WAT4CAM
Long-term Experiment

Reang Kesei, Battambang province

2021 - 2022

Prepared by: Mathilde DIONISI – CIRAD

With the support of Sovanna SOTHEA, Bendith TAI, and Sophal KOUN

PRESENTATION AND FIRST RESULTS

SUMMARY

WAT4CAM PROJECT

The WAT4CAM program[1], i.e. “Water Resources Management and Agroecological Transition for Cambodia”, was established in 2018. The project aims to improve integrated water resources management, as well as irrigation system management in Cambodia. The WAT4CAM program is funded by the Royal Government of Cambodia, the French Agency for Development, and the European Union.

The WAT4CAM program is divided in 4 main components:

- Component 1: Rehabilitation and completion of irrigation and drainage infrastructures;
- Component 2: Improvement of irrigation management;
- Component 3: Support to water resources monitoring & management;
- Component 4: Support innovative farming practices and support to rice value chain.

The fourth component supports the building of sustainable and resilient agriculture in Cambodia, especially for rice crops. It aims to improve performance and resilience of agricultural productions, support climate smart agriculture, and support research for development of agroecological practices and cropping systems in irrigated areas. The fourth component is divided in 4 sub-components:

- Sub-component 4.1: Institutional Support;
- Sub-component 4.2: Research and development on agroecological practices;
- Sub-component 4.3: Agricultural extension in the irrigation schemes Preks;
- Sub-component 4.4: Rice, Vegetable and Horticulture Value Chains Support.

The WAT4CAM experiment in Reang Kesei is part of the Sub-component 4.2 “Research and development of agroecological practices”, and compare different set of cropping practices in rice cropping systems.

[1] For further information: WAT4CAM (wat4cam-mowram.com)

REANG KESEI EXPERIMENT

This experiment is located in Sanghae district, in Battambang province.

FIELD COORDINATES: 12.57N, 103.15E
FIELD OWNER: MR. PHAL ROTHA

The experiment has 4 systems, randomly replicated 4 times (16 elementary plots). Each system is divided in 3 fertility levels (Figure 1; Table 1).

Figure 1. Design of the WAT4CAM experiment in Reang Kesei

Table 1. Description of the systems and fertility levels of the experiment

	2021	2022
T1	**Cycles**: Rice + rice **Varieties**: Sen Kra Ob, Sar Ngae **Tillage**: Plowing **Sowing**: Broadcast (200kg/ha)	**Cycles**: Rice + rice **Varieties**: Sen Kra Ob, Sar Ngae **Tillage**: Plowing **Sowing**: Broadcast (200kg/ha)
T2	**Cycles**: Rice + rice + cover-crops **Varieties**: Sen Kra Ob, Sar Ngae **Tillage**: No plowing **Sowing**: No-till seeder (125kg/ha)	**Cycles**: Rice + rice + cover-crops **Varieties**: Sen Kra Ob, Sar Ngae **Tillage**: No plowing **Sowing**: No-till seeder (125kg/ha), broadcast (200kg/ha)
T3	**Cycles**: Rice + cover-crops **Varieties**: Phka rumduol **Tillage**: No plowing **Sowing**: No-till seeder (80kg/ha)	**Cycles**: Rice + rice + cover-crops **Varieties**: Sar Ngae, Sar Ngae **Tillage**: No plowing **Sowing**: No-till seeder (125kg/ha), broadcast (200kg/ha)
T4	**Cycles**: Rice + cover-crops **Varieties**: Phka Rumduol **Tillage**: No plowing **Sowing**: No-till seeder (80kg/ha)	**Cycles**: Rice + cover-crops + maize **Varieties**: Phka Rumduol **Tillage**: No plowing **Sowing**: No-till seeder (80kg/ha)

T1 represents the conventional farmer practices.

Sen Kra Ob Sar Ngae	**F1**	NPK 74-56-7.5	NPK 74-56-7.5
	F2	NPK 46.5-44.5-7.5 Biochar (500kg/ha) Organic fertilizer (150kg/ha)	NPK 46.5-44.5.7.5
	F3	Biochar (1000kg/ha) Organic fertilizer (300kg/ha)	Ash of rice husk (2000kg/ha) Organic fertilizer (300kg/ha)
Phka Rumduol	**F1**	NPK 52.5-46-0	NPK 52.5-46-0
	F2	NPK 32-23-0 Biochar (500kg/ha) Organic fertilizer (150kg/ha)	NPK 32-23-0
	F3	Biochar (1000kg/ha) Organic fertilizer (300kg/ha)	Ash of rice husk (2000kg/ha) Organic fertilizer (300kg/ha)

The biochar has been replaced with ash of rice husk in 2022 because of high price increase of biochar products.

Mineral fertilizer application in the experiment

ASSESSMENT METHODOLOGY

Crop growth

We assess the Leaf Area Index development, biomasses of the different components of rice plants at flowering stage and harvest, and final yields.

Leaf Area Index dynamics

The Leaf area index is measured with the Sunscan tool[2] during vegetative stage, with 3 samples per plots (Figure 2). In 2021, only the LAI of Sen Kra Ob and Phka Rumduol varieties were assessed (first cycle). The LAI of Sar Ngae variety will be assessed in 2022.

SunScan measurements in the experiment

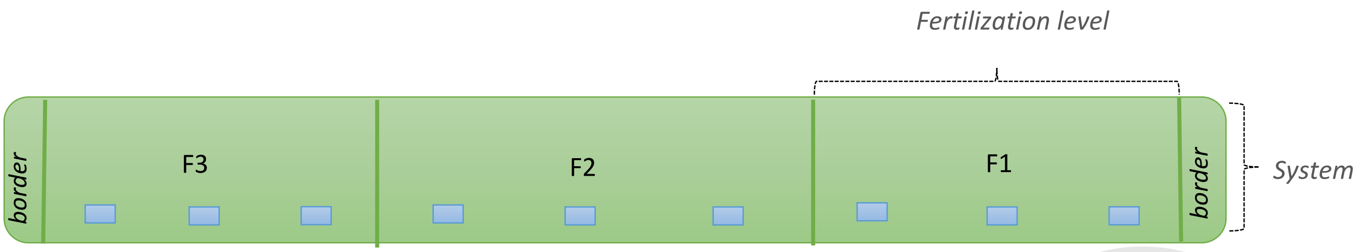


Figure 2. Position of samples in plots for leaf area index measurements

[2] For further information: Sunscan Canopy Analysis System - Dynamax

Growth assessment at flowering stage

we characterize crop growth at flowering stage with 2 samples of 1/2m² per plot (Figure 3).

