ว.เกษตรศาสตร์ (สังคม) 1 : 104-113 (2535)

On-Farm Conditions Limiting Yield Elaboration Process of Transplanted Rice in Southern Thailand

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ABSTRACT

An on-farm experiment was conducted during the 1988-1989 rainy season, to grade the conditions limiting the grain yield elaboration process of transplanted rice after different managements of nurseries. 48 kg nitrogen/ha application was compared with no application in mainplots transplanted with seedlings coming from three treatments : 45 days, 30 days, 30 days fertilized with 20 kg nitrogen/ha. The other techniques were decided by the farmer. Nitrogen application on mainplot affected the elaboration of the spikelets of the transplanted 45 days old seedlings only, yet below the level expected (1,200 against 9,000 spikelets/m^2). Grain filling appeared to be affected by several insect damages. Otherwise, the rice crop hardly responded to the treatments. Some trouble was provoked by stem borer damages in the elaboration of the spikelets. Though the plant density was low in every treatment, ranging from 40 to 100 plants/m^2, it was not limiting. The importance of the insect damages and existence of a limiting element in the soil other than nitrogen are assumed.

Key words : rice, on farm research, yield elaboration, Southern Thailand.

INTRODUCTION

The interest of agronomical research work of the Farming System Research kind lies in the possibility to analyse the diversity of the yields resulting from different farmers' plots conditions, together with the particularity of some situations where the yields fail to reach potential levels of the crop.

Yet only a comprehensive approach, taking into account the agronomic theory, appropriate for studying the diversity among farmers' plots.

According to a previous study in Phatthalung Province, Southern Thailand, based on an agro-ecological zonation and a typology of cropping systems, farmers grow rice in each defined environmental unit in different ways. Formulation of hypotheses on the conditions limiting the yield was made then on the basis of this typology (Moreau *et al.*, 1988b).

In the units where water is available from an irrigation network, nitrogen, resulting from low applications, was assumed to be limiting. An on-farm survey allowed this hypothesis to be confirmed on the whole through simultaneous analyses of the yield elaboration process

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and nitrogen requirements for the crop (Moreau *et al.,* 1988b).

Yet some plots do not follow the pattern. Among them, some fail to reach the level allowed by the nitrogen applications. Apart from detected casses of rice bug *(Leptocorias sp.)* damages during the grain maturing period, other hypotheses had to be defined.

According to similar situations in studied nearby areas of the Province Baert & Bergez, 1987), where the farmers' plots are located at the end of canals, farmers were shown to be not always able to manage their nurseries in an optimum way, that is transplanting one month after sowing the nursery (depending on the variety) and fertilizing ten days before transplanting. Because of poor water availability, transplanting is delayed and no fertilizer is then applied in the nurseries.

The purpose of this study is to find out the effect of such a management of the nursery on the grain yield elaboration process of the rice crop. The study was carried out in Ta Chiat irrigation area in Phatthalung Province during the 1988-1989 rainy season.

MATERIALS AND METHOD

Theoretical Considerations

a) At the plot level, comparison between two treatments is possible only when one single factor varies among them (Crozat *et al.,* 1988). In the case of comparing the effects of a non fertilized delayed nursery with a fertilized non delayed nursery, two factors differ : the fertilization dressing and the age of the nursery.

In order to avoid confusion of effects, a "bridge" between these two treatments is required to satisfy the comparison (Kamnalrut *et al.,* 1989). Three nursery treatments are ultimately analysed :

- a non fertilized delayed nursery.
- a non fertilized non delayed nursery.
- a fertilized non delayed nursery.

b) The effects of these treatments on the growth and development of the crop can be compared in a comprehensive way refering to a model used as a link between the studied situation (Sebillotte, 1989). Here the extent of the crop responses to the treatments are analysed referring to the model of potential yield elaboration process of the variety, generated previously (Le Gouis *et al.,* 1990).

Design

Two fertilizer applications were tested as mainplots in a split-plot arrangement with 2 replicates : a non fertilized control, allowing estimation of the soil supply to the crop, and a 48 kg nitrogen/ha application. The subplots corresponded to the 3 origins in the nursery mentioned above. Soil was sandy clay loam to sandy loam.

