in Szechwan province.

In rice, ratooning is advantageous because it allows a multiple harvest from a single sowing. For example, it permits two crops to be grown in a season too short for two sown or transplanted crops, it allows rescheduling of crops that have been damaged by storms or other problems, or it can be used to produce pure lines of rice seed in nurseries without replanting.

There can be problems with ratooning of rice; many of these such as tillering behavior, buildup of pests and diseases and management factors will be discussed in specific sections to follow.

Sorghum Ratooning

Both grain and forage sorghums can be ratooned. Indeed, until recently most ratooning of sorghum was carried out in the forage varieties. However in recent years ratooning of grain sorghum has been attempted, with varying degrees of success, in Australia, India, Philippines, and the USA (Hawaii and Taxas).

Ratooning success is dependent upon management factors and genetic capability of the plants. Many plant breeding programs have consciously selected against heavy tillering, so ratoon capacity in many commercial lines is more of an artifact of perenniality of sorghum than a scientific innovation. It remains to be seen what improvements could be made in sorghum ratooning if improved ratoon capacity became a breeding objective.

Factors Involved in Successful Ratooning

Tillering capacity and behavior are the most important genetic factors affecting ratooning in grasses. Factors such as tiller number, point of origin, and tiller vigor are all important in ratoon capacity of cereals. Also, amount and vigor of the root system contribute to ratoon capacity, for a good root system is essential to permit the cut stubble to recover and to produce tillers and new shoots immediately after harvesting. Under good growing conditions, it is a truism that (1) high tillering capacity coupled with a vigorous root system will produce good ratoons, (2) low tillering plus a good root system may produce a fair ratoon, (3) high tillering and a poor root system may produce a fair ratoon, (3) high tillering and a poor root system may produce poor to fair ratoons, and (4) low tillering plus a poor root system produce poor ratoons.

Point of origin of tillers is important in ratoon performance Tillers that arise from the crown or from buds on the lower stem nodes are often vigorous and uniform in development. However, tillers that develop from nodes higher on the stem (as often happens at higher cutting heights) frequently break off as the tillers grow and become heavy, or die because the roots that develop fail to make contact with the ground.

Tillering behaviour under field management also is important in ratoon success or failure. Such behavior often is governed by interactions between genetic and cultural factors. For example, if the point of origin of most of the tillers of a sorghum variety is several centimeters higher than the crown and a low cutting height is used at harvest, poor ratoon will often result because of the removal of potential tiller buds. Therefore, it behooves plant breeders and agronomists developing rice or sorghum varieties that may be used in ratoon systems to breed for ratoonability and test their performance under such conditions in the field.

In sorghum, many breeders have sought to reduce tillering so as to ensure uniform maturity of the plant crop. This may be quite desirable for sorghum that will be used in single crop systems, but it would not be desirable for ratoon systems. By contrast, heavy tillering of rice is considered to be desirable by most plant breeders, and previous selections for heavy tillering should improve ratoon capacity.

Table 1 presents information on tillering capacity in some rice varieties; such information confirms the need to characterize cereal varieties and lines for tillering capacity in the "plant" crop and the ratoon(s).

Tillering Research

Tillering in grain sorghum as an aid to ratoon systems had received little attention until recently when Escalada (1973) undertook a series of careful studies to understand tillering performance in the field. This work has been published (Escalada and Plucknett, 1975a, 1975b, 1977, in press).

Early tillers develop from basal nodes of the plant and, as the plant grows and elongated internodes develop, tillers arise from nodes higher on the stem. At low plant populations shading of lower parts of the plants is reduced, and heavier tillering results. At higher plant populations, tillering is delayed and many of the tillers that are initiated die as shading becomes intense.

In the plant crop, first tillers develop about one month after sowing. In ratoon crops, first tillers arise about 1 week after harvest of the stover.

Very early and late tillers seldom become productive, in terms of grain yield.