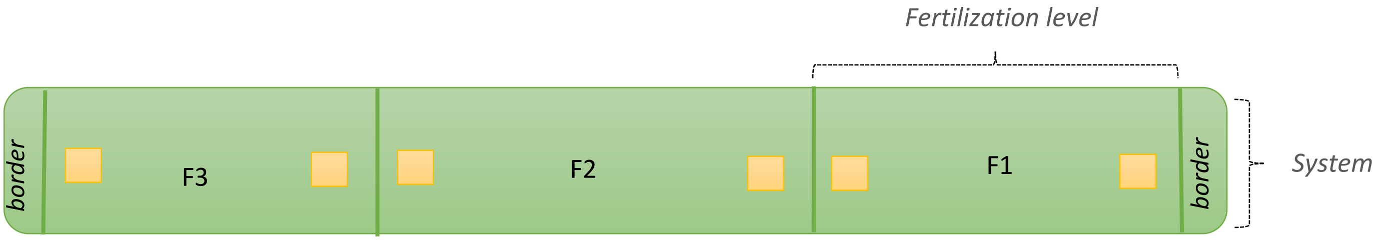


Figure 3. Position of samples in plots for assessment of growth at flowering stage

We count the number of plants, tillers, and panicles per sample, and weight the fresh and dry biomasses of the plants, leaves, and stems.

Growth assessment at harvest

We monitor the growth assessment with two set of samples during harvest (Figure 4):

- ✓ 5 samples of 4m² per plot *(harvest assessment)*
- ✓ 5 samples of 0,25m² per plot *(yield components assessment)*

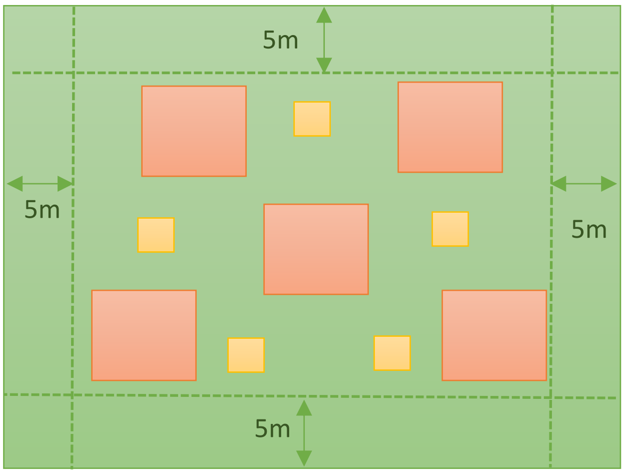


Figure 4. Position of samples for growth assessment and yield at harvest

We count the number of plants, tillers, and panicles per sample of 0,25m², and weight the fresh and dry biomass of stems, full grains, and empty grains. We assess the thousand-kernel-weight of full and empty grains. We then calculate the number of grains per panicle and the sterility rate.

We weight the fresh biomass and dry biomass of stems for the samples of 5m². The yield is calculated for total grains and full grains, for 14% moisture:

*Final weight of grains = Fresh weight * (100- fresh moisture) / (100-14)*

Pest dynamics

The insect pest and diseases are assessed in 3 samples for each plot following a diagonal. Weed levels are not assessed in the experiment because herbicides are used.

The pest and disease injuries are monitored with the criteria detailed in Table 2.

Table 2. Criteria for assessment of insect pests and diseases in the experiment

Pest/Disease	Observations	Symptoms
Leaf blast *Pyricularia oryzae*	Incidence Severity on leaves	
Panicle/neck blast *Pyricularia oryzae*	Incidence Severity on panicles	
Sheath blight *Rhizoctonia solani*	Incidence Severity on tillers	
Narrow brown spot *Sphaerulina oryzina*	Incidence Severity on leaves	
Brown spot *Cochiobolus miyabeanus*	Incidence Severity on leaves	
Leaf scald *Monographella albescens*	Incidence Severity on leaves	
Bacterial leaf streak *Xanthomonas oryzae*	Incidence Severity on leaves	
Tungro *Rice tungro bacilliform virus*	Incidence	
Bacterial leaf blight *Xanthomonas oryzae*	Incidence Severity on leaves	
Sheath rot *Sarocladium oryzae*	Incidence Severity on tillers	
Red stripe *Gonatophragium*	Incidence	
Stem borer *Chilo suppressalis*	Incidence	

Incidence is calculated with the number of tillers infected on 20 tillers.
Severity on leaves is calculated with the % of damaged surface on the 3 first leaves of 3 infected tillers.

RESULTS 2021

Crop growth

Leaf Area Index dynamics

The Leaf Area Index was measured from the 28th of June to the 23th of August 2021 for Sen Kra Ob variety, and 27th of September 2021 for Phka Rumduol variety (Figure 5). The LAI of Sar Ngae was not measured in 2021.

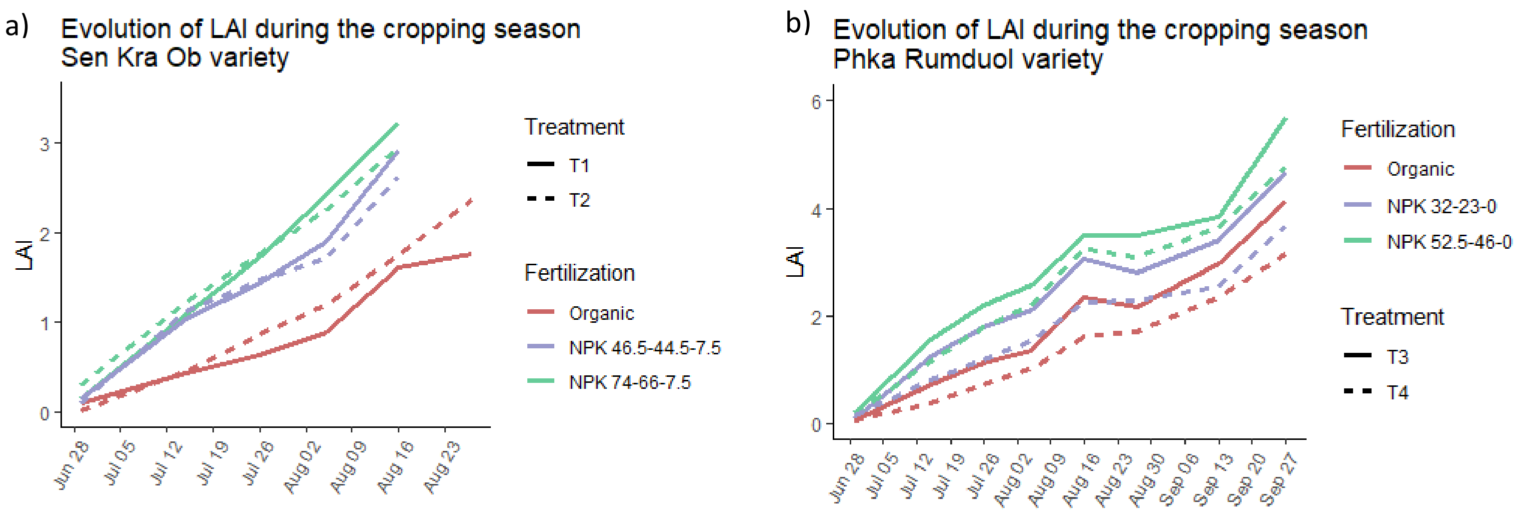


Figure 5. Evolution of Leaf Area Index of a) Sen Kra Ob variety; b) Phka Rumduol variety in WAT4CAM experiment (first cycle)

For Sen Kra Ob variety, the plots with organic fertilization flowered a bit later and the leaf area index stayed lower than the plots with synthetic fertilization.