One mainplot corresponded to one farmer's plot, providing as much homogeneity of environmental conditions as possible (same soil, same cropping system). In order to avoid water contamination from the fertilized to the non fertilized treatments, the former were located downstream.

Elementary subplot size was around 12 × 25 m.

Table 1 : Legend of the figures 1 to 10

A, B	: blocks
N	: fertilized in mainplots
1	: 45-days-nursery treatment
2	: 30-days-nursery treatment
3	: 30-days-nursery fertilized treatment
——	: potential curve of RD7 in Southern Thailand (LE Gouis & APAKUPAKUL, 1990)

Rice Cultivation

According to the reasons mentioned above, the nurseries were managed in one farmer's plot. They were sown with seeds of RD7 variety. Seedlings were transplanted later on the same day. Ultimately the seedlings came from three different origins : 45 days old, 30 days old and 30 days old fertilized with 20 kg nitrogen/ha 10 days before transplanting.

Plant density in mainplots resulted from the farmers' practices with an average 22 cm spacing between hills with a target of 4 plants/hill ; that is 70 to 100 plants/m^2.

Nitrogen dressing was split into two applications in fertilized mainplots : 20 kg of 16-20-0 per rai (20 kg N/ha) 10 days after transplanting and 10 kg of urea 45% per rai (28 kg N/ha) at stage II of Matsushima (Matsushima, 1966), aiming at the following target levels :

Systemic Furadan insecticide was broadcast on the nurseries 15 days before transplanting and on mainplots 20 days after transplanting.

Data Collection

General features of water level, pests and diseases were recorded weekly.

The following data were collected per treatment at the beginning of panicle initiation, stage II of Matsushima (Matsushima, 1966). These were : number of plants/m^2, dry matter of aerial parts/m^2 and N content of aerial parts.

Grain yield and yield components data, the dry matter of vegetative parts, the height of the plants and the morphological pattern of the panicles were also collected at harvest on 3 monitoring squares of 1 m^2 each.

The effects of the treatments were appraised. The elaboration of the grain yield was revealed by a step by step analysis of its component parts (Crozat *et al.*, 1986 ; Crozat *et al.*, 1988 ; Moreau *et al.*, 1988a ; Sebillotte, 1989).

RESULTS

1) Average Levels of the Treatments

The effects of the treatments on the grain yield are not significant (Table 2). Moreover the average level of the yield about 130 g/m^2, is below expected.

Though the differences between the mainplot levels are significant at 10% level for the

	Nitrogen applications in mainplot	
	0 kgN/ha	**50 kgN/ha**
1st application	-	20 kgN/ha
assumpt. of soil supply(*)	23 kgN/ha	23 kgN/ha
gain for 1 kgN/ha(*)	6 Pa/m^2	6 Pa/m^2
TARGET No.OF PANICLES/m^2	138 Pa/m^2	258 Pa/m^2
2nd application	-	28 kgN/ha
assumpt. of soil supply(*)	33 kgN/ha	33 kgN/ha
gain for 1 kgN/ha*	300 Sp/m^2	300 Sp/m^2
TARGET No.OF SPIKELETS/m^2	9,900 Sp/m^2	18,900 Sp/m^2
average sterility	25%	25%
average dry weight of one thousand seeds	25 g	25 g
TARGET YIELD g/m^2	185 g/m^2	350 g/m^2

(*) : from Moreau *et al.*, 1988

elaboration of the spikelets and the panicles, they are also below expected (16 against 120 Pa/m^2 and 1,540 against 9,000 Sp/m^2).

Only the 45-day-nursery treatments slightly affected the eleboration of the number of spikelets/panicle (Table 2).

Last, the lower plant density of the 45 days old treatment (Table 2) comes from a lower number of plants/hill. The seedlings were thicker which reduced the average number of plants/hand as usual in farmers' practices for transplanting.

All treatments showed a pattern of weakness and low height of the plants, under 60 cm. As the case of surrounding plots, the leaves were covered with brown colored spots.