TABLE 1. Influence of Variety on Tiller Numbers in Plant and Ratoon Crops of Rice (after Balasubramanian *et al*, 1970)

Variety	Plant Crop No. of Productive Tillers Per Hill	Ratoon Crop No. of Total Tillers Per Hill	No. of Productive Tillers Per Hill
ADT 27	9.6	10.1	5.6
CO 32	7.9	8.4	4.6
IR-8	6.8	10.2	5.1
J. S.	6.4	6.3	3.8

In general, the first two tillers that develop often die, apparently because the young plant cannot support them until it becomes well established.

Light intensity has a profound effect on behaviour of tillers. Low light intensity (including shading) results in fewer total tillers and even fewer productive tillers. This often means that tillering is reduced in the humid tropics during cloudy or rainy periods.

Seasonal effects can be great. In Hawaii tiller numbers are lower during winter when cloudy conditions, lower temperatures, and shorter daylengths prevail. Indeed, the differences in tillering and resultant ratoon performance can be greater between winter and summer than between first and third ratoon crops (Escalada and Plucknett, 1975b).

Temperature can have a significant effect on tillering. In a study involving various combinations of daylength and temperature, low temperature (24C day/15.6C night) and short daylength (10 hours) resulted in 6 to 8 tillers per plant but in a low number of productive tillers (1 per plant). On the other hand, increased temperature (32.4C day / 24C night) coupled with short daylength (10 hours) increased productive tillers (1 to 3). Higher temperature (32.4C day / 24C night) and longer daylength (14 hours) resulted in more productive tillers (1 to 4).

Plant nutrition, particularly nitrogen, has a significant impact on tillering. When plant nutrition is poor, fewer tillers arise and very few, if any, become productive.

Plant population can affect tillering significantly. The reduced tiller number per plant caused by shading effects at high plant populations was mentioned earlier. At low populations, more tillers per plant but fewer productive tillers per ha develop. As plant populations increase, fewer tillers per plant develop, but more productive tillers per ha result.

Cutting height affects both number of potential tiller buds and carbohydrate reserves in the plant. Cutting heights of 3 and 8 cm proved to be reasonable for ratoon sorghum, in terms of uniform growth and maturity (Escalada, 1973).

Pests and Diseases

Ratooning is frequently criticized because of pest and disease buildup. In some situations such buildup can occur to the point where ratooning may have to be abandoned.

Cultivars suitable for ratooning should have resistance to major pests and diseases. Bahar and De Datta (1977) found that ratoon rice had a high incidence of grassy stunt virus disease, while transplanted seedlings of the same age were not affected. They concluded that ratooning of virus susceptible varieties could be risky.

Vigor and productivity of tillers or ratoons can be seriously reduced by insects or disease. In Hawaii, Escalada (1973) found that when sorghum stubble was cut short (3 cm), red stalk rot or anthracnose (*Colletotrichum graminicola*) caused serious stalk loss and resulted in losses in stand.

Some ratoons may fail because of weed problems. For example, in ratoon sorghum, grass weeds, both annual and perennial, may be present in sufficient