Lodging of Phka Rumduol variety

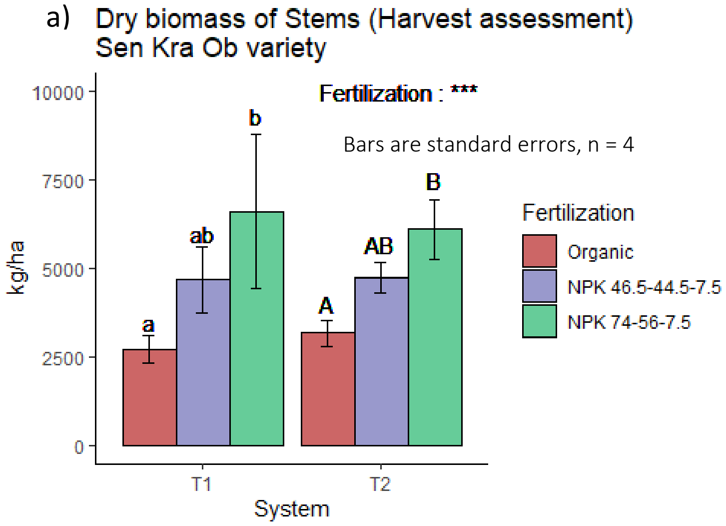
For Phka Rumduol variety, we observed a high rate of lodging after flowering, especially in the plot with high synthetic fertilization, probably due to the overgrowth of the plants. This excessive growth might be due to the previous nitrogen history of the field.

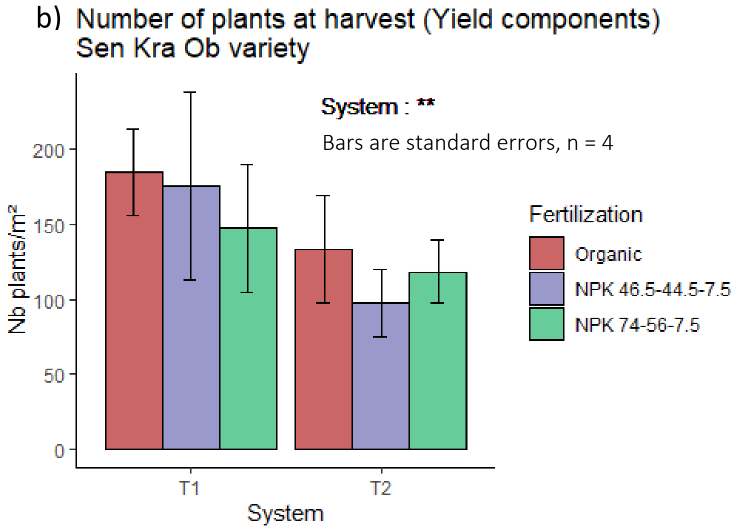
Growth assessment

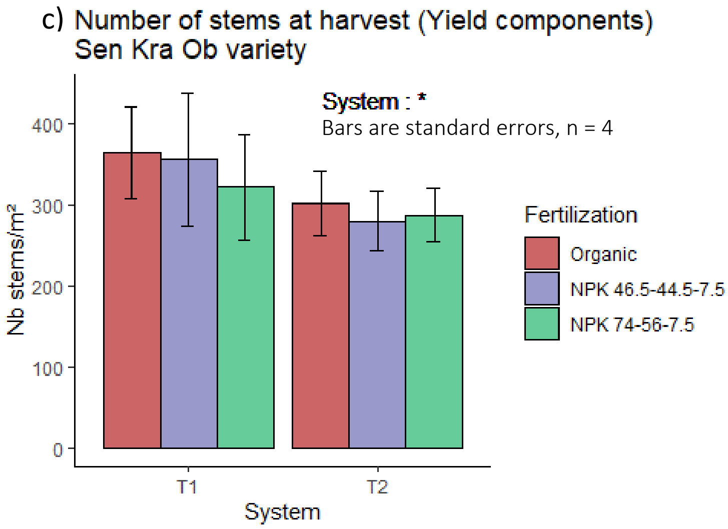
No statistical differences were found for the biomass of rice plant components at flowering stages. For Sar Ngae variety (second cycle), the assessment was done at harvest only.

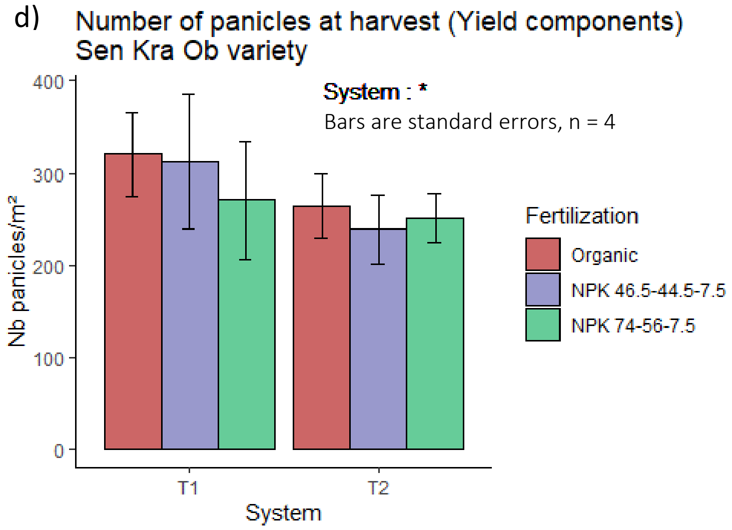
Sen Kra Ob variety – First cycle

The dry biomass of stems (Figure 6a), number of grains per panicles (Figure 6f), and sterility rate (Figure 6g) were statistically different according to the fertilization level. The number of plants (Figure 6b), stems (Figure 6c), and panicles (Figure 6d) were statistically different according to the system.









