[Rice in India has a long history dating back to prehistoric times. Rice improvement programmes in a planned manner can however, be said to have started from the beginning of this century. The development of new varieties suited to different situations received the greatest attention and this gradual improvement was through the traditional methods of breeding. This continued to be so till the introduction of the new short statured and high yielding varieties. Their introduction led to a new era often called "the era of green revolution". During this period, new changes occurred not only in the varietal concept but also in the agro-technology essential for the realisation of high yields. However, the spread of these new high yielding varieties raised both hopes and fears. Despite the increase in production and productivity, the rice production in the country still remained linked to the vagaries of monsoon. Ways and means to mitigate the adverse effects of climatic factors of rice production were soon advanced. Ed.]

RICE IMPROVEMENT IN INDIA

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RICE, probably the oldest and the most important food crop of India, as indeed of Asia, is of great antiquity. The rice grown in the countries in Asia (*Oryza sativa*) has evolved from an annual progenitor over a broad belt extending from the Gangetic plains along the foot hills of the Himalayas across Upper Burma, Northern Thailand, Laos to Northern Vietnam and South China (Roscheviz[8]; Ramiah[7]; Chatterjee[3]; Chang[2]), The cereal was brought under cultivation simultaneously but independently at more than one site. In India, excavation at Lothal has revealed the use of paddy husk in potteries, bricks, etc., Lothal civilization was around 3800–2800 B.C.

Besides the primary centres of origin, secondary centres of origin in India could well have been in Assam and the adjoining areas and Jeypore tract in Koraput District (Orissa). Rice in India presents a panoramic picture, its diversity and consequently a great variability providing a vast scope for genetic improvement.

The cultivated annual forms in South and South-East Asia belong to 3 sub-species, *viz*., *indica, keng* or *japonica* and *javanica* (*bulu* and *gundil*). The *javanica* is restricted in its distribution in Indonesia; *japonicas* originally from North China later spread to Japan and Korea. The *japonicas* and the *javanicas* are products of selection from the *indica* sub-species distributed in South and South-East Asia.

Rice improvement in India, in a strict sense, can be said to have begun from the early part of this century although varietal classification and the use of rice for different purposes can be traced back to much earlier period. At the initial stage, improvement was mainly through selection—inter and intra-varietal. Introduction and selection played a role in the next phase. Varieties from one state were tested in other states and the best released (SR 26B, N 22, FR 13A, FR 43B, Ptb 10, etc.). To create variability, the basis for selection, hybridization between varieties was later initiated and this marked the third stage. Crosses were effected between related types and even with semi-wild forms (*O. sativa* var. *longistaminata*). Simultaneously, introductions from other countries came to be tested for their suitability. Shinei, Ch. 45, Ch. 988, Ch. 1039 are examples of successful introductions. These diverse approaches led to the release of a series of varieties in the country (Ramiah,[6,7]; Ghose, *et al.*[5]).—In 40 years since 1911, the rice research stations developed nearly 450 varieties of which, a large majority of varieties are tall, of varying durations and with tendency to lodge. These have local adaptability and a stability of performance under low risk and low management conditions. Yields are relatively low, but stable.

The beginning of second half of this century witnessed the first major programme reorientation. The *indica* × *japonica* hybridization programme, sponsored by the F.A.O., was initiated in 1950 (for the benefit of South-East Asian countries) to develop varieties that combine wide adaptability of the *indicas* and the fertilizer response (especially to nitrogen) and high yield potential of the *japonicas* A similar programme was launched at the national level by the Indian Council of Agricultural Research (I.C.A.R.) in 1951 for the benefit of states in India. The latter programme led to the development of ADT 24 in Tamil Nadu. A limited success can be attributed to (i) failure in many cases to grow the segregating populations under high fertility (N-level), (ii) nature of segregation (being of quantitative nature) for most characters differentiating the parents, (iii) a low segregating population that did not permit the expression of all character combinations and consequently less selection efficiency, (iv) the inherent differences in the response of the varieties (*indicas* and *japonicas*) to differences in day length and temperature and their consequent effect in the selection process, (v) the occurrence of sterility to varying degrees in the cross combinations, (vi) the belief that the increased yield is often associated with an increase in height and duration, (vii) the complication involved in the environmental influence on the character expression especially height and duration, (viii) a wide difference in the grain characteristics and cooking quality between the varieties belonging to the two sub species and (ix) a probable bias on quantity rather than on quality.

