GENERATION OF STANDARD DATA ON THE YIELD ELABORATION PROCESS IN THE VARIETY OF RICE RD7 IN SOUTHERN THAILAND, EXAMPLES OF THEIR USE FOR ANALYSING THE MANAGEMENT OF THIS CROP IN FARMING CONDITIONS [1/]

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Abstract

On farm experiments have been conducted during four seasons in Southern Thailand, specially in one homogeneous irrigated agroecological unit of Ta Chiat irrigation area, Phatthalung Province, in order to generate reference curves for the grain yield elaboration process in the variety of rice RD7.

Data are available for plant stands ranging from 25 to 350 plants/m², allowing up to 400 panicles/m². The level of spikelets per panicle can reach 90 and no percentage of grain filling exceeds 85%. A close relationship is found between the biomass at panicle initiation and the final number of panicles/m² colleced at harvest. Nitrogen requirement, under no other limiting conditions, appeared to be of 1 kg nitrogen/ha for a gain of 6 panicles/m² or 300 spikelets/m².

Grain yield elaboration process in diverse farmers' plots conditions could then be analysed in a comprehensive way by taking into account the varietal potentiality on one hand, and the environment and the farmers' practices on the other. Cases of error were found in the dates of splitting the fertilizer dressings. Limiting factors other than nitrogen could be assumed in some farmers' plots.

บทคัดย่อ

การศึกษานี้ได้ทำการทดสอบในไร่นาเกษตรกร 4 ฤดูในพื้นที่เขตชลประทานท่าเฉียด จ.พัทลุง เพื่อหา "เส้นโค้งอ้างอิง (reference ourves)" สำหรับใช้คาดคะเนผลผลิตของข้าว กข. 7

ข้อมูลจำนวนต้นต่อพื้นที่มีตั้งแต่ 25-350 ต้น/ม³ ซึ่งมีจำนวนรวงได้ถึง 400 รวง/ม² แต่ละรวงมีได้ถึง 90 เมล็ดต่อรวง เป็นเมล็ดสมบูรณ์ดีประมาณ 85% ผลจากการศึกษานี้พบว่า น้ำหนักแห้งทั้งหมดในระยะแตกรวงมีความสัมพันธ์อย่างใกล้ชิดกับจำนวนรวงต่อพื้นที่เก็บเกี่ยว ความต้องการไนโตรเจนภายใต้สภาวการณ์ที่ไม่ขาดอะไรอย่างอื่น อยู่ที่ประมาณ 1 กก. ไนโตรเจน/เฮกตาร์ ซึ่งจะทำให้มีรวงเพิ่มประมาณ 6 รวง/ม² หรือประมาณ 300 เมล็ด/ม²

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การคาดคะเนผลผลิตในสถานการณ์ต่าง ๆ ของเกษตรกรสามารถทำได้โดยคำนึงถึงทั้งศักยภาพผลผลิต และสภาพแวดล้อมของแปลงเกษตรกร ความผิดพลาดในวันที่แบ่งใส่ปุ๋ยได้ถูกพบปัจจัยจำกัดอื่น ๆ นอกจากไนโตรเจนสามารถสันนิษฐานได้ในแปลงเกษตรกรบางแปลง

INTRODUCTION

Most studies carried out in a Farming Systems Research and Development framework have to take into account some technical diagnoses on the way the farmers manage their productions, before starting to look for means to improve them.

At first, a regional typology based on the functioning of the Agricultural Production Systems (APS) provides information on the determinants, different in each type, playing upon the combination of the productions (CAPILLON, 1985). It also enables an understanding of the techniques performed by the farmers as a result of the choices made by them, given their situation, according to their objectives (TREBUIT et al., 1988). For instance, the farmer will not aim at a maximum yield for his crops, but at a target yield compatible with the functioning of his APS (SEBILLOTTE, 1988). Two different diagnoses have to be made :

1) the diagnosis on current level of output compared with the target level of output given by the farmer,
2) and the diagnosis on the current level of output and the way to reach it compared with regional standards (SEBILLOTTE et al., 1989). This latter requires tools which allow an analysis of the relations existing between the techniques performed and the final output.

Regarding crop productions, the existing relation between the techniques performed on the plot and the yield is not a direct one and must be replaced by relations taking into account the evolution in the states of the crop on one hand and that in the states of the environment on the other (SEBILLOTTE, 1989). This is easily understood in cases when the technique is only performed on the environment and not directly on the crop (land preparation, fertilizer dressings, weeding or some cases of water management).

Such relations come into play in the studied cropping system, which is defined as "a set of techniques performed on plots which are handled in an identical way. Each cropping system is defined by :

- the kind of crops and their succession order,

- the itineraries of techniques applied to these several crops, which include the choice of the varieties of the selected crops"[2] (adapted from SEBILLOTTE, 1976). In relation with the environment, three sources of variation in yield, taken into account in such definition of the cropping system, can be distinguished (SEBILLOTTE, 1987) :

1) the climatic potentiality of a given crop in an area,

2) the reduced potentiality due to the nature of the soils in the area

3) and the reduced potentiality due to the modalities of the farmers' plots management. Making a cultural diagnosis consists of taking each of these sources of variation into consideration, which is made possible when USING THE CROP FOR REVEALING THE KIND OF MISFUNCTIONING IN THE CROPPING SYSTEM (SEBILLOTTE, 1987).

To do this, analysing by the yield elaboration procces (YEP), breaking the yield into its component parts and finding models explaining their elaboration, it is necessary to follow the crop from settlement to harvest.