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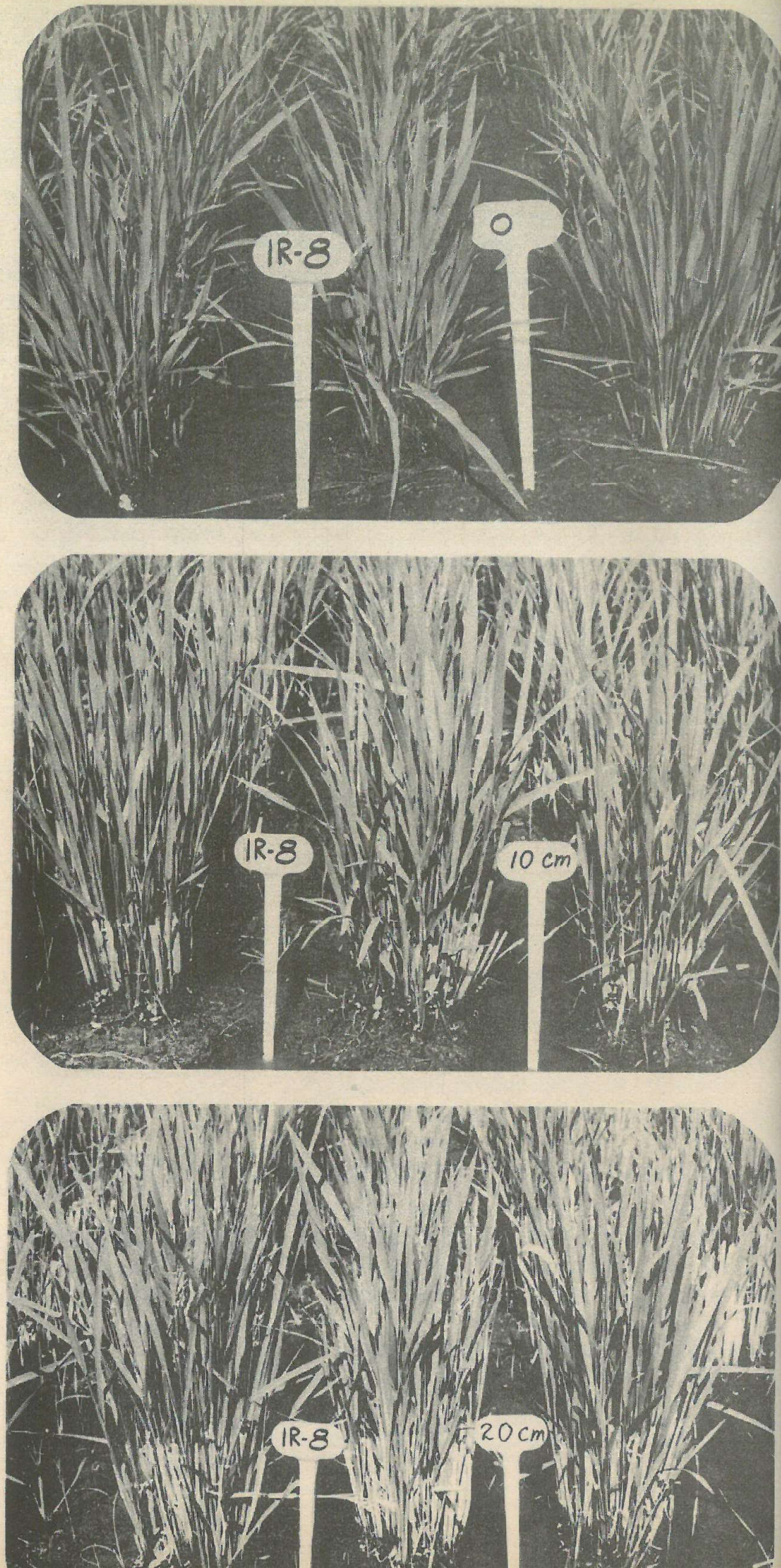

quantities at harvest so as to carry over and be a serious problem in subsequent non-cultivated ratoons. Obien *et al* (1976) found that paraquat [1, 1' di-methyl-4, 4' - bipyridilium] applied over the fresh stubble at the first 5 days after stover harvest knocked down and controlled persistent weeds adequately, when paraquat was used in combination with pre-emergence herbicides. Applying paraquat more than 5 days after harvest killed or injured young tillers.

Cultural and Management Factors

Much can be done by management to make ratooning successful. Manipulation of the crop through use of fertilizers, adjustments in planting date and planting factors, pest control, water management, and harvesting methods, including cutting height, can do much to ensure successful ratoons.

Probably the first most important is *to grow a good plant crop*. A poor plant crop will seldom produce a good ratoon, although a ratoon crop that develops in the summer under favorable conditions may yield higher than a plant crop grown in winter (Plucknett *et al*. 1971).