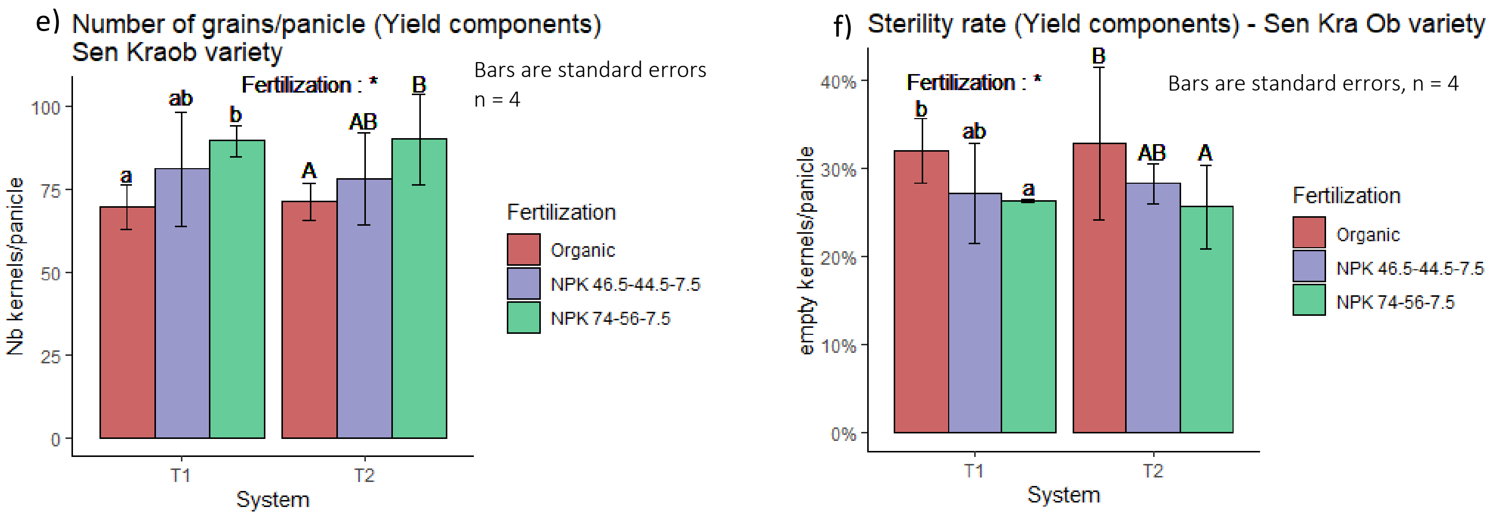


Figure 6. Measurements of yield components of rice crop at harvest for Sen Kra Ob variety (first cycle)

Yield components: samples of 0.25m²; Harvest assessment: samples of 5m²

The high mineral fertilization (NPK 74-56-7.5) favored a higher stem biomass and number of grains per panicles compared to the organic fertilization ($p<0.01$). The sterility rate was also lower in plots with high mineral fertilization than organic fertilization ($p<0.05$). The higher number of plants, stems, and panicles in T1 ($p<0.05$) can be explained by the higher sowing rate (i.e. 200kg/ha for T1 in manual broadcasting, against 125kg/ha in sowing in row for T2).

The different fertilizations also leaded to different yields (Figure 7).

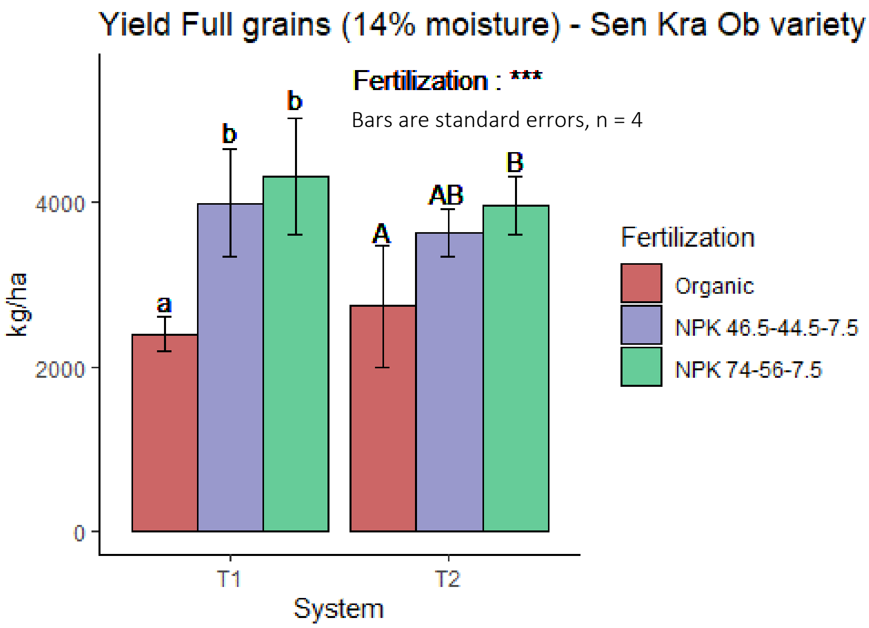


Figure 7. Assessment of yield (14% moisture of full grains) of Sen Kra Ob variety (first cycle)

Harvest assessment: samples of 5m²

The yield of organic fertilized plots was lower than the plots with high mineral fertilization (NPK 74-56-7.5), and than the plots with mix of mineral and organic fertilization (NPK 46.5-44.5-7.5) for T1 (conventional farmer practices) ($p<0.001$).

Summary data of the yield components of Sen Kra Ob variety in first cycle are presented in Table 1.

Table 1. Measurements of yield components of rice crop at harvest for Sen Kra Ob variety (first cycle)

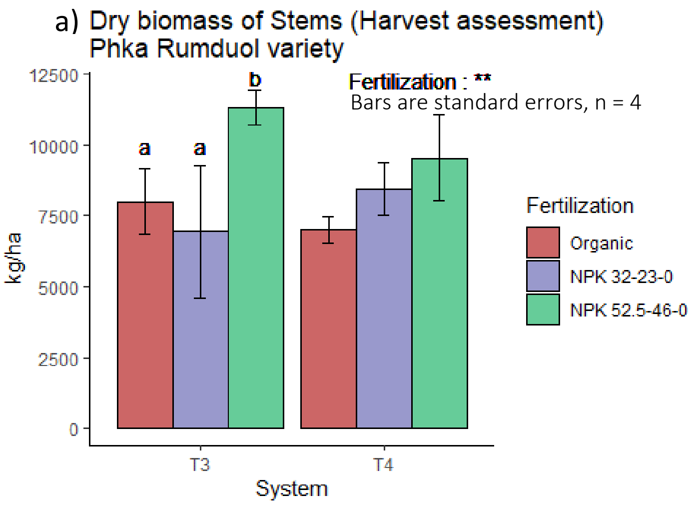
Yield components: samples of 0.25m²

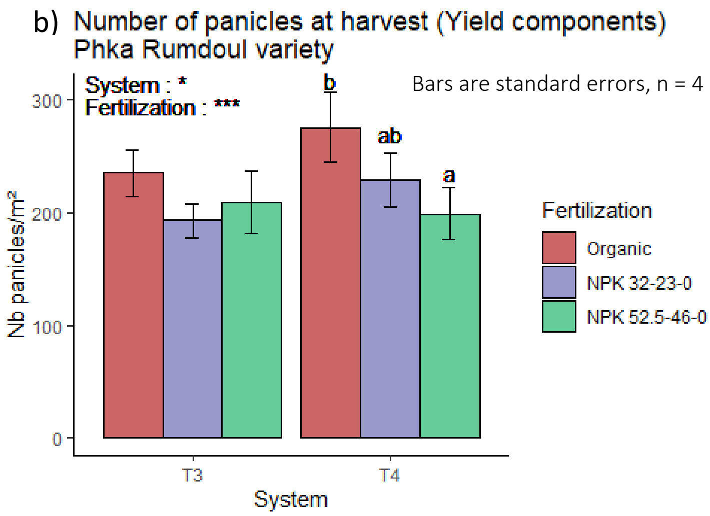
System	Nb of stems/m²	Stems *(kg/m²)*	Nb of panicles/m²	Nb Grains */panicles*	Sterility rate *(%)*	Thousand-kernel-weight *(g)*	Full grains *(kg/m²)*
T1 NPK 74-56-7.5	322	0.917	271	89.5	26,3	26.9	0.472
T1 NPK 46.5-44.5-7.5	356	0.863	313	81.0	27,1	26.0	0.464
T1 Organic	364	0.514	320	69.5	32	24.1	0.353
T2 NPK 74-56-7.5	287	0.969	251	89.8	25,6	25.9	0.420
T2 NPK 46.5-44.5-7.5	280	0.739	239	78.1	28,3	27.1	0.350
T2 Organic	302	0.503	265	71.3	32,8	24.9	0.321

Sorting of stems and leaves for assessment of Sen Kra Ob yield components at flowering stage

Phka Rumduol variety – First cycle

The number of panicles (Figure 8b), and empty grains per panicles (Figure 8d) were statistically different according to both fertilization level and system. The dry biomass of stems (Figure 8a) and dry biomass of full grains (Figure 8c) were statistically different according to the fertilization level.