2) Analysis of the Elaboration of the Yield Components

Apart from little non controlled variation in the weight of one thousand filled grains, the yield is mainly limited by the number of filled grain/m^2 (NFG/m^2) (Figure 1).

In no case does the NFG/m^2 reach the potential of the variety (Figure 2).

The increase in NFG/m^2 follows that in the number of spikelets/m^2 (NSp/m^2) in the 45-day-nursery treatment (Figure 2). The correlation per monitoring square reaches $r^2 = 0.795$ (Table 3).

In the other nursery treatments, NSp/m^2 is not the major source of variation of NFG/m^2 ($r^2 = 0.301$ per monitoring square (Table 3) which reaches a plateau around 5.200 FG/m^2 (Figure 2).

In mainplot A, all the treatments gather around 0.7 FG/Sp. The treatments in fertilized mainplots show an increase in the percentage of sterility (Figure 2). These plots were observed to have water remaining during the grain maturing period due to their downstream location.

Though the grain filling stage alters the elaboration of the grain yield, the low levels of NSp/m^2 and of the number of panicles/m^2

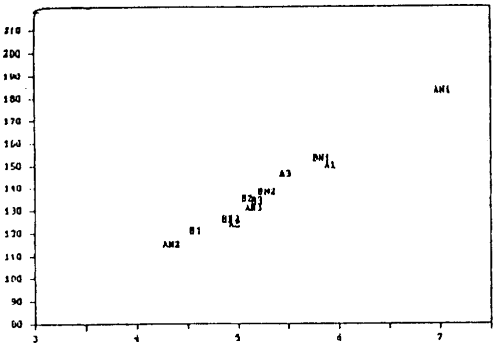
Table 2 Analysis of variance on the yield and the yield components data

Variables	Factors									
	Nitrogen in mainplot				Nursery managements					
	0 kg		50 kg	C.V.	45 days		30 days		30 days 20 kg N	C.V.
Yield (g/m^2 at 0% humidity)	131	-	136	5.6%	147	-	125	-	129	12.9%
1000 seed dry weight	26.13	-	26.13	4.6%	26.10	-	26.52	-	25.77	3.2%
Filled Grains/m^2	5,050	-	5,230	8.0%	5,650	-	4,790	-	4,990	13.3%
% Grain Filling	60.7	-	58.3	5.8%	55.5	-	59.5	-	63.5	11.3%
Spikelets/m^2	7,920	S_{10}	9,460	6.4%	9,320	-	8,220	-	8,540	11.2%
Spikelets/panicle	62.0	-	65.5	8.6%	71.0	S_{10}	59.3	-	61.0	7.8%
Panicles/m^2	129	S_{10}	145	3.0%	131	-	139	-	140	8.8%
Plants/m^2	64	-	78	8.0%	65	S_5	75	-	73	13.0%

S_5, S_{10} : significant at 5%, 10% level

There is no significant interaction between the factors

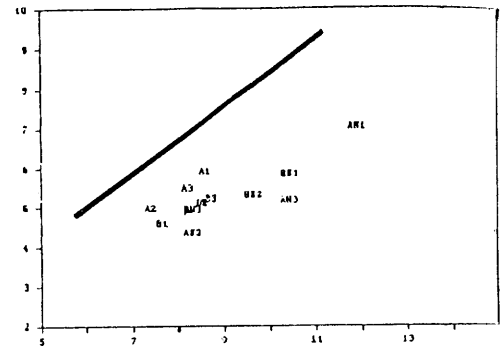
Grain Yield (g of dry matter/m^2)



No. of Filled Grains/m^2 (x 10^3)

Figure 1 : Relationship between the grain yield/m^2 and the no. of filled grains/m^2, recorded per treatment at harvest (legend in Tab.1).