Such models already exist for various crops and particularly for cereals (workshop in wheat are used as references (SEBILLOTTE, 1989; MEYNARD, 1985)), and in rice (DURR, 1984; PIGEAIRE, 1980). In Southern Thailand, the YEP analysis in rice has already been used for five years in experiments as well as surveys (KAMNALRUT, 1990).

The purpose of this study is to gather data of four years of surveys and experiments on rice in Southern Thailand with the same variety. This enables the consturction of models related to its YEP in different climatic and environmental conditions. Ultimately, diagnosis on some farmers' cropping systems can be made using this tool.

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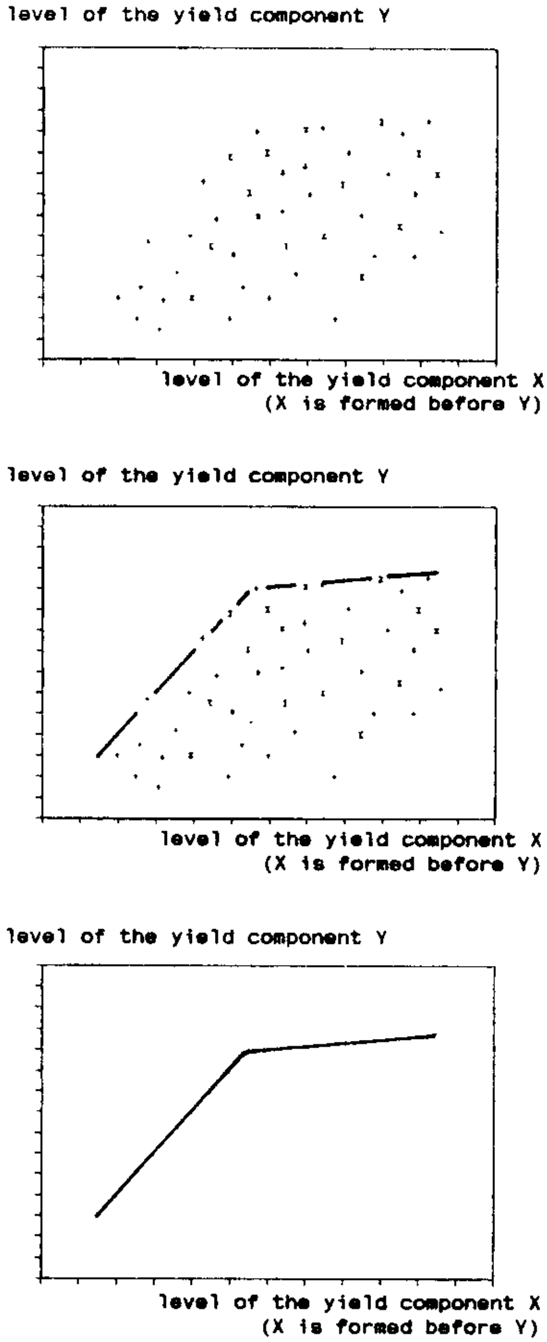
2 The concept of itinerary of techniques ("logical and well-ordered combination of techniques which allow the control of the environment and to get a given crop out of it" (adapted from 14) has successively been taken up again in (2) (3) and (20) with an emphasis on the "given crop" as resulting from the farmer's objectives, in (11) dealing with the succession of the techniques along time, finally in (17) as "type C references" for diagnosing a technical action.



a.

b.

c.

Figure 1 : steps in determining the potential relationship between two successive yield components. (adapted from 3)

a : location of the experimental points on the figure (+, x and * may correspond to different studies).

b : drawing the envelope curve.

c : the envelope curve becomes the potential curve relating the two yield components

Material and method

1) THEORETICAL RECALL OF THE SCHEME OF THE YIELD ELABORATION PROCESS

The concept of the yield elaboration process is widely developed in CROZAT et al., 1988, and in MOREAU et al., 1988 a, this latter being concerned solely with the rice crop. Only main elements are quoted here. The grain yield results from the level of its several component parts which, successively, comprise its elaboration. A potenteal relationship exists between the level of each component and the level of the component formed before it, as shown in Fig. 1. This potential is determined by drawing the ENVELOPE CURVE of the poins scattered on the figure. The highest values reached by some points are assumed to correspond to optimum situations of growth and development of the crop (Fig.1). A statistical design would be required to parametrize the envelope curve. However sufficient it is to draw it by hand to undergo diagnosis on cropping systems, without any other mathematical modelizing.

In the case of rice, the YEP is modelised as follow (Fig. 2):

grain yield/m^2 = weight of 1 grain x no. of filled grains/m^2

no. of filled grains/m^2 = no. of spikelets/m^2 x no. of filled grains/spikelet

no. of spikelets/m^2 = no. of panicles/m^2 x no.of spikelets/panicle

no. of panicle/m^2 = no. of plants/m^2 x no. of panicles/plant

Potential relationships between the growth and the development of the crop are also to be taken into account (DURR, 1984 ; MEYNARD, 1985):