Meanwhile, crosses were also effected between *indicas* and *bulus* at the Central Rice Research Institute (CRRI), Cuttack. CR 1014, a late maturing, tall and non-lodging variety with medium slender grains and good cooking quality was developed from the cross T 90 × Urang Urangan.

At about the same period, a relatively short statured variety (later named "Dee-geo-Woo-gen") was identified in a population of a local variety "Woo-gen" in Taiwan. "Dee-geo-Woo-gen" was crossed to a Chinese cultivar "Tsai Yuan Chung" in 1949 and from this cross was evolved Taichung (Native) 1 (*T*(*N*) 1). *T*(*N*) 1 was released in 1956. This is insensitive to day length, early in maturity (115 days), short statured (90 cm), non-lodging and with erect, thick and dark green leaves. Tillering is good and leaves have late senescence. Under good management and high nitrogen level, *T*(*N*) 1 records 6 to 8 tonnes per hectare.

Taichung (Native) 1, Dee-geo-Woo-gen and I-Geo-Tze were brought from Taiwan to the International Rice Research Institute (IRRI) in 1960 (Manila, The Philippines) and crossed with several varieties. From the combination Peta × Dee-geo-Woo-gen was developed IR 8–288–3. This along with 302 lines (including TN 1) were tested at the Central Rice Research Institute, Cuttack, in

1965. Three lines from this combination and a few from Peta × Tong-kai-Rotan combination (IR 5 series) gave yields ranging from 5 to 7 tonnes per hectare. Meanwhile, in 1965, the IRRI named IR 8-288-3 as IR 8.

IR 8 was later released in India in 1966 followed by Jaya (TN 1 × T 141) and Padma (T 141 × TN 1) in 1968. The introduction of T(N) 1 and IR 8 in the country in the mid sixties and their utilisation in the national programme for the development of new varieties marked the beginning of the era of "Green Revolution"

