



# Handbook on Upland Rice Cultivation



*Capacity Building Project  
for the Implementation of the Executive Programme  
for the Agricultural Revival*

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# Introduction

Rice is new crop for farmers in Sudan, but it is sure that farmers can obtain not only profit through cultivating it but also opportunity to eat healthy food by cooking it. Rice is new crop. Therefore, there is not enough information on cultivating it. There are also not enough extensionists who have knowledge, techniques and experiences on rice cultivation. Meanwhile, there are enormous accumulations of knowledge and techniques on rice cultivation in the world. Sudan is the huge country and has different environmental conditions on soil, climate, and so on. However, the fundamental rice cultivation knowledge and techniques can be utilized to most of the field in Sudan. This hand book provides the fundamental knowledge and techniques on rice cultivation in Sudan. The Project believes that farmers realize high yield and obtain profit with support of skilled extensionists by utilizing this book. Extensionists must improve and increase their techniques and experiences on rice cultivation for farmers continuously.

Understanding without practice produces nothing at all !



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**How can you realize high yield**  
**on upland rice cultivation**  
**in your field ?**



**Please follow this book up to the end**  
**and implement practical effort !**

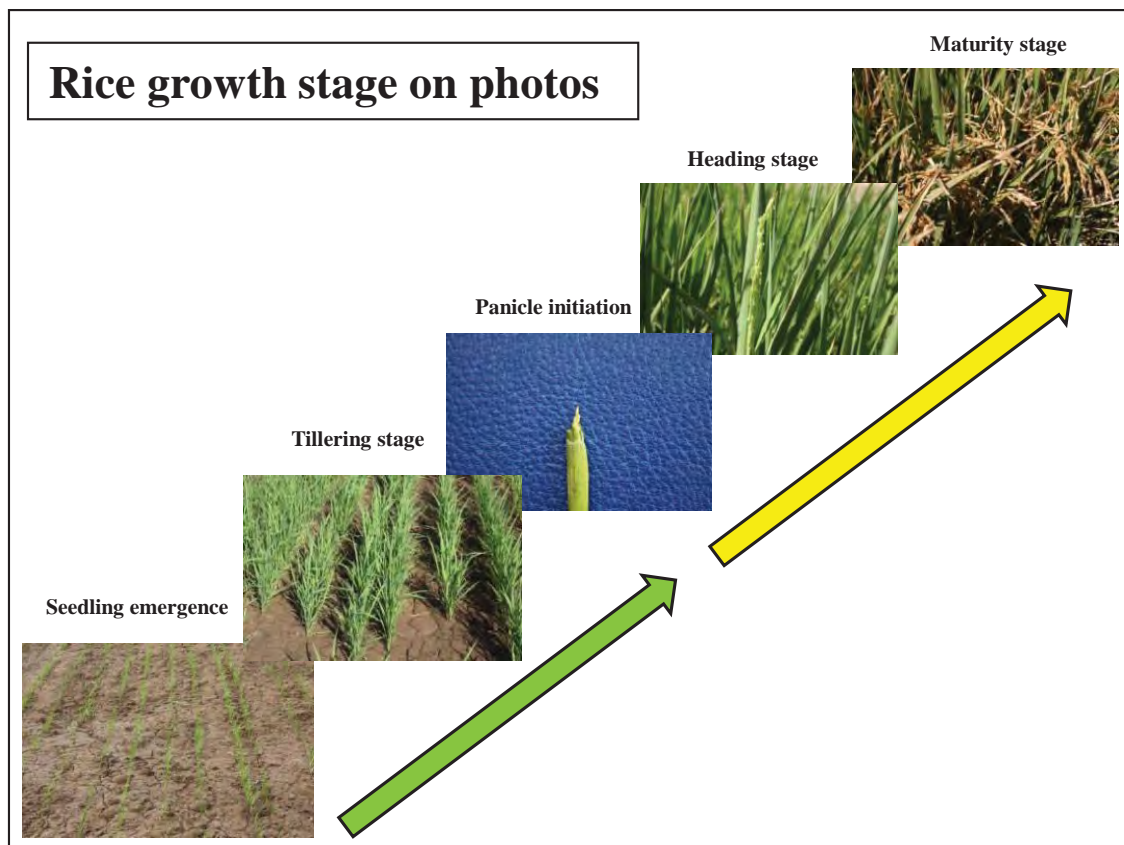
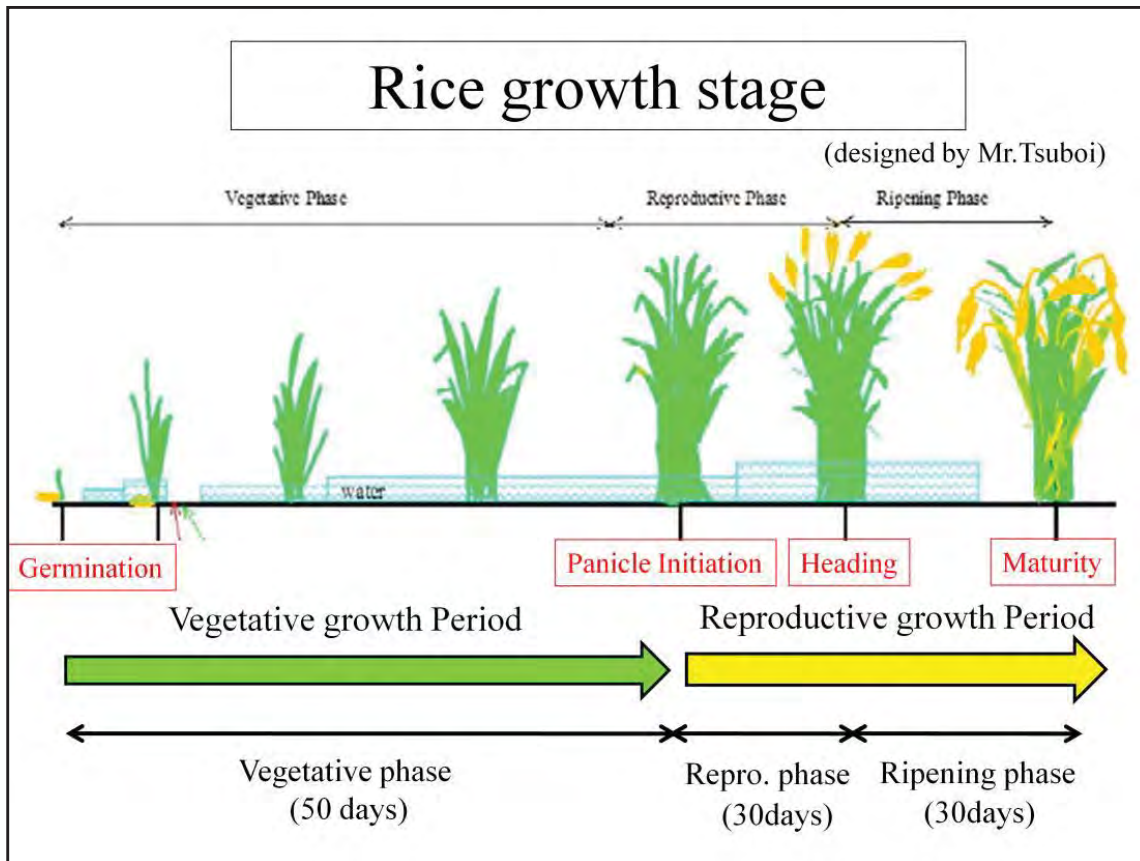