Figure 2 : The yield elaboration process in rice as in MOREAU et al., 1988a

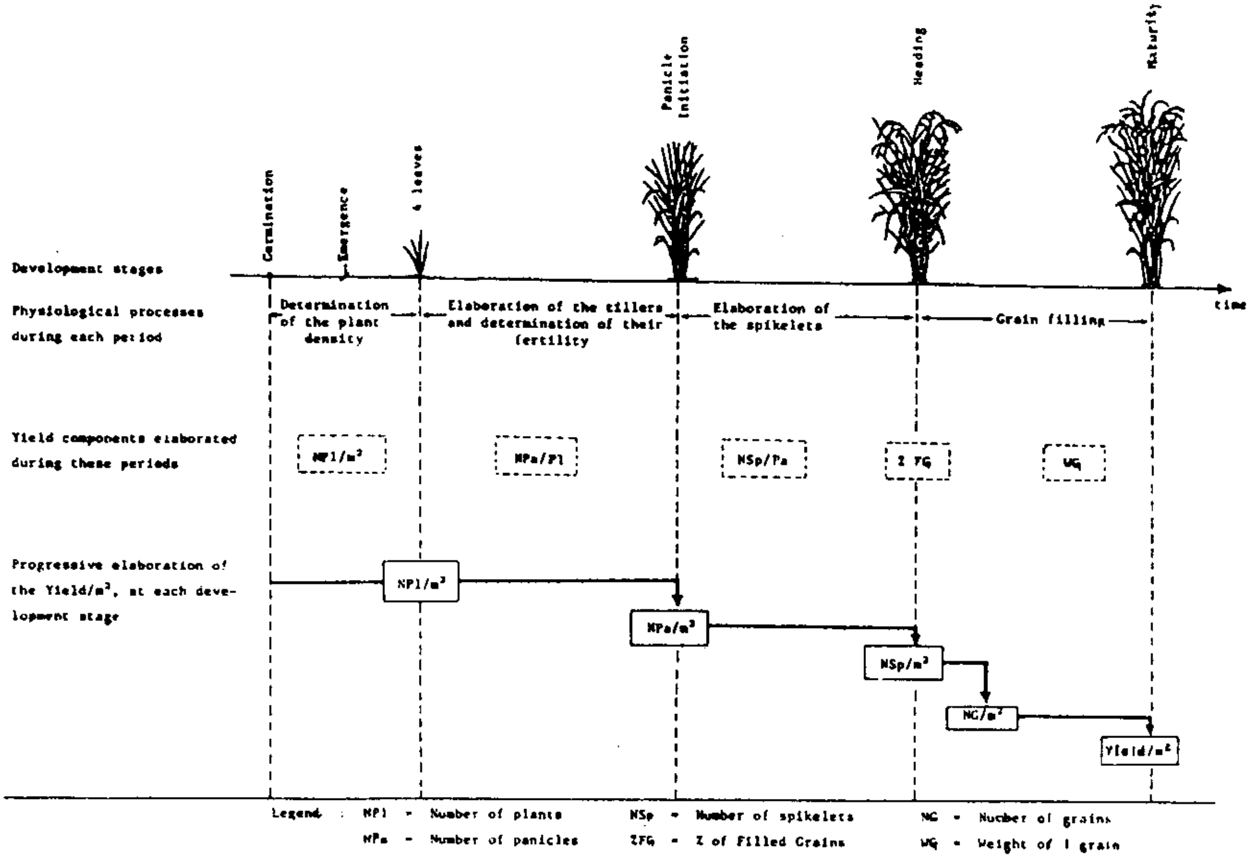


Table 1 : On-farm and on-station surveys and experiments analysing the yield elaboration process in the variety RD7 in Southern Thailand

Year symbol	Location	Soil	Crop Settle-ment(2)	Studied factors: plant stand (Pl/m²)	nitrogen dressing (kg N/ha.)	other (s)	Remarks(1)
1987	Sathing Phra, Songkhla Province		D.S.	22 - 240	0 - 200		Complete follow-up of the growth and the development of the crop (2).
1987 1988		sandy-clayey sandy-loam clayey	 P.G. T.P.	not controlled 50 to 400	0 - 30 - 50		on-farm survey (11) on 7 farmers' plots, covering a wide range of situations
1988 1989	Agro-ecological unit no, 3 of Ta Chiat	sandy-clayey	P.G.	not controlled 77 to 340	50	intra-plot variation of the ground level	2 farmer's plots, 25 samples covering wide range in the plant stand (13).
+1988 1989	irrigated area, Phatthalung Province (11)	clayey	T.P.	45 to 85	0 - 25	nursery : N and no N high-low Pl/m²	experiment in Ta Chiat Training Station. 3 blocks
1988 1989		sandy-loam	T.P.	45 to 90	0 - 50	nursery : 45 and 30 days	on-farm survey in one environment, 2 blocks N and no N
x1989		sandy-clayey	T.P.	80 - 160 - 240	0 - 50	nursery : N and no N	on-farm survey in one environment, 2 blocks
o1989		sandy-clayey	T.P.	80 - 160 - 240	50		on-farm survey in one environment, 4 rep.

(1) in each survey or experiment, one treatment aims at reaching the potential of the variety
(2) D.S. = dry seeded broadcast ; P.G. = pre-germinated seeds broacast;
T.P. = transplanted (the target no. of plants/hill is 4)

the potential biomass/m^2 at panicle initiation is a function of the no. of plants/m^2 at the settlement of the crop,

the potential no. of panicles/m^2 is a function of biomass/m^2 at panicle initation.

All the yield components can be collected at harvest on each sample, usually monitoring squares of 1 m^2 each. Analysis of the former relationships between yield components can then be carried out on the basis of all individual samples (thus taking into account the intra-treatment variability). Yet, the analysis of the latter relationships between biomass at panicle initiation and NPa/m^2 are to be generated on homogeneous areas, because the biomass is collected at panicle initiation and the no. of panicles/m^2 at flowering or at harvest, on other monitoring squares. Sampling is therefore essential, particularly in farmer' s plots where the intra-plot heterogeneity has to be controlled and requires a stratification of the environment.