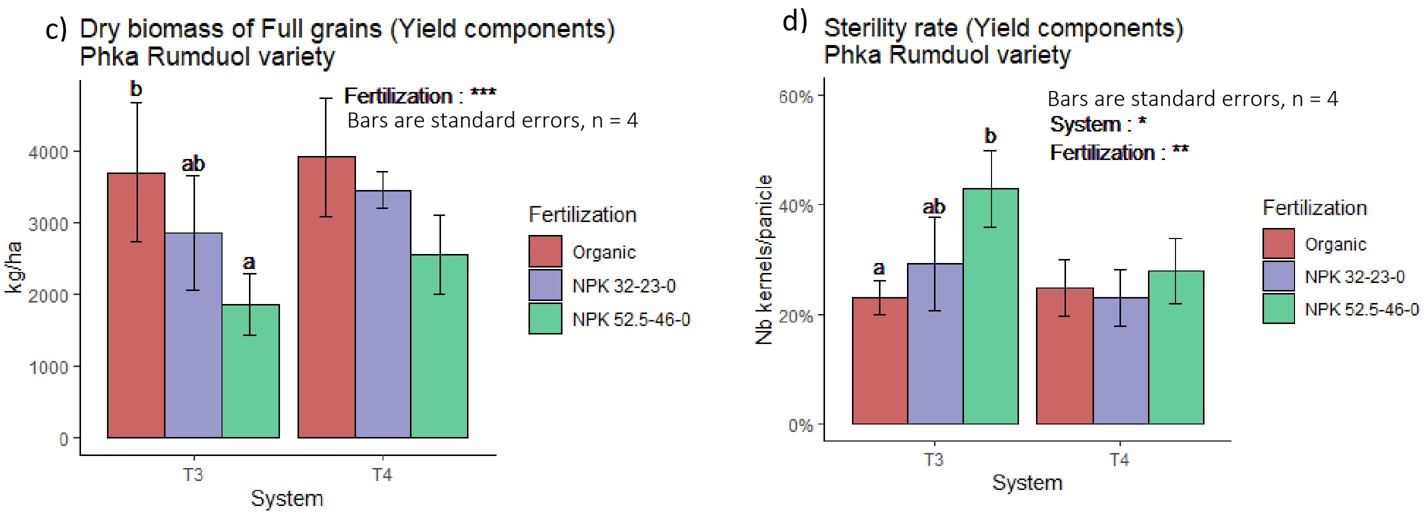


Figure 8. Measurements yield components of rice crop at harvest for Phka Rumduol variety (first cycle)

Yield components: samples of 0.25m²; Harvest assessment: samples of 5m²

As for Sen Kra Ob variety, the high mineral fertilization (NPK 52.5-46-0) favored a higher stem biomass for Phka Rumduol variety in T3 compared to organic fertilized plots ($p<0.01$). However, the lodging of Phka Rumduol leaded to a diminution of full grain biomass ($p<0.001$), and a higher sterility rate ($p<0.01$) in the plots with high mineral fertilization compared to the plots with organic fertilization. These effects were especially observed in T3, even though there were no differences in cropping practices between T3 and T4 in 2021. In T4, the organic fertilization favored a higher number of panicles compared to the plots with high mineral fertilization ($p<0.001$). The differences between the systems could be due to the placement of the systems within the plots and the access to irrigation.

No statistical difference ($p>0.05$) was observed between the systems and fertilization levels for Phka Rumduol variety (Figure 9).

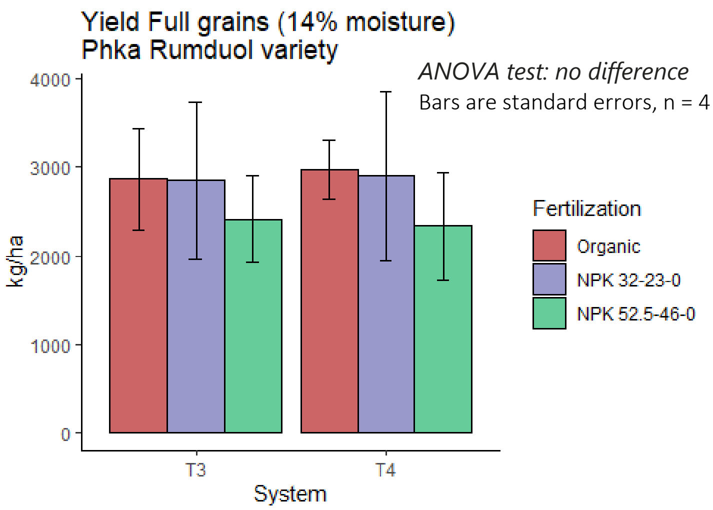


Figure 9. Assessment of yield (14% moisture of full grains) of Phka Rumduol variety (first cycle)

Harvest assessment: samples of 5m²

The lower yield for high mineral fertilization can be explained by the high rate of lodging in these plots for Phka Rumduol variety at harvest. It is interesting to note that the yield of Phka Rumdoul under organic management is similar to the yield under chemical-based management and even higher when high dose of inorganic fertilizer is used. This contrast with the results obtained for Sen Kra Ob, a high yielding rice variety that respond to increasing dose of inorganic fertilizer. Under an irrigation pattern, it is also doable to target a short cycle rice variety (March - June) followed by Phka Rumdoul that require much less amount of chemical inputs.

Summary data of the yield components of Phka Rumduol variety in first cycle are presented in Table 2.

Table 2. Measurements of yield components of rice crop at harvest for Phka Rumduol variety (first cycle)

Yield components: samples of 0.25m²

System	Nb of stems/*m²*	Stems *(kg/m²)*	Nb of panicles/*m²*	Nb Grains */panicles*	Sterility rate *(%)*	Thousand-kernel-weight *(g)*	Full grains *(kg/m²)*
T3 NPK 52.5-46-0	277	1.131	209	69.0	42,9	22.9	0.186
T3 NPK 32-23-0	250	1.002	193	94.3	29,1	23.8	0.286
T3 Organic	276	1.103	235	81.5	23	25.0	0.370
T4 NPK 52.5-46-0	257	1.130	199	76.1	29,7	24.3	0.255
T4 NPK 32-23-0	271	1.059	229	81.9	23	24.4	0.345
T4 Organic	316	1.043	276	77.3	24,9	25.2	0.391

Sorting of full and empty grains for Phka Rumduol variety

Sar Ngae variety – Second cycle

The number of kernels per panicles (Figure 10a), empty grains per panicles (Figure 10b), and dry biomass of stems (Figure 10c) were statistically different according to fertilization level.