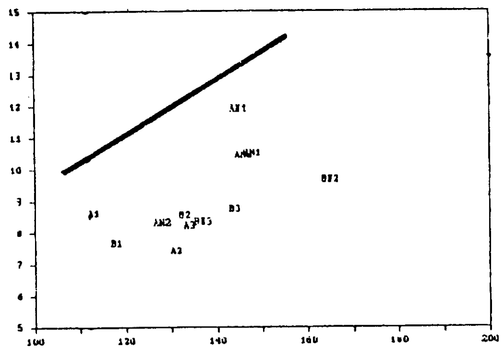
No. of Filled Grains/m^2 (x 10^3)



No. of Spikelets/^{2} (x 10^3)

Figure 2 : Relationship between the no. of filled grains/m^2 and the no. of spikelets/m^2, recorded per treatment at harvest (legend in Tab.1).

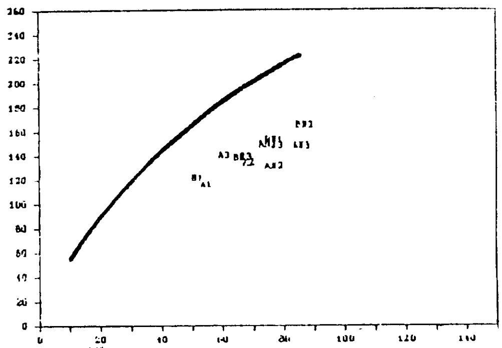
No. of Spikelets/m^2 (x 10^3)



No. of Panicles/m^2

Figure 3 : Relationship between the no. of spikelets/m^2 and the no. of panicles/m^2, recorded per treatment at harvest (legend in Tab.1).

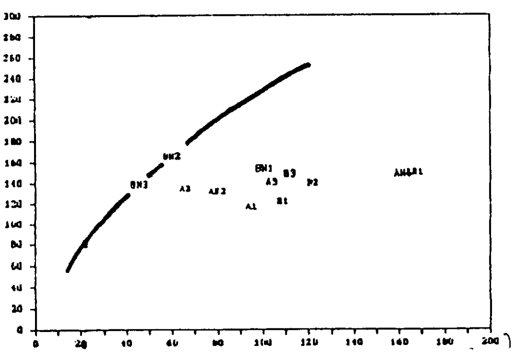
No. of Panicles/m^2



No. of plants/m^2

Figure 4 : Relationship between the no. of panicles/m^2 and the no. of plants/m^2, recorded per treatment at harvest (legend in Tab.1).

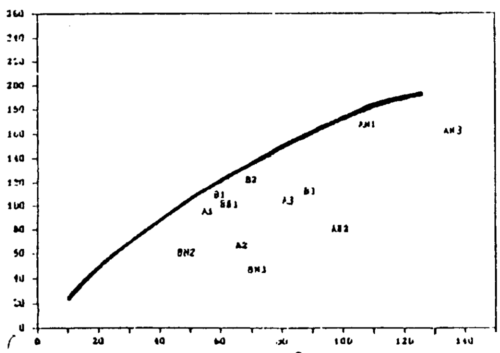
No. of Panicles/m^2



Aerial Biomass at Panicle Initiation (g/m^2)

Figure 5 : Relationship between the no. of panicles/m^2 and the aerial biomass/m^2 at panicle initiation recorded per treatment (legend in Tab.1).

Aerial Biomass at Panicle Initiation (g/m^2)



No. of Plants/m^2 at Panicle Initiation

Figure 6 : Relationship between the aerial biomass/m^2 and the no. of plants/m^2 recorded per treatment at panicle initiation (legend in Tab.1).

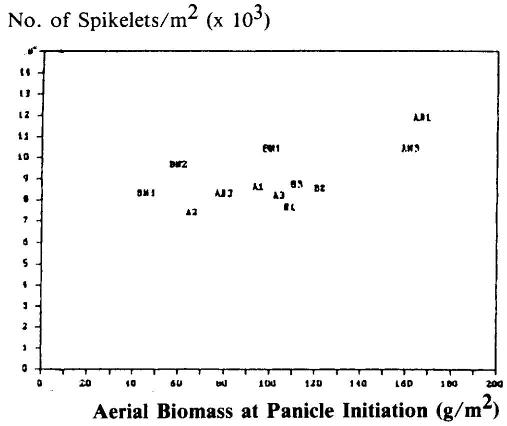


Figure 7 : Relationship between the no. of spikelets/m² and the aerial biomass/m² at panicle initiation, recorded per treatment (legend in Tab.1).