## Important Technical Points on Upland Rice Cultivation before Postharvest

- ① Using Pure Seed
- ② Good Land Preparation (Leveling)
- ③ Proper Sowing Operation
- ④ Sowing at Optimum Time
- ⑤ Effective Weed Control
- ⑥ Appropriate Irrigation
- ⑦ Harvesting at Proper Time

Japan International Cooperation Agency







## General Cropping Calendar for Upland Rice

- ↓ • **Seed preparation** (Implementing Germination Test)
- ↓ • 1st Land preparation : Pre-watering, Plowing, Harrowing, etc.
- ↓ • Fertilizer application (Basal Dressing : NPK, TSP, SSP, etc.)
- ↓ • **2nd Land Preparation** : Harrowing, **Land leveling**
- ↓ • **Sowing seeds**
- ↓ • **Weed control** (Pre-emergence : Pendimethalin, etc.)\*
- ↓ • Irrigation
- ↓ • **Weed control** (Manual weeding)
- ↓ • Fertilizer application (Topdressing: Urea, etc. )
- ↓ • **Weed control** (Post-emergence : 2,4-D, etc.)\*
- ↓ • **Irrigation (Panicle Initiation ~ Heading ~ Maturity)**
- ↓ • **Harvesting**

**\*If herbicide is not used, timely hand weeding is indispensable.**

## **Cultivation Points for yield more than 1t/fed Implement below operations appropriately !**

1. **Seed rate : 40kg/fed, Sowing space : 30cm or more**
2. **Even/flat land leveling** should be secured.  
→ if good land leveling is not done, **seed can not germinate and grow at lower place in the field.**  
**Land should be leveled evenly without bump and dent.**
3. **Weed control** should be implemented at early stage.  
→ if herbicide is not applied, hand weeding should be done **at least 2 times during 1 month after sowing.**
4. **Irrigation interval** :  
Germination ~ Panicle initiation : **1time/5 - 6days**  
Panicle initiation ~ heading~ maturity : **1time/2 - 3days**  
→ it varies according to soil and field condition, **but before soil dries, irrigation should be implemented.**

## ① Using pure seed



**Using purified seeds is first step for high yield**



Purity is most important factor as seed

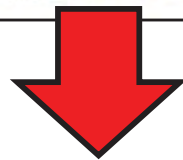


**Mixed seed**



**Pure NERICA 4**

**✘ Mixed seed causes**  
**difficult cultivation and low quality**



Using mixed seed causes problems on  
**① Management (= Yield) ② Quality**

**① Management(Yield) ;**  
Implementing uniform management on irrigation, fertilization, harvest, etc. is very difficult.

**➡ Low yield !**

**② Quality ;**

**1) Implementing milling properly is very difficult.**

**➡ A lot of broken rice !**

**2) Various color, tastes, and shape/size of rice**

**➡ Low quality !**



# Let's remove off-type to keep purity !

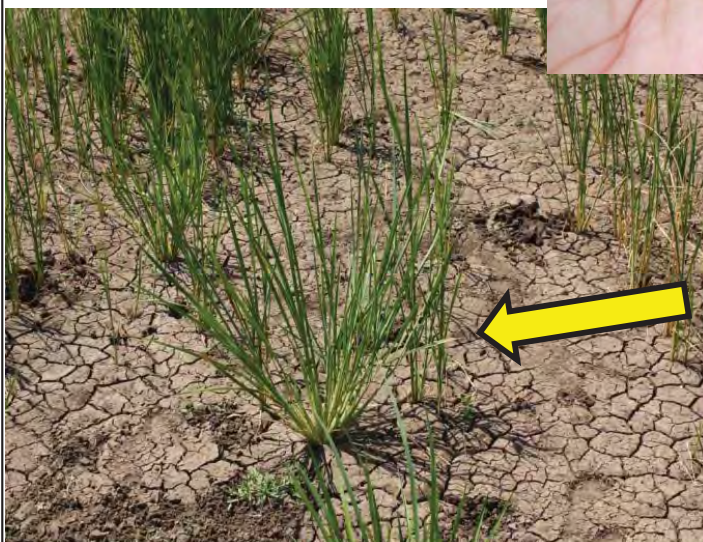


NERICA 4



Off-Type

Grain shape & Maturity period



Off-Type

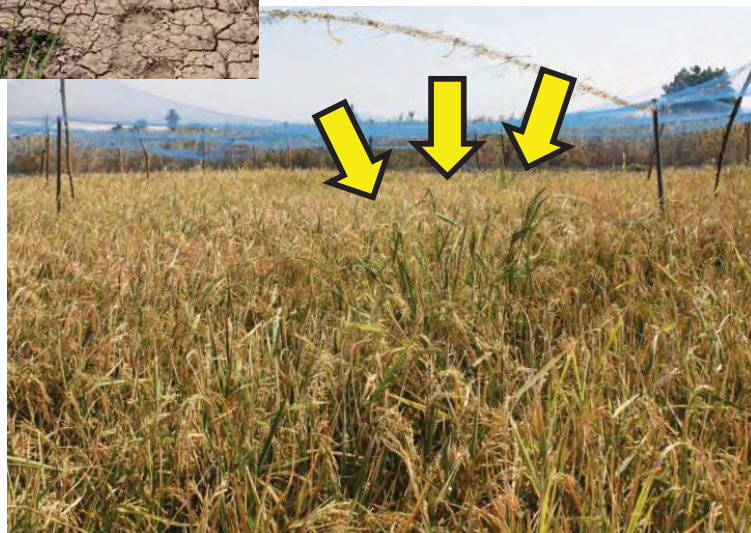


Plant shape