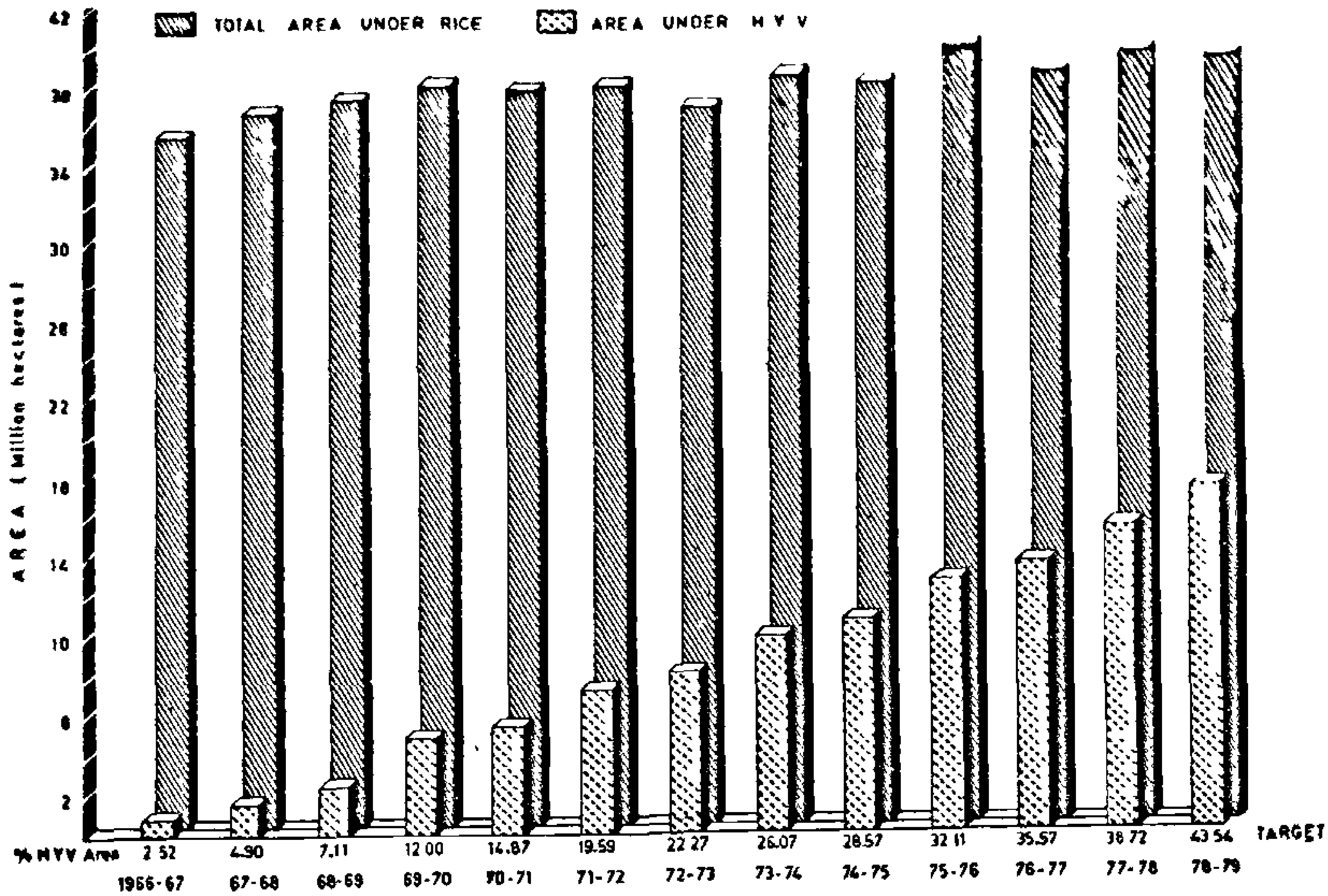
Since then, 161 varieties have been released by agricultural universities and State Departments of Agriculture besides 23 by the Central Sub-Committee for Variety Release (Seetharaman and Shoba Rani[9,10]). Of these, Jaya, IR 8, Mahsuri, IR 20, Pankaj, Jagannath, Ratna, Tella Hamsa, Rasi, Surekha, Sita, Phalguna, RP 4-14, ADT 31, Vani, Iman, MR 136, Triveni und a few others have sizable coverage. The rest have restricted distribution.

Rice improvement in terms of increased productivity is dependent on the variety and adoption of suitable agro technology. Alongside variety improvement programmes, changes were hence introduced in crop management. There was a shift in emphasis from low fertilizer application to high fertilizer use and then to moderate level of fertilizers coupled with adoption of low cost input technology for the efficient use of fertilizer. In this adoption process, the effectiveness of granulated compost, urea briquettes, neem cake coated urea, etc., in fertilizer use technology was soon recognised (Anonymous[1]). A judicious adoption of an organo inorganic fertilizer combination technology was suggested not only for yield optimisation but also for its maximisation.

The introduction of fertilizer responsive varieties and high cost input technology, however, aggravated problems of increased disease and insect attack. Diseases and insects which were considered of less importance earlier began to assume greater importance. A few of these observed earlier during one season only began to affect the crop during both the seasons. To have an effective control, new pesticides (dust, spray, granular formulations) were identified. However, their frequent use led to pest resurgence. To meet the new challenges, a two-pronged approach (development of resistant lines and recourse to need-based application of insecticides based on economic threshold level) was adopted. These programmes were later effectively supported by a pest surveillance and monitoring system. These rapid developments led to the adoption of an integrated pest management system, the components of which included variety, moderate levels of fertilizer use, good crop husbandry, need-based chemical control and pest surveillance.

Increased production potential of new varieties led to a large scale adoption. However, the trend in coverage under the high yielding varieties was slow (Fig. 1) due to (i) growing awareness for quality; (ii) susceptibility of most of the varieties to one or more diseases and/or insects and (iii) non-realisation of the anticipated yield in the rainfed areas (lowlands and uplands). Quality improvement was attempted in the high yielding varieties besides incorporation of genes for resistance. Simultaneously, to compensate the earlier bias in the variety improvement programmes, emphasis shifted to productivity increase in rainfed rice.