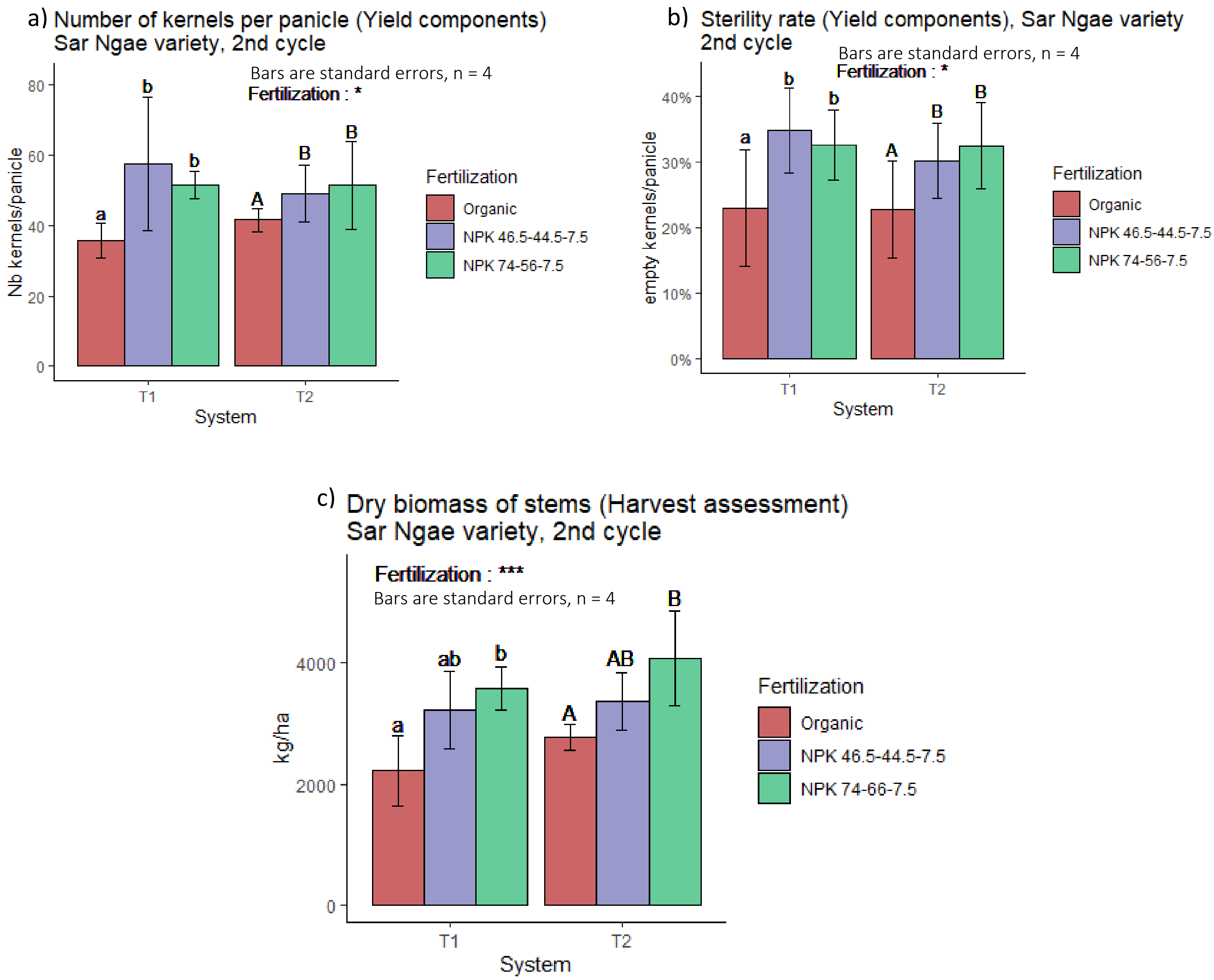


Figure 10. Measurements of yield components of rice crop at harvest for Sar Ngae variety (second cycle)

Yield components: samples of 0.25m²; Harvest assessment: samples of 5m²

The rice grown in organic plots had a smaller number of grains per panicles, but also a lower sterility rate than the rice grown in plots with mineral fertilization ($p<0.05$). As for Sen Kra Ob and Phka Rumduol variety, the high mineral fertilization (NPK 74-56-7.5) favored a higher stem biomass for Sar Ngae variety compared to organic fertilized plots ($p<0.001$).

No statistical difference ($p>0.05$) was observed between the systems and fertilization levels for Sar Ngae variety (Figure 11).

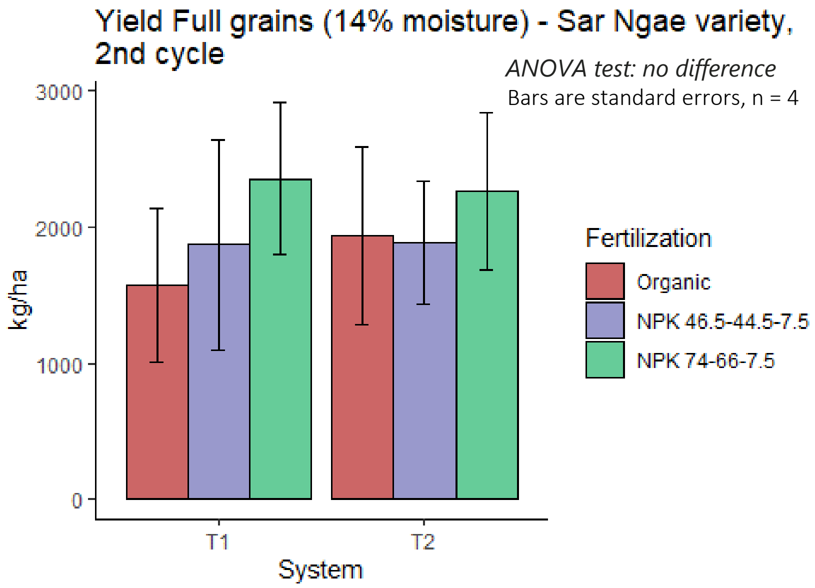


Figure 11. Assessment of yield (14% moisture of full grains) of Sar Ngae variety (second cycle)

Harvest assessment: samples of 5m²

Summary data of the yield components of Sar Ngae variety in second cycle are presented in Table 3.