2) CHOICE OF THE VARIETY

The selected variety RD7 is chosen in this study for the following reasons :

- RD7 is promoted by the extension officers. Widely cultivated in Central and Northern Thailand the variety seems to have promising potentialities in Southern Thailand.
- the data collected over several seasons can be compared, for the variety is stable and not degenerating;
- the results of five seasons of studies analysing the YEP are available in Southern Thailand, covering a wide range of climatic and environmental conditions.

RD7 is a 115-day non-photoperiodic variety. The phyllochrone is recorded to be around 140 to 150 degree-days with a base temperature at 0 degree Celcius. The first tiller never appears. Stage II of MATSUSHIMA, corresponding to the beginning of the panicle initiation (MATSUSHIMA, 1966), occurs between zero and seven days after the beginning of elongation.

3) RICE CULTIVATION

Table 1 sums up the seven studies carried out in Southern Thailand where data are available on the YEP in the variety RD7 . In each experiment or survery, one of the treatments aims at reaching the potential of the variety, related to the the crop settlement, in conditions of farmers' plots. Yet no evidence is shown that the theoretical potential of the variety is actually reached.

All the seeds came from Phatthalung Seed Center and have not been re-graded before use.

Results

1) ELABORATION OF THE NO. OF PANICLES/m^2 (NPa/m^2)

The no. of panicles/m^2 (NPa/m^2) results from the growth and the development of the crop during the vegetative phase. The biomass/m^2 at panicle initiation is an indicator of the growth and the development of the the crop during this phase. Moreover a potential relationship links the NPa/m² and the biomass/m² at panicle initation (DURR, 1984; MEYNARD, 1985). This latter is also potentially given by the plant settlement in the plot at sowing or at transplanting. Fig. 3 and 4 show these relations in the case of the variety RD7.

The pattern of these relations closely follows former results on wheat (MEYNARD, 1985) or on rice (DURR, 1984). In both cases the curve is non-linear, the slope decreases at the highest values.

At 25 plants/m² the potential biomass/m² reaches 80 g/m² where at 100 plants/m² it reaches 170 g/m². In the considered studies, the potential biomass/m² at panicle initiation increases with increasing plant density up to 350 g/m² (Fig. 3).

The increase in the potential NPa/m² follows that in the biomass/m² at panicle initiation. 140 Pa/m² is obtained for 50 g/m², 250 Pa/m² for 100 g/m² and 370 Pa/m² for 200 g/m². No further increase in NPa/m² is hown when the biomass/m² increase over 200 g/m² (Fig. 4).

If data are not collected at panicle initiation, analysis may be done through the potential curve of the relationship between the NPa/m² and the plant density, both data collected at flowering or at harvest (Fig. 5).

A compensation is shown in the lowest NPl/m² where 4 Pa/plant can be elaborated under 25 plants/m². At 100 plants/m² the potential NPa/m² is 240, where at 200 plants/m² it reaches 350 Pa/m². One monitoring square was shown to have more than 400 Pa/m² in the axis of the curve. However the other treatments show a limit at 370 Pa/m².

2) ELABORATION OF THE NUMBER OF SPIKELETS/m² (NSp/m²)

The end of the elaboration of the spikelets takes place at stage XII of MATSUSHIMA (MATSUSHIMA, 1966), about 7 to 10 days after panicle initiation in the case of RD7. The experiments and surveys did not take into account the increase in the biomass between the panicle initiation and the stage XII of MATSUSHIMA, for the duration between these two stages is short. Had this been done, a relationship between the increase in biomass between the two stages and the potential NSp/m² could have been generated. Instead the level reached by the NSp/m² is compared only with NPa/m² (Fig. 6).

Though most of the points follow a linear curve at 85 Sp/m² intercepting the axes origin, cases were found where NSp/m² is over this line. Considering the potential curve as being a linear one (DURR, 1984), the potential NSp/Pa would be 90 Sp/Pa.

3) ELABORATION OF THE NUMBER OF FILLED GRAINS/m^2 (NFG/m^2)

The filling period constitutes the end of the reproductive phase and the end of the yield elaboration process (Fig. 2).

In RD7 the percentage of filled grains does not vary with the NSp/m^2. In all the experiments and the surveys, the relaton bewenn NFG/m2 and NSp/m^2 is very close to a linear one. The potential is reached when the percentage of filled grains is 85% (Fig. 7).