It should be pointed out that ratooned sorghum can experience a series of changes in daylength, temperature, solar radiation and soil moisture (or rainfall) during the periods from planting of the plant crop and harvest of the first or subsequent ratoons. These different environmental factors account for most of the seasonal effects on ratoon performance; hence planting date can have a significant effect on ratoons. In general, a planting date that produces a good plant crop will be most satisfactory. In monsoonal climates, planting near the start of the rains will often ensure sufficient moisture to develop the ratoon crop.

Application of fertilizer or irrigation soon after harvest of the plant crop or previous ratoon can do much to promote rapid growth and development of tillers. Of the plant nutrients, nitrogen is probably most critical for successful ratoons (Golingai, 1972; Escalada, 1973).

Harvesting practices can also affect ratoon performance. The effect of cutting height has already been stressed. In general, in both rice and sorghum, a low cutting height promotes vigorous uniform tillering and uniformity at harvest. Higher cutting heights produce earlier maturity of ratoons. Higher cutting heights may be justified in situations where stock rot disease are likely to be active, and where the avenue of infection is through the cut portion of the stem. In such situations leaving a few more internodes on the plants may present a sufficient vegetative barrier against movement of the organism down the stem to the crown where it could kill or injure the crown itself or the young developing tillers.

Rice presents a special problem in the matter of cutting heights and tiller development, because many of the new shoots that develop after harvest push through the stems of the stubble. These stubble shoots produce panicles very quickly (Figure 1). Unless a low cutting height is used, fewer new tillers arise from basal buds on the crown. With low cutting height, most of the old stubble is removed, the area near the crown is exposed, and vigorous basal bud development is encouraged. This situation could prove to be a drawback, however, on large farms for it might be very difficult to cut rice sufficiently low on a field scale in order to stimulate ratooning. Of course, farmers with small crop areas could perform such an operation by hand on small fields, but it might be less possible under large-scale-mechanized operation.

Operations such as mechanized combine harvesting or panicle harvest (as is practiced in rice in some parts of Indonesia) could also present some problems for farmers. For either rice or sorghum, it would not be desirable to cut and run through the combine more of the plant than the panicle and just enough of the upper stem to ensure harvest of as much grain as possibte. This would mean that in order to ratoon the crop, either the crop would have to be cut by hand or machine and then mowed, or knocked down in such a way that tillering can occur, When the stover (stalks and leaves without the grain) is desired for animal feed or other uses, it could be removed by hand cutting. by mowing or by forage harvester. If the stovor or straw are not to be removed, then the stubble must be crushed down low enough so that tillering can begin. A word of caution is needed here; leaving too much stover or straw may provide a smothering-type barrier to tiller development. Texas rice growers do crush their old rice crop down by rolling it mechanically in order to produce a ratoon crop.

Time of harvest can influence subsequent ratoons signiticantly. This was shown most dramatically in work by Golingai (1972) in which he harvested plant crop and first ratoon sorghum at 15, 20, 25, 30, and 35 days after 80% flowering (DAF) of grain sorghum. Heaviest tillering resulted when sorghum was harvested 15 DAF in the plant crop and 15 and 21 DAF in the first ratoon. High tillering at early harvest dates was in contrast to grain yield which increased as harvesting was delayed to 30-35 DAF. On balance, it appeared that the dual goals of heavy tillering (and subsequent good ratoon performance) and grain yield could be achieved by harvesting at 30 to 35 DAF. This work was confirmed by Krantz *et al* (1974) who concluded that early harvest enhanced ratoonability. The principle involved here is to harvest the grain at physiological maturity and then remove the stover as soon as possible to encourage early development of the ratoon.

Any harvest of field operation that causes damage to the crown, roots. bud-producing nodes, or tillers of rice of sorghum will affect the subsequent ratoon. Hence, management field operations being tested should be evaluated for their effect on ratoon performance.