Table 3. Measurements of yield components of rice crop at harvest for Sar Ngae variety (second cycle)

Yield components: samples of 0.25m²

System	Nb of stems/*m²*	Stems *(kg/m²)*	Nb of panicles/*m²*	Nb Grains */panicles*	Sterility rate *(%)*	Thousand-kernel-weight *(g)*	Full grains *(kg/m²)*
T1 NPK 74-56-7.5	432	0.456	311	51.5	32.6	25.4	0.270
T1 NPK 46.5-44.5-7.5	345	0.398	272	57.4	34.8	25.4	0.243
T1 Organic	395	0.306	292	36.5	23.0	25.9	0.200
T2 NPK 74-56-7.5	473	0.454	354	51.4	32.5	25.4	0.294
T2 NPK 46.5-44.5-7.5	433	0.419	337	49.3	30.2	25.4	0.288
T2 Organic	412	0.393	319	41.6	22.8	25.6	0.263

Harvest of Sar Ngae variety (big plot for harvest assessment)

Pest dynamics

First cycle

We observed very low incidence of animal pest and diseases during the vegetative stage.

Bacterial leaf blight on Phka Rumduol was the only disease with incidence concerning more than 1% of the plot (Figure 10).

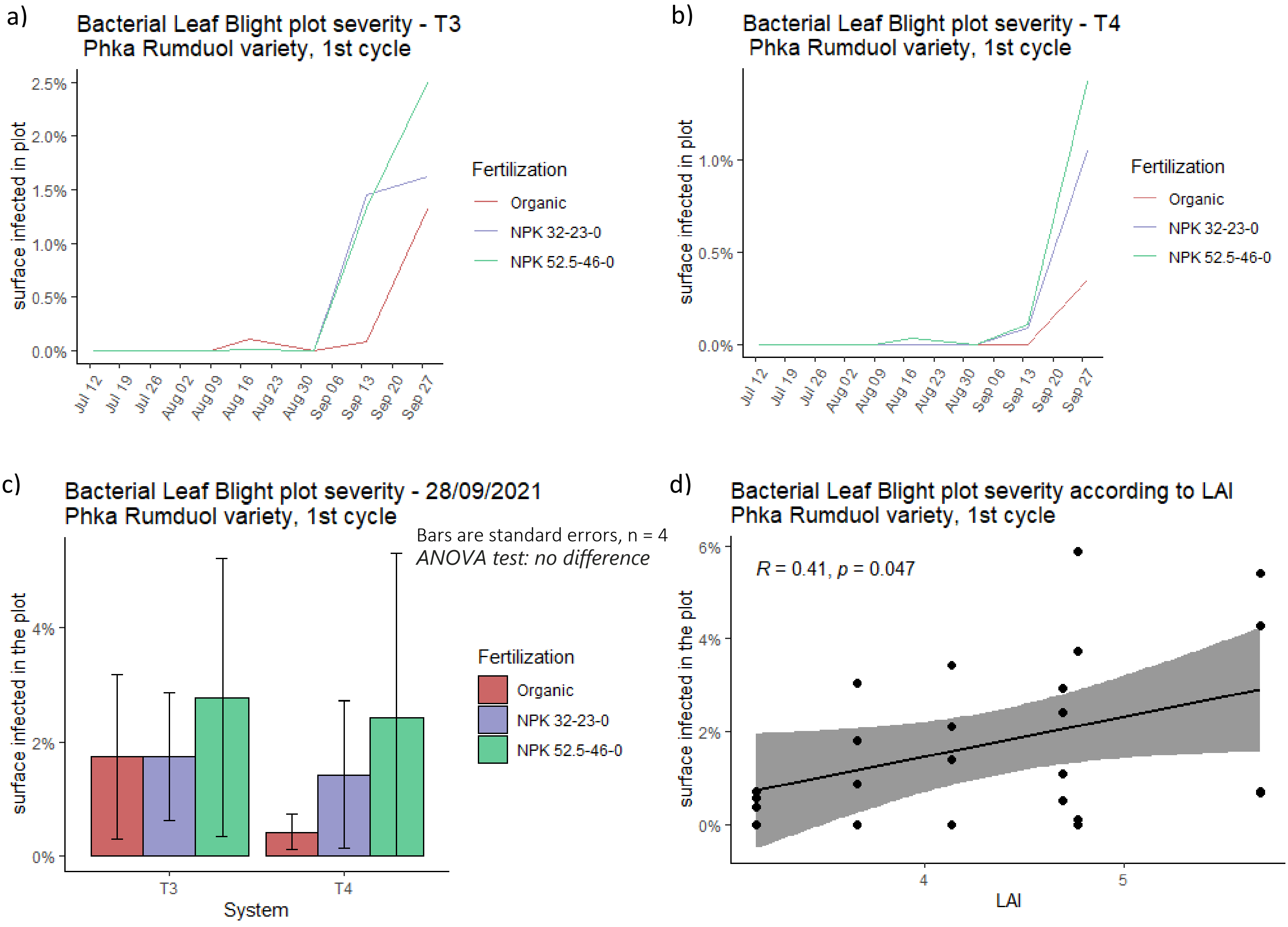
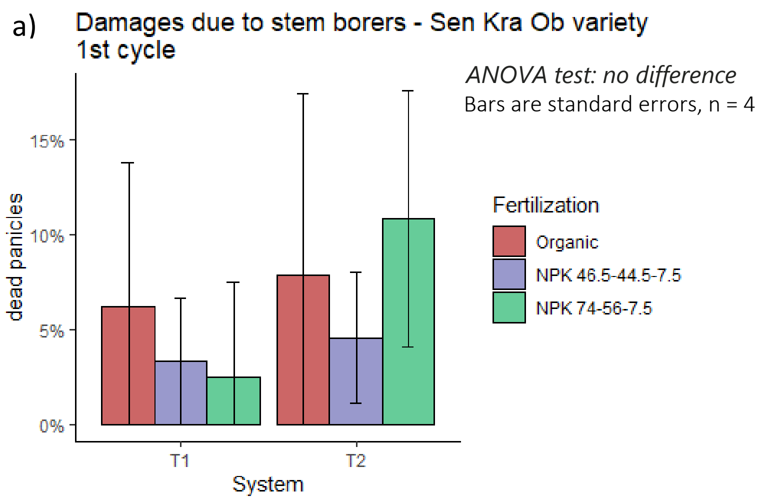


Figure 10. Bacterial Leaf Blight assessment on Phka Rumduol variety
a) BLB severity on T3 plots; b) BLB severity on T4 plots; c) BLB severity on plots on the end of vegetative stage; d) Correlation between BLB severity and LAI

The infection began late in the season, at the beginning of September 2021. Hence, the disease impact on crop growth was limited. No statistical difference was found between the fertilization levels, but the disease severity as the plot level seemed to be correlated with the Leaf Area Index ($p<0.05$).

Low incidence of animal pest and diseases were observed during the reproductive stage. Stem borers were the main pests causing crop losses in all of the field monitored (Figure 11).