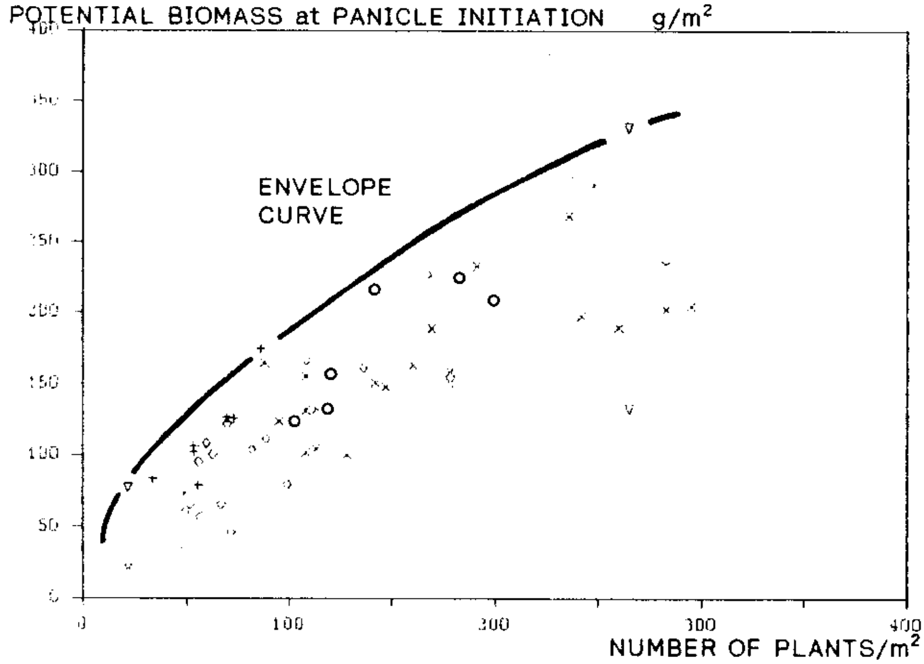


Figure 3 : Relationship between the poential biomass in g/m² at panicle initiation and the plant density recorded per treatment during the five seasons of experiments and surveys. One symbol refers to one survey or experiment (see Tab. 1)

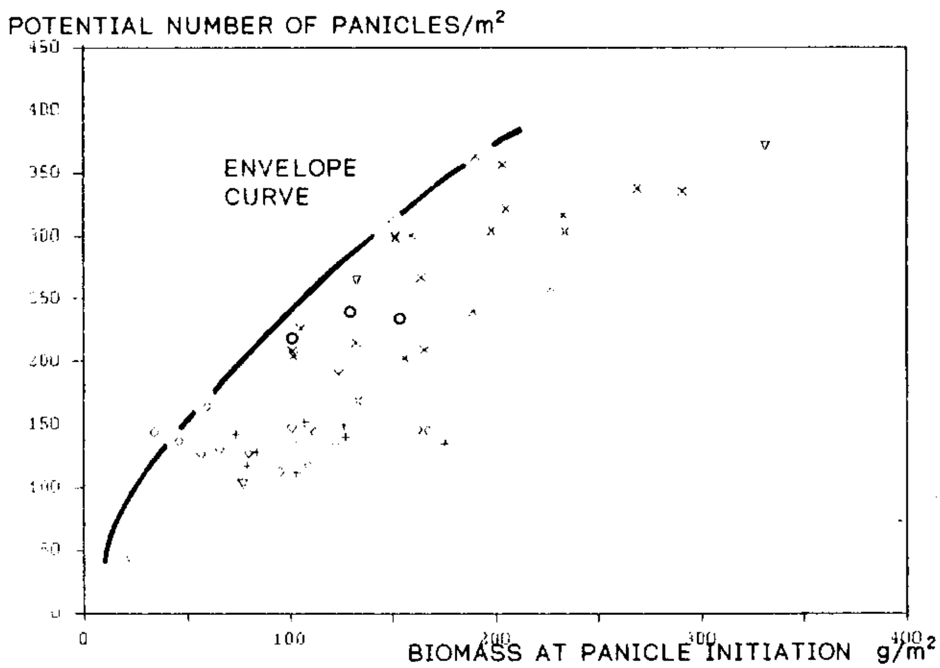


Figure 4 : Relationship between the potential number of panicles/m² and the biomass at panicle initiation in g/m² recorded per treatment during the five seasons of experiments and surveys. One symbol refers to one survey or experiment (see Tab. 1)

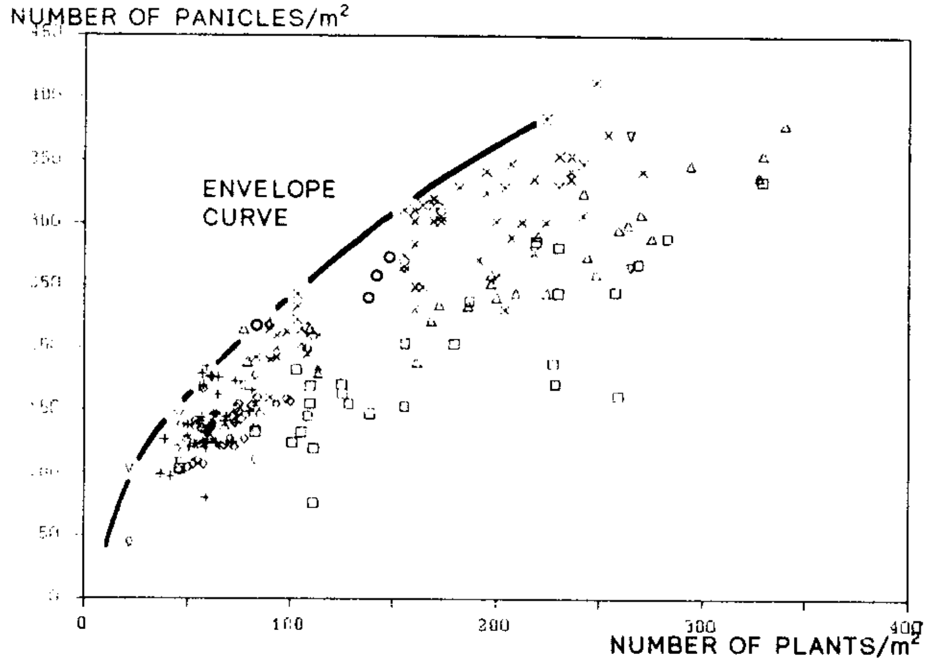


Figure 5 : Potential relationship between the number of panicles/m² and the number of plants/m² recorded in the monitoring squares during the five seasons of experiments and surveys. One symbol refers to one survey or experiment (see Tab.1)