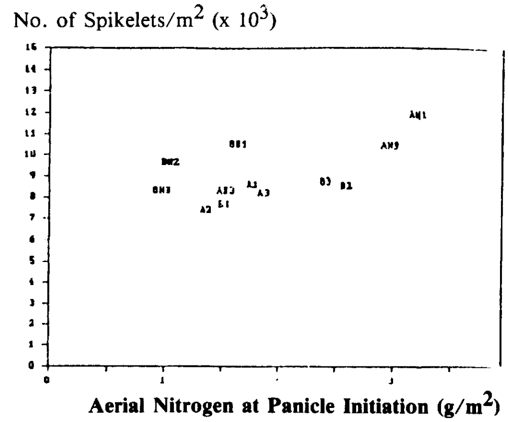


Figure 8 : Relationship between the no. of spikelets/m² and nitrogen in aerial parts/m² at panicle initiation, recorded per treatment (legend in Tab.1).

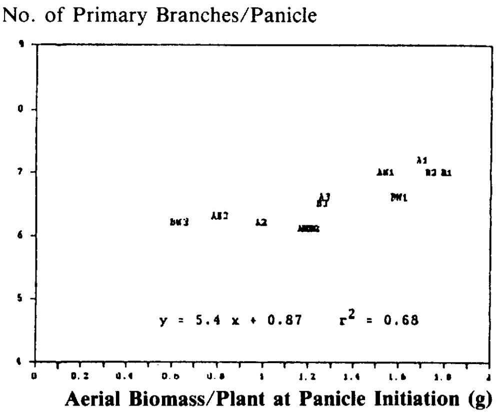


Figure 9 : Relationship between the no. of primary rachis branches/panicle and the aerial biomass/plant at panicle initiation (legend in Tab.1).

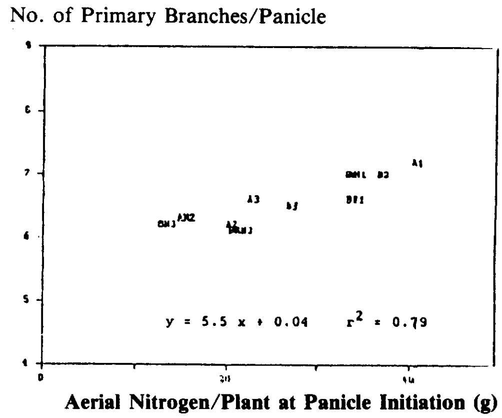


Figure 10 : Relationship between the no. of primary rachis branches/panicle and the aerial nitrogen/plant at panicle initiation (legend in Tab.1).

(NPa/m^2) are also to be analysed.

NPa/m^2 is not the major source of variation of NSp/m^2 (Figure 3) ; the elaboration of the spikelets shows various responses to the elaboration of the panicles. Apart from the treatments AN1 and A1, NSp/m^2 fails to reach the potential allowed by NPa/m^2 (Figure 3).

NSp/m^2 is positively correlated with the height and the dry matter of the aerial parts of the plants at harvest (Table 3). That is, variation in NSp/m^2 corresponds to that in the condition of growth of the crop. The relatively high levels reached by the treatments AN1 and A1 around 80 Sp/Pa (Figure 3), which appeared to have higher plants, are thus explained.

Early stem borer *(Schocnobius incertulas* [– Walk.]) damages on the 30-days-nursery treatments, as in the treatments AN2, BN2 and BN3, and mainly late stem borer damages on the 45-days-nursery one affect NSp/m^2 (Table 3).

The elaboration of the spikelets depends on the state of growth and development of the crop at panicle initiation (Durr, 1984). In this survey NSp/m^2 shows a significant response to the dry matter at this stage, and more precisely to the nitrogen taken up by the crop, thus explaining the low response of NSp/m^2

to NPa/m^2 in the treatment A2 (Figure 7 and 8, Table 3).