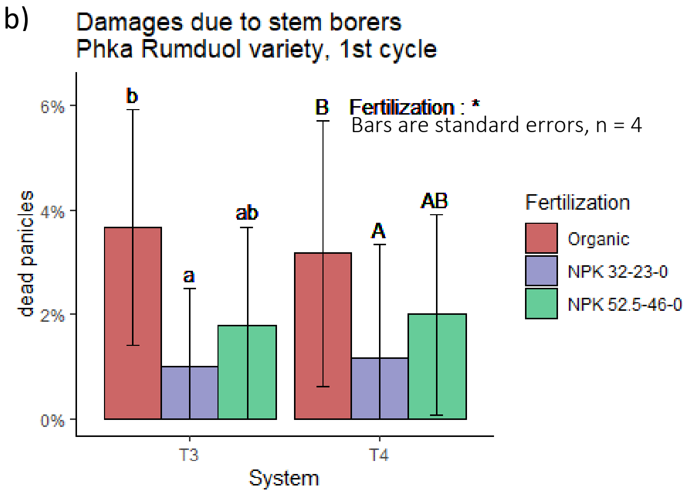


Figure 11. Damages due to stem borers for a) Sen Kra Ob variety; b) Phka Rumduol variety

There was no statistical difference between the systems and fertilization for Sen Kra Ob variety, but we observed a difference in the damages due to stem borers according to fertilization for Phka Rumduol variety: the plots with organic fertilization were statistically more attacked than the plots with mix of mineral (NPK-46.5-44,5-7.5) and organic fertilization ($p<0.05$).

Second cycle

We observed low levels of leaf blast during vegetative stage, with no statistical differences between the plots (Figure 12).

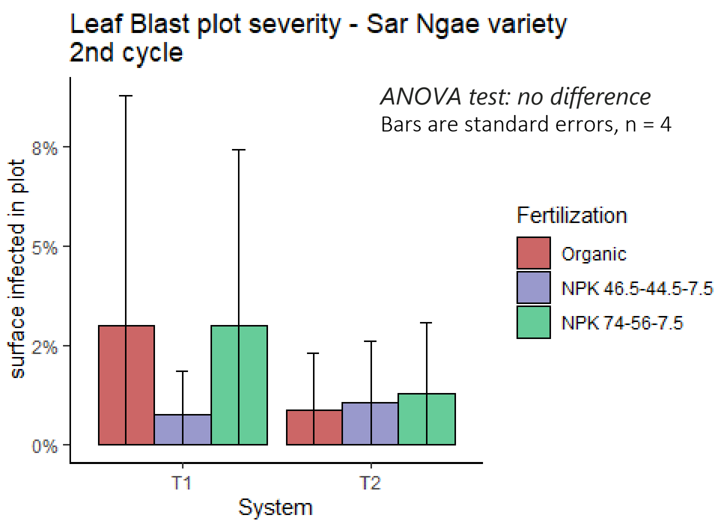


Figure 12. Severity of leaf blast at plot level in second cycle of rice (Sar Ngae variety)

We observed a higher rate of panicle blast damages for plots fertilized with NPK 74-56-7.5 in T1 (conventional farmer practices) at reproductive stage that for other plots (p<0.01). We also observed losses due to stem borer, with no statistical differences between the plots (Figure 13).

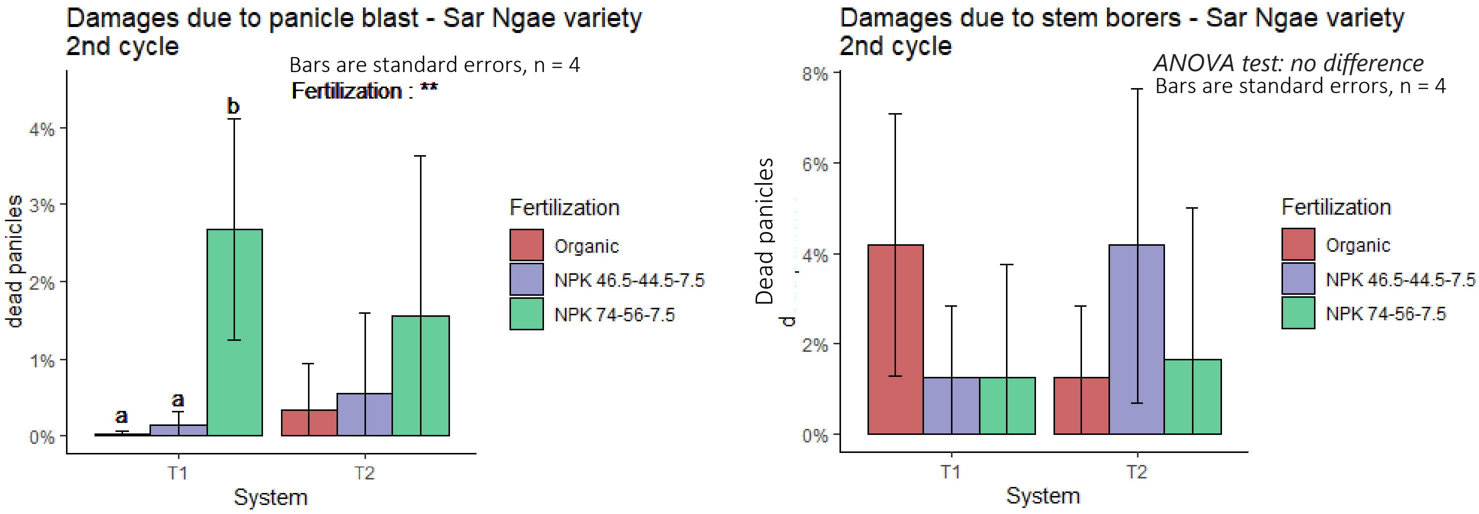


Figure 13. Losses due to a) panicle blast, and b) stem borer in plots in second cycle of rice (Sar Ngae variety)

The high mineral fertilization (NPK 74-56-7.5) favored damages due to panicle blast compared to the plots with mix of mineral fertilization (NPK 46.5-44.5-7.5) and organic fertilization, or just organic fertilization in T1 (conventional farmer practices) (p<0.01); however, there is no statistical differences in T2. There were also no statistical differences in the damages due to stem borers between the plots.

Bacterial Leaf Blight infection on Phka Rumduol variety - September 2021

PERSPECTIVES

Soil samplings were made for baseline in May 2021, and soil sampling for analysis of NH_4^+ and NO_3^- concentration in soil layers were made in June 2022; the samples will be analyzed with the BioFunctool protocol at the Royal University of Agriculture in the course of 2022. The soil data will then be integrated in the analysis of the systems and fertilization effects.

The biomass of cover-crops has been measured from February to April 2022. The protocol and results will be detailed in another document.

The crop growth and pest monitoring will be used for the calibration and validation of a rice crop model integrating cropping practices and pest levels as input. The model is developed in a CIRAD PhD project, in partnership with the Royal University of Agriculture (RUA) and the National University of Battambang (NUBB).

Economic analysis will be made in order to identify the potential profit of each cropping systems.

The Field Team

- DIONISI Mathilde *CIRAD, PhD scholar*
- KOUN Sophal *Technician*
- KEO Nimol *DALRM*
- LENG Vira *DALRM*
- SOTHEA Sovanna *RUA, Intern*
- TAI Bendith *Technician*
- THANON Nuon *RUA, Intern*
- Dr ADAM Myriam *CIRAD*
- Dr SENG Vang *DALRM*
- Dr SESTER Mathilde *CIRAD*
- Dr TIVET Florent *CIRAD*

For more information, contact mathilde.dionisi@cirad.fr