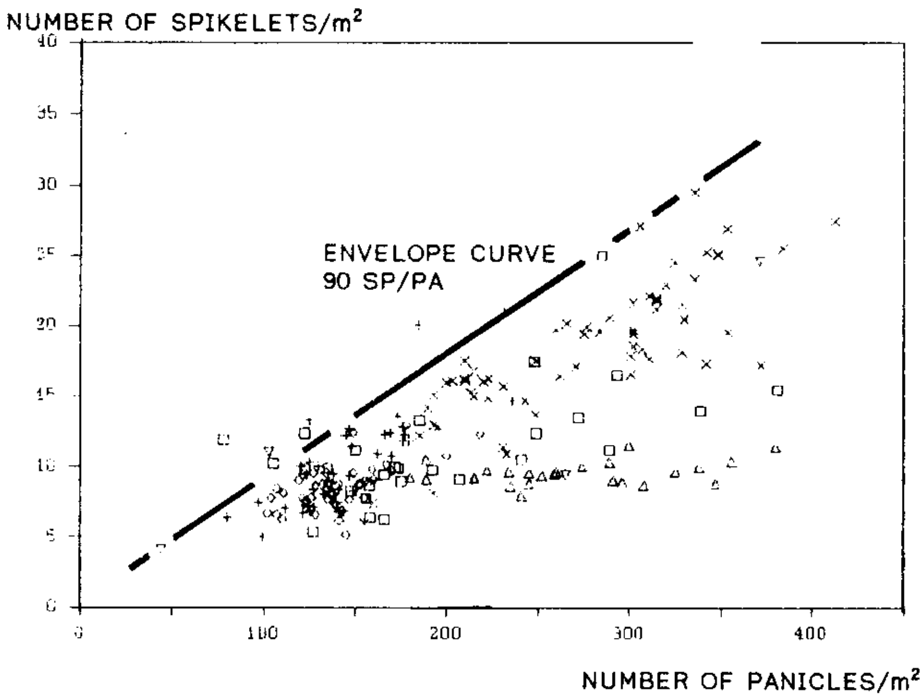


Figure 6 : Potential relationship between the number of spikelets/m² and the number of panicles/m² recorded in the monitoring squares during the five seasons of experiments and surveys. One symbol refers to one survey or experiment (see Tab. 1)

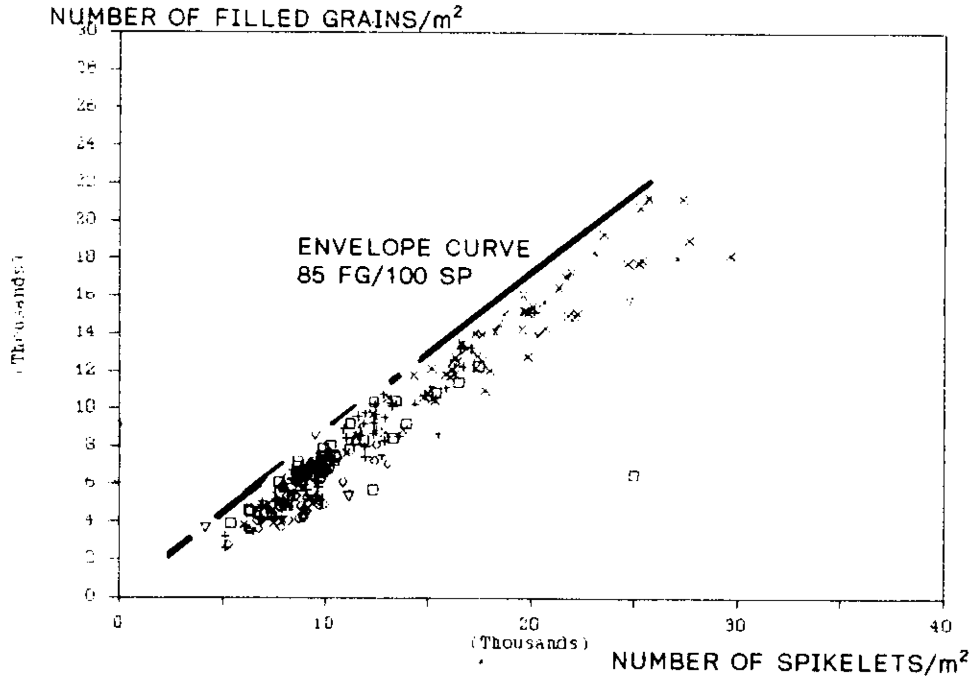


Figure 7 : Potential relationship between the number of filled grains/m² and the number of spikelets/m² recorded in the monitoring squares during the five seasons of experiments and surveys. One symbol refers to one survey or experiment (see Tab. 1)