Escalada (1973) found that suitable cutting heights varied somewhat with the season of growth. In summer, low (3 cm) and high (13 cm) cutting heights did not perform as well as the intermediate height (8 cm), while during winter the 13 cm cutting height, performed best These results were thougt to be due to the following factors : low cutting in summer did not leave enough food reserves for development of the tillers ; and the 13 cm cutting height grain yields were lower than those of the 8 cm cutting height because fewer tillers survived to become productive. However, during winter the 13 cm cutting height proved best because it provided an effective vegetative barrier to stalk rot organisms that in the lower cutting heights killed or injured the tillers

The evidence to date indicates that height of cutting is quite site specific, depending upon factors such as the crop to be grown, diseases and insects present, soil moisture, fertilizers, and seasonal effects.

In rice, unless good water management is possible, low cutting heights can kill the tillers (Banker and De Datta, 1977). Under poor water management cutting height should be about 15-23 cm above the ground. However, such high cutting will reduce yields and crop uniformity somewhat, although crop duration will be shorter.

In general, regardless of cutting heights used, ratoon yields will usually be lower than the plant crop, and succeeding ratoon yields will decrease steadily. This is not always the case, however, and yields of ratoon crops have been obtained that are higher than those of previous plant crop or ratoon crop (s). (Plucknett *et al.*, in press)

Higher cutting height usually results in lower yields, less uniformity, and shorter crop duration than low cutting.

Ratooning Research at the International Agricultural Research Centers

IRRI has recently initiated rice ratooning experiments as part of its agronomic program (Bahar and De Datta, 1977; IRRI, 1979). It previously had conducted some sorghum ratooning work in its Multiple Cropping Program (Bradfield, 1969). In recent studies transplanted IR32 produced 2.3 t/ha when the plant crop was cut low, while IR36 performed poorly in ratoon systems. Low cutting heights led to longer crop duration (IRRI, 1979). In 1979 IRRI began an investigation of ratoon capacity of rice varieties (IRRI, 1980). Over 2000 varieties and breeding lines were evaluated; 303 were found to have good ratoon capability, and 139 of them showed uniform flowering.

ICRISAT has also begun to assess sorghum lines for ratoon capability, by evaluating 54 sorghum lines (ICRISAT, 1978). Generally, very early types (75-85 days) produced good plant crop yield (3313 kg/ha) and a good ratoon crop (2251 kg/ha). Grassy types were good ratooners, some giving as much as 80 per cent of the yield of the plant crop. Early types (85 - 95 days) were more variable. CSH-6 gave best yields (1443 kg ha plant crop and 2548 kg/ha ratoon).

ICRISAT has also begun to evaluate ratooning of pigeon peas(ICRISAT,1978). In this crop, selective harvest ratooning is practiced. and management to produce flush periods of grain harvest will be required. In early experiments, irrigation was found to be particularly important in influencing ratoon yields of pigeon pea.

ICRISAT has previously worked with sorghum and pearl millet ratooning in its Farming Systems Program (Krantz, 1975; ICRISAT, 1977). Poor ratoonability of sorghum varieties and heavy shoot fly attack led to poor ratoon yields and to a decision to evaluate ratoonability of genotypes. ICRISAT considers ratooning to be potentially important because it; "is another means ...... to provide a continuum of cropping for 5-8 months from the onset of the mansoon" (Krantz, 1975); reduce the costs and difficulties of establishment a second crop", and "can be useful way of growing a 'partial' second crop where moisture is limiting" (ICRISAT, 1978).

Cropping Systems

Ratooning by itself is a multiple cropping system, but it can also be part of a cropping or cropping pattern. For example, in India ratoon cropping of sorghum can be used to produce a good second grain crop following harvest of a high - yielding plant crop (Krantz, 1975). Also when short droughts, insect attack, or other problems overtake the plant crop, it may be best to harvest the standing crop for forage and reschedule or recycle the crop so as to produce a good ratoon near the end of the ratoon (Venkateswarlu, 1974).

Ratoon sorghum or ratoon rice can be fitted into an overall cropping system to produce two crops in a period too for two short crops, and yet provide sufficient time for another crop(s) to be grown during the off-season crop in sequence with rice as a main crop (Bradfield, 1969). Ratoon crops can be easily fitted into inter, relay, double, or triple cropping sequences with other crops, particularly vegetables, other cereals or tree crops.

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