In no other limiting conditions apart from nitrogen, the NSp2Pa is linked to the development of the primary and secondary rachis-branches of the panicles (Manaka *et al.,* 1971 ; Durr, 1984). Here, insect damages affected the development of the panicles and NSp/Pa is not related to the number of primary rachis-branches/panicle. Yet, the variation in these latter follows that in the state of growth, and mainly nitrogen content in the plants, at panicle initiation (Figure 9 & 10).

The elaboration of FG/Pa sums up the two phases of elaboration of Sp/Pa and FG/Sp, correlating positively NFG/m^2 to NPa/m^2 and to the number of primary rachis-branches/panicle (Table 3). Insect damages being taken into account, a negative effect remains due to a delay in the maturing stage (Table 3). The treatments AN2, AN3 and BN2, which had to be harvested later than the others, are those mainly concerned.

Though the number of plants/m^2 (NPl/m^2) is low, between 50 and 90 Pl/m^2, NPa/m^2 fails to reach the potential allowed by the variety in every treatment. However, the elaboration of the panicles responded to the plant density (Figure 4), the extent of which is larger in the 45-day-nursery treatment than in the other nursery treatments (Table 3).

However NPa/m^2 fails to reach the potential allowed by the aerial biomass at panicle initiation/m^2 and is limited in every treatment at a plateau around 150 Pa/m^2 (Figure 5). No other source of variation of NPa/m^2 is explained.

Last, the elaboration of the biomass at panicle initiation reaches the potential allowed by the variety for the 45-days-nursery treatment only (Figure 6). In every case the variation of the dry matter/m^2 at panicle initiation follows that in nitrogen in the aerial parts of the plants/m^2 at the same time (r^2 = 0,952 among within monitoring square data).

Except stem borer damages in AN2, BN2 and BN3, neither the treatments nor other observations explain the variation in the nitrogen content in the aerial parts of the plants.

Table 3 Regression analysis on the yield component data.

						Number of samples
45-DAYS-OLD-NURSERY						
NFG/m^2 =	391	+ 0.56 x NSP/m^2 79.5% $S_{0.1}$ **				12
NFG/m^2 =	- 2,772	+ 41.8 x NPA/m^2 50.0% S_1	+ 636 x 1P 20.2% S_1	- 235 x AT 11.7% S_5	- 342 x SB 7.3% S_{10}	12
NSP/m^2 =	-11,137	+ 64.6 x NPA/m^2 68.5% $S_{0.1}$	+ 243 x H 10.0% S_5	- 216 x AT 7.0% S_{10}		12
NSP/m^2 =	- 1,285	+ 62.4 x NPA/m^2 75.4% S_{20}	+ 1232 x NII/m^2 20.2% -			4 (treatment mean)
NPA/m^2 =	- 5.5	+ 2.27 x NPL/m^2 84.8% $S_{0.1}$				11
30-DAYS-OLD-NURSERIES						
NFG/m^2 =	1,497	+ 0.41 x NSP/m^2 30.1% S_1				24
NFG/m^2 =	- 1,031	+ 22.7 x NPA/m^2 40.9% $S_{0.1}$	+ 502 x 1P 15.8% S_1	- 54 x AT 6.2% S_5	- 69 x NM 6.4% S_{10}	24
NSP/m^2 =	- 3,367	+ 35.1 x NPA/m^2 63.2% $S_{0.1}$	+ 2.95 x DM/m^2 6.9% S_5	+ 127 x H 3.2% S_{10}	- 183 x SB 6.7% S_1	24
NSP/m^2 =	- 530	+ 51.7 x NPA/m^2 50.4% S_1	+ 823 x NII/m^2 19.1% S_1	- 2.3 x DMII/m^2 7.8% S_5		8 (treatment mean)
NPA/m^2 =	+ 71	+ 0.95 x NPL/m^2 53.2% $S_{0.1}$				24

** : Percentage of the variation explained by the covariable and its level of significance in %

NPL/m^2 : Number of Plants/m^2 NPA/m^2 : Number of Panicles/m^2 DM/m^2 : Dry Matter g/m^2
NSP/m^2 : Number of Spikelets/m^2 NFG/m^2 : Number of Filled Grains/m^2 NII/m^2 : N at Pa. init. g/m^2
Y : Grain Yield in grams/m^2 WTG : Weight of Thousand Filled Grains DMII/m^2 : DM at Pa. init. g/m^2
H : Aerial height at harvest (cm) NM : Non Mature Panicles/m^2 1P : Primary Branch/Panicle
SB : Notation of Early Stem Borer Damages AT : Notation of Late Insect Damages (mainly Stem Borers)