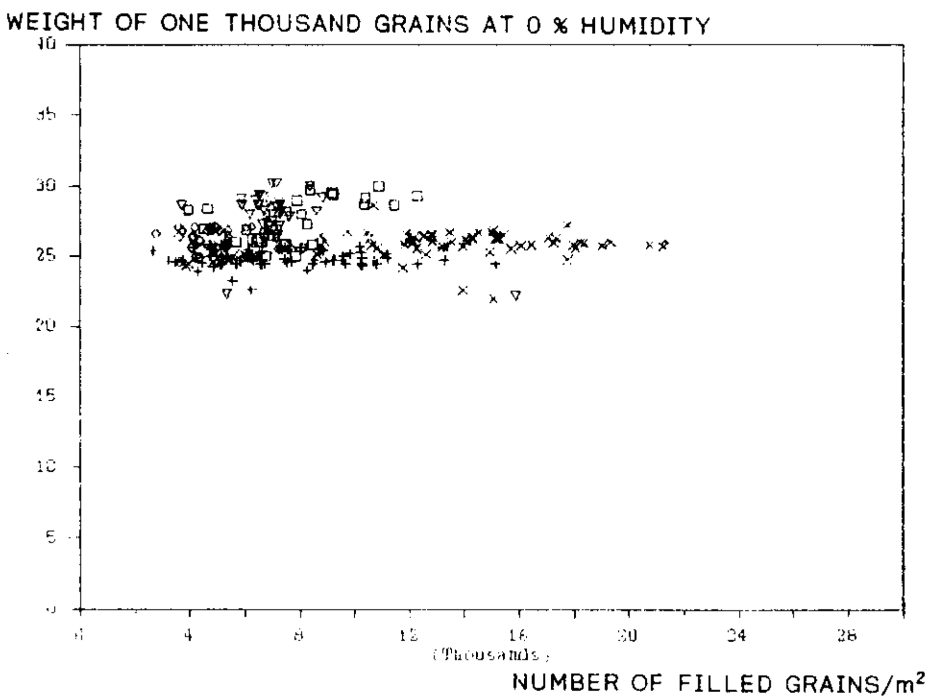


Figure 8 : Relationship between the weight of one thousand grains at 0 % humidity and the number of filled grains/m² recorded in the monitoring squares during the five seasons of experiments and surveys. One symbol refers to one survey or experiment (see Tabl.1)

4) POTENTIAL WEIGHT OF A THOUSAND GRAINS (WTG)

The relation between WTG at 0 % humidity and NFG/m^2 is shown in Fig. 8. The WTG is usually stable within one treatment-plot.

In the lowest NFG/m^2 (NFG/m^2 < 14,000), the highest values of the average per plot of WTG at 0 % humidiy reach 29 g. Over 14,000 FG/m^2, no values higher than 27 g. are encountered. However no plots with data under 14,000 FG/m^2 reaching 29 g have samples over 14,000 FG/m^2. Thus, no conclusion on possible compensation can be drawn.

Yet, no potential for the WTG at 0 % humidity can be considered for fiew information is available on the way the data have been collected for some studies. Though variation in WTG exists, the variation in the grain yield within and between treatments mainly depends on the variation in NFG/m^2.

5) NITROGEN REQUIREMENTS

The two main steps corresponding to a strong requirement for growth factors are elaboration of the panicles and elaboration of the spikelets. A former study analysed the demand of the crop for nitrogen by making nitrogen the limiting factor for growth and development of the crop (MOREAU et al., 1988b). A further survey indirectly confirmed the results (SAEDARNG et al., 1990).

Under no other limiting condition,

- 1 kg of nitrogen/ha is required during the vegetative phase to gain 6 Pa/m^2,
- 1 kg of nitrogen/ha is required at panicle initiation, stage II of MATSUSHIMA, to gain 300 Sp/m^2

The nitrogen requirements correspond here to the amount of nitrogen available in the soil.

Using the models of the YEP and the nitrogen requirements mentioned above, it is possible to forecast the steps of the management of the fertilizer dressings for the variety RD7 in Southern Thailand for several target objectives of the grain yield. An example is given here under :

target grain yield		350 kg/rai	
	=	220 g/m^2	
↓			
targer NFG/m^2		7,700	
↓			
target NSp/m^2		9,600	<- 32 kg N/ha
↓			
target NPa/m^2		115	<- 19 N/ha
↓			
target plant stand		50	

References are needed in each case of cultural diagnosis, in each agro-ecological unit, to evaluate the soil and water supplies during these two steps. In the agro-ecological unit number 3 of Ta Chiat Irrigation area, Phatthalung Province (MOREAU et al., 1988b), the assumption of global soil supply ranges from 50 to 70 kg N/ha, depending on soil texture, water management and the evolution of the residues of the previous crop (mainly depending on wether the straw is burned or not).

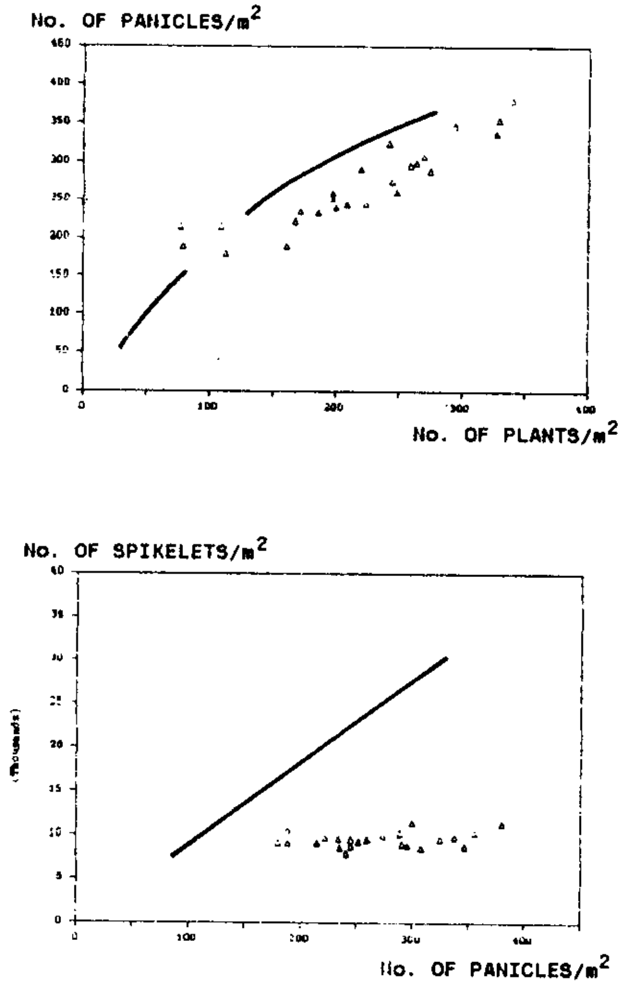


Figure 9 : Elaboration of the panicles and the spikeles recorded in each monitoring square during the 1988 experiment on pre-germinated RD7 (13).