The rainfed rice (rice in lowlands and uplands) in India constitutes 70-75% of the country's total rice acreage. Large areas in parts of Bihar, Orissa, West Bengal, Uttar Pradesh remain waterlogged during *kharif* and in the absence of adequate drainage, yields are low. Productivity improvement was sought to be achieved through variety substitution and through improvement in agro-technology to the extent possible. Phalguna, IET 5656 (Swarna Dhan), CR 1006, CR 1009, CR 1015 came to be cultivated besides Mahsuri in ill-drained areas. The introduction of these new strains, however



TREND IN HYV COVERAGE

FIG. 1

resulted only in a slight upward trend in, productivity.

Likewise, productivity increase in the uplands was low, the success being marginal due to the development of early drought tolerant lines (Cauvery, Kanchan, Rasi, Bhavani, Kiran, etc.); even here, yield stability could not be realised for want of effective weed control and inability to provide life-saving irrigation at critical stages of crop growth.

Present prospects of increased productivity in the rainfed lowlands are also limited in the absence of drainage. Takase and Kano (1968) cited by Chattopadhyay[4] visualised productivity increase and growth in production as a development process involving step-wise improvement in infrastructure (Fig. 2).

Need for qualitative and quantitative improvement in infrastructural development can hardly be over emphasised. Without such improvements, increase in yields can only be moderate; nor can the yield potential be realised in the presence of several location specific constraints.

State-wise productivity figures for the years 1979–80 and 1978–79 are projected in Fig. 3. In the favourable year of 1978–79, against the national average of 1·33 tonnes/ha, Madhya Pradesh, Assam, Bihar, Orissa, Rajasthan and Uttar Pradesh recorded yields of 0·70, 0·96, 0·98, 1·0, 1·11, 1·15 tonnes/ha respectively. In the drought year (1979–80), Madhya Pradesh, Uttar Pradesh, Rajasthan, Bihar and Orissa had respectively average yield of 0·38, 0·49, 0·54, 0·70, 0·71 tonnes/ha. The national average was 1·08 tonnes/ha. Yield improvement in Madhya Pradesh, Uttar Pradesh, Bihar and Orissa—the focal States—has to be achieved for a general increase at the national level. The area under rice in these states constitutes 49% of the total acreage. Yield improvement in these States shall receive greater attention.

Recent estimates indicate that the potential for N-use, for stabilising mean yield at 2·4 tonnes/ha, on a national scale, assuming that the percentage area irrigated will rise by

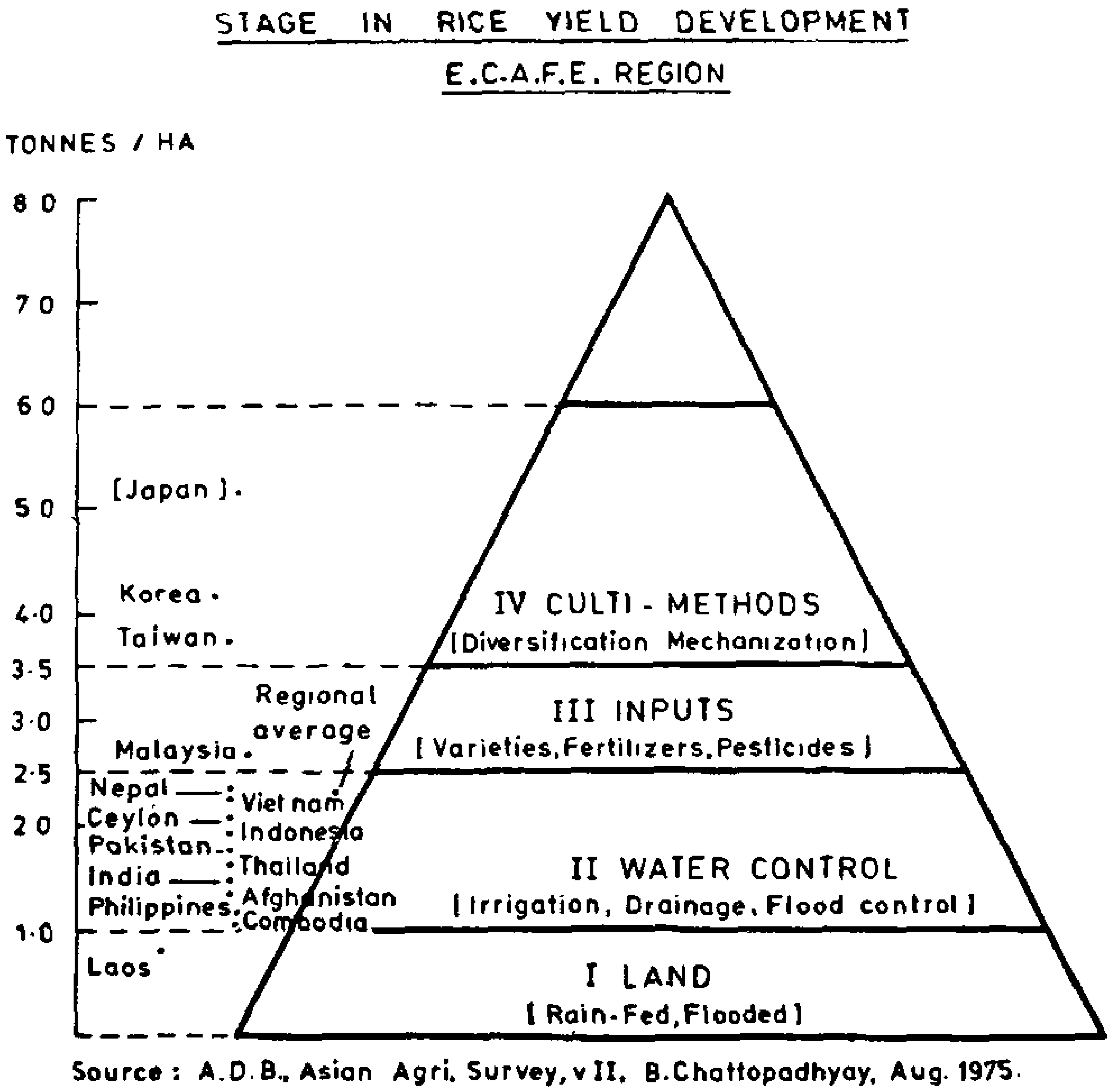


Fig. 2

50% and the coverage under HYVs to around 42% is likely to be around 65 kg N/ha as against the current level of 25 kg N/ha. Fertilizer use (especially nitrogenous) has to be stepped up and in this process, the use of a combination of organo-inorganic sources of nitrogen holds promise. Increased productivity requires adoption of high cost input technology; but, the latter should not be a substitute component to low monetary input techniques.

In the remaining decades of this century, efficiency of increased fertilizer use would have far reaching importance in the light of soaring prices of inorganic form of fertilizers and our dependence on non-renewable sources of energy to meet the increasing demand of modern agriculture. To meet this input demand and to achieve increased production to meet growing economic demand for rice, assured and controlled water supply through irrigation development is a pre-condition. The differing roles of irrigation, (*i.e.*, stabilization of harvest fluctuations and a consequent increase in the average yield over the years, the introduction of additional crop wherever possible, flexibility in the cropping pattern and cropping intensity, increased use of fertilizers, better fertilizer efficiency and adoption of better farming techniques) make it obligatory to improve water management both qualitatively and quantitatively. This approach alone can delink the Indian agriculture from the vagaries of monsoon.

Greater production in the context of overall 'self-sufficiency' would mean a switch over from productivity from one crop to productivity per unit land area. Success in the new strategy hinges on "turn around" time. Partial mechanization (if not full) alone would reduce this period. More and more power tillers, harvestors and driers would be needed. A greater use of mechanical power is visualised.

Progress since the mid-sixties is considerable; but challenges still exist. Forecasts have been

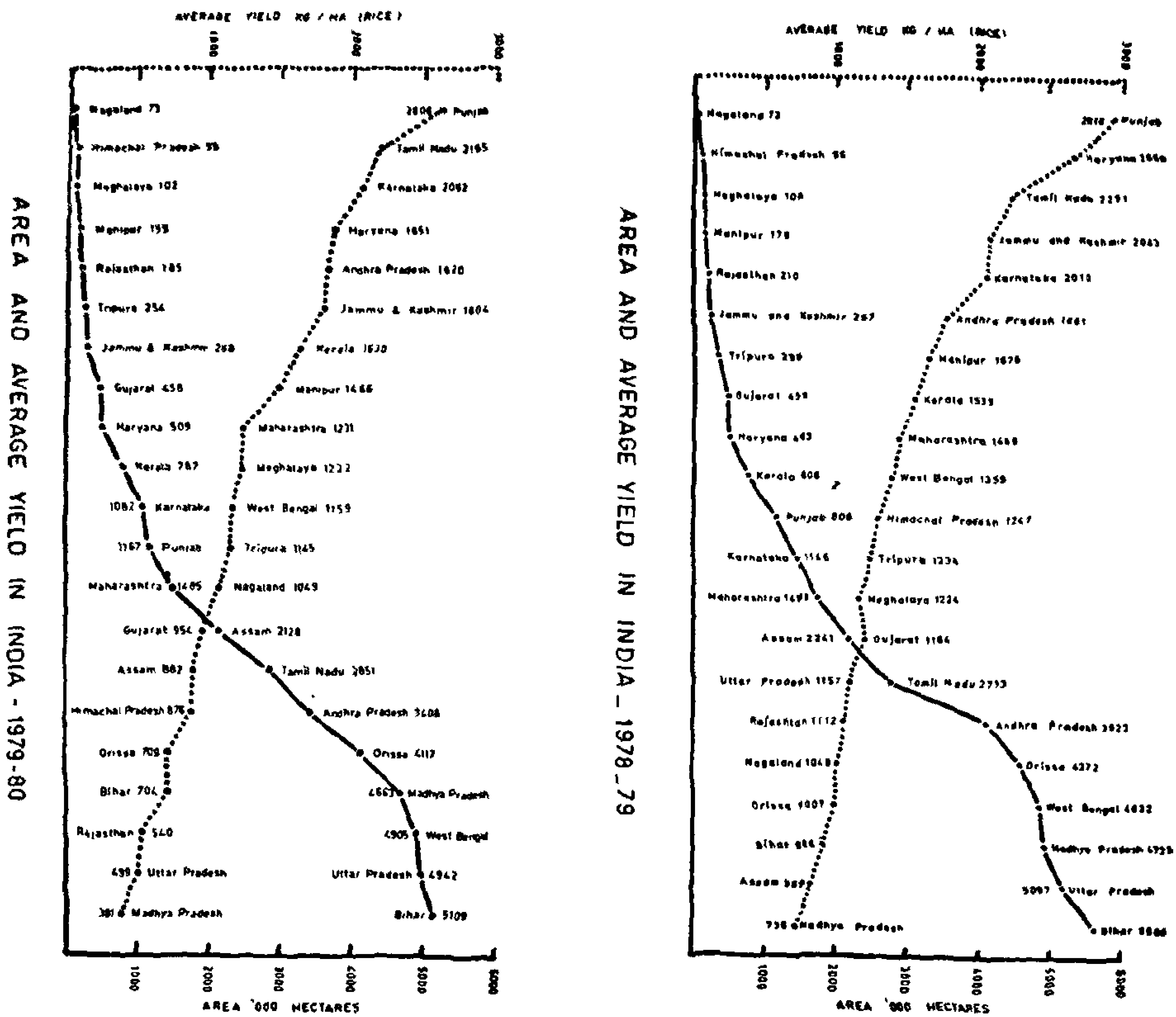


FIG. 3

made about the rate of progress needed to achieve the projected objectives. With emphasis on an integrated systems approach in the background of overall cropping pattern and cropping intensity, it should be possible to realise the production targets.

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