DISCUSSION

RD7 is a short maturing variety. In this survey, the ripening stage of the crop appeared before the other surrounding plots grown with late and medium maturing varieties. Therefore the farmer could not manage to drain the surveyed plots dry after flowering. Water remained in the fertilized mainplots nearly until harvesting and affected the maturation of the grains.

Despite two *broadcasts* of systemic Furadan insecticide, insects damaged the crop. The attack of leaf hoopers (*Nephotettix virescens* [– Dist.] in the nurseries could be reduced to a low level but that in stem borers' could not. Not only the resistance of the RD7 variety can be called into question. When only a couple of plots are sown with RD7 in the studied area, these would be preferentially damaged. The intensity of the damages originates from both the earlier development of RD7 and its lower resistance to pests and diseases than the surrounding local varieties grown by the farmers. Application of systemic insecticide requires specific climatic conditions for high efficiency, such as air hygrometry, which cannot be appraised in the studied farming conditions. Therefore, high amount of active ingredient is required to ascertain an efficient absorption. The farmers are nevertheless reluctant to spray a high quantity of any insecticide, though posessing enough given by extension officers. They feel it is dangerous for their health in the long term. It kills the fish in the paddies in the short term.

The effects of the 45-day-nursery treatment are beyond those of other nursery treatments, contrary to the underlying hypotheses of the 15 days longer light and nutrient limitations. However, while the light limitation may not be rejected (the average 700 Pl/m^2 in the nursery renders this limitation plausible) nutrient limitation may not have been operating.

The nurseries were settled in a plot where the farmer is used to sowing nurseries and specially dressing manure from time to time. These dressings may have allowed the seedlings remaining 15 days longer in this plot not to be limited either by nitrogen or by any other growth factor. Moreover, the plants appeared to have taken advantage of the delayed transplanting, reaching the highest levels of growth and development of the crop in mainplots.

Though the plant population density was low, ranging from 40 to 100 Pl/m^2 in the monitoring squares at harvest, it did not limit the elaboration of the other yield components, unlike other surveys in the area (Moreau *et al.*, 1988 ; Saedarng *et al.,* 1990)

The 30-days-nurseries both fertilized and non-fertilized treatments reached successive plateaux, at 150 Pa/m^2 and 9,000 Sp/m^2, which represent about the target levels of non-fertilized mainplots. The responses to the fertilization applications were negligible. Although insect damages were more severe in fertilized treatments, this was not the only reason. Moreover, the microscale heterogeneity is responsible for a non negligible part of the remaining global variability.

Thus, the most plausible assumption is that AN ELEMENT OTHER THAN NITROGEN LIMITED THE GRAIN YIELD ELABORATION PROCESS.

According to the literature, two elements can be proposed as being limiting (De Datta, 1981) :

- sulfur deficiency symptoms are similar to the nitrogen ones rendering a possible confusion during the prior diagnosis. The effects on the growth and development of the plant are recorded to induce a reduction in the number of panicles and the number of spikelets/panicle, as revealed in this survey. Reasons cited for the occurrence of sulfur deficiency, such as higher use of urea, less use of manure and the increasing use of modern varieties, are also applicable and would explain the levels reached by the 45-day-nursery treatment.

- Potassium deficiency may have induced the brown colored spots of the leaves.

As an improvement in the cropping systems performed by the farmers in such environment, it is necessary to identify the limiting elements operating, otherwise any recommendation for using improved varieties, as well as increasing the amount of nitrogen applications will go unheeded.

As in the case of the survey for the elaboration of NFG/m^2, NSp/m^2 and NPa/m^2, a linear relationship between two successive yield components does not imply that the latter is only limited by the former.

The limitation is only due to the yield component formed before when the points are located on the potential curve. Otherwise, (the points are scattered under the potential curve), another factor or condition also limits the elaboration of the yield component.

Analysing by comparing the results of an agronomical survey or experiment with the model of potential yield elaboration process of the crop is necessary to ascertain the origin of the limitation in the yield elaboration process of the crop.

LITERATURE CITED

Baert, V. and V. Bergez', 1987. *Un systeme agraire du Sud-Thailande : Phatthalung.* D.A.A. thesis. Institut National Agronomique Paris-Grignon. Paris, France.

Crozat, Y., A. Sitthicharoenchai, P. Kaewvongsri, S. Pornpinatepong, and P. Chitapong, 1986. *The improvement of rice cultivation in Sathing Phra area, Songkla Lake basin. Illustration of a methodology based on the yield differentiation between farmers' plots.* Thai-French F.S.R. Project, Faculty of Natural Resources, Prince of Songkla University-Thailand. Publication n^o 6.

Crozat, Y. and P. Chitapong, 1988. *The on-farm agronomical survey : a tool for grading limiting factors of a crop and designing new technologies.* in "PRINCE OF SONGKLA UNIVERSITY. 1988. Farming Systems Research and Development in Thailand : Illustrated Methodological Considerations and Recent Advances. Hat Yai, Thailand : The Thai-French F.S.R. Project."

De Datta, S., 1981. Principles and practices of rice production. Willey-Interscience publication, USA.

Durr, C., 1984. *Systemes de culture et elaboration du rendement du riz (Oryza sativa L.) en Camargue.* PhD thesis. Institut National Agronomique Paris-Grignon. Paris, France.

Kamnalrut, A., D. Moreau, B. Le Gouis, and P. Thongkham, 1989. *A method of cultural diagnosis of crop by relating situations between on-farm and on-station observations.* Thai-French F.S.R. Project, Faculty of Natural Resources, Prince of Songkla University-Thailand. Presented at the 6th Thailand National Farming Systems Seminar, Khon Kaen Thailand, 1989.

Le Gouis, B., and R. Apakupakul, 1990. *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.* Thai-French F.S.R. Project, Faculty of Natural Resources, Prince of Songkla University-Thailand. Presented at the 7th Thailand National Farming Systems Seminar, Surattani Thailand, 1990.

Manaka, T., and S. Matsushima, 1971. *Analysis* *of yield. Determining process and its application to yield prediction and culture impovement of lowland rice (100).* Proc. Crop Sci. Soc. Japan, 40, 101-107. [quoted in DURR, 1984]

Matsushima, S., 1966. *Crop Science in Rice. Theory of Yield Determination and its Application.* Fuji publishing, Tokyo, Japan.

Moreau, D., A. Kamnalrut and S. Boonvanno, 1988. *The concept of yield elaboration process in rice : a tool for on-farm diagnosis.* Presented at the 1st Seminar on Rice in Southern Thailand, Narathiwat-Thailand. 1988.

Moreau, D., A. Kamnalrut, P. Thongkum, and S. Boonvanno, 1988. *Cultural diagnosis on rice cropping systems in Phatthalung Province Southern Thailand.* Thai-French F.S.R. Project, Faculty of Natural Resources, Prince of Songkla University-Thailand. Publication n^{o} 8. Presented at the 2nd Seminar on Rice in Southern Thailand, Phatthalung, Thailand. 1988.

Saedarng, B. and B. Le Gouis, 1990. *Effect of the intra plor variation in the plant density on the yield elaboration process in pre-germinated broadcasted rice : on-farm case study in Southern Thailand.* Thai-French F.S.R. Project, Faculty of Natural Resources, Prince of Songkla University-Thailand. Presented at the 3rd Seminar on Rice in Southern Thailand, Hat Yai, Thailand. 1990.

Sebillotte, M. 1989. *Approaches of the on-farm agronomist : illustrated methodological considerations.* Development Oriented Research on Agrarian Systems Project, Kasetsart University Kamphaengsaen Campus-Thailand. Presented at the 4th Thailand National Farming Systems Seminar, Prince of Songkla University, Hat Yai-Thailand. 1987.