Table 2 : Nitrogen balance in the crop during the two phases of elaboration of the panicles and the spikelets during the 1988 experiment on pre-germinated RD7 (12).

	Elaboration of the Panicles	Elaboration of the Spikelets
Level reached	360 Pa /m^2	11,000 Sp / m^2
Gain for 1 Kg N/ha	60 Pa/m^2	300 Sp/m^2
Nitrogen Uptaken	60 kg N / ha	36 kg N / ha
Soil Supply (9)	20 kg N / ha	35 kg N /ha
Fertilizer Dressing	10 kg N / ha	30 kg N / ha
Nitrogen Offer	30 kg N / ha	65 kg N / ha
Balance	-30 kg N / ha	+ 30 kg N / ha

Case studies using the YEP to reveal misfunctionings of cropping systems

1) MISFUNCTIONING IN THE TIMING OF THE FERTILIZER DRESSINGS

One study consisted of analysing the effect of the plant stand resulting from broadcasting pre-germinated seeds on the grain yield. Two farmer's plots were sowed and 25 monitoring squares settled on them (SAEDARNG et al., 1990).

The final grain yield, varying from 170 to 220 g at 0 % humidity/m^2,did not respond to the high heterogeneity of the plant stand, ranging from 77 to 340 plants/m^2

Yet the level of fertilizer dressing, 50 kg of nitrogen/ha, aimed at a target yield of 400 g/m^2. The analysis of the components showed that the variation in the panicles responded completely to the variation in the plant stand whilst the grain yield was drastically limited by the NSp/m^2 (Fig. 9). The management of the crop by the farmer was called into question : the second fertilizer dressing was shown to be too early compared with the state of development of the crop and had been taken up by the crop to elaborate more panicles (Table 2).

In such cases an operating criterion should be brought to the fore to allow a possible determination of the beginning of the panicle initiation in farming conditions. Moreover such standards would make the adoption of new varieties by the farmers easier.

2) MISFUNCTIONING DUE TO ENVIRONMENTAL CONDITIONS

The purpose of the last experiment conducted in the 1988 rainy season was to understand the effect of several nurseries management crossed with nitrogen dressings in main plots on a transplanted rice crop, on the YEP in an area where relatively low yields were observed (KAMANLRUT et al, 1990b)

Finally the elaboration of the panicles did not respond to the treatments and particularly to the first fertilizer dressing on the main plots (0 against 20 kg nitrogen/ha applied during tillering). The state of growth of the treatments at panicle initiation was not called into question and the NPa/m² did not reach the potential allowed by the biomass at panicle initiation (Fig. 10).

Plant analysis at this stage revealed that nitrogen appeared not to be limiting either, It was suggested that a limiting element, other than nitrogen and persistant in the area (explaining on part of low yields formerly observed) affected the development of the panicles. New studies could then be planned on the basis of this hypothesis.

Here the farmers' management of their plots, applying low nitrogen dressing, is coherent with the limited potentiality of the environment.

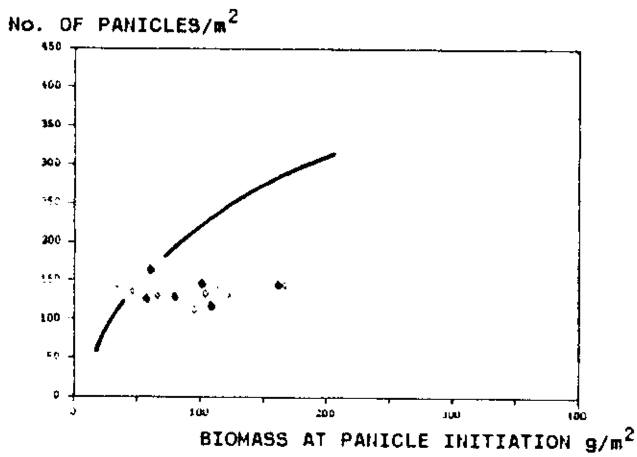


Figure 10 : Relationship between the NPa/m² and the biomass at panicle initiation during the 1988 experiment on transplanted RD7 [7].
◊ = no nitrogen dressing in main plot
♦ = 50 kg nitrogen/ha in main plot (20 of which dressed during tillering)

Through the analysis of the YEP of the cultivated crops, the coherence and the weakness of any cropping system can be evaluated. Analysing the effects of the techniques using only statistical tools such as the analysis of variance fails to address the problem of understanding the phenomena at work and the diversity of the encountered situations, which are often relegated to non analysed block effects.

Based on cumulative acquisition of knowledge, each new study on the YEP with the same cultivar allows the model to be confirmed or refined and leads the analysis in comparison with results from other sites and former studies.

Yet, if the relation

TECHNIQUE -> YIELD

is to be rejected (SEBILLOTTE, 1985), so must the relation

TECHNIQUE -> YIELD COMPONENT

be replaced by the relations

TECHNIQUE -> ENVIRONMENT -> YIELD COMPONENT

The experimental treatments, analysed as having an effect of the crop (SEBILLOTTE, 1985) consist of different states of the environment, resulting directly or not from the applied techniques. Only in this case, and provided underlying hypotheses are confirmed, may the analysis of variance be used as a tool for studying cropping systems in a comprehensive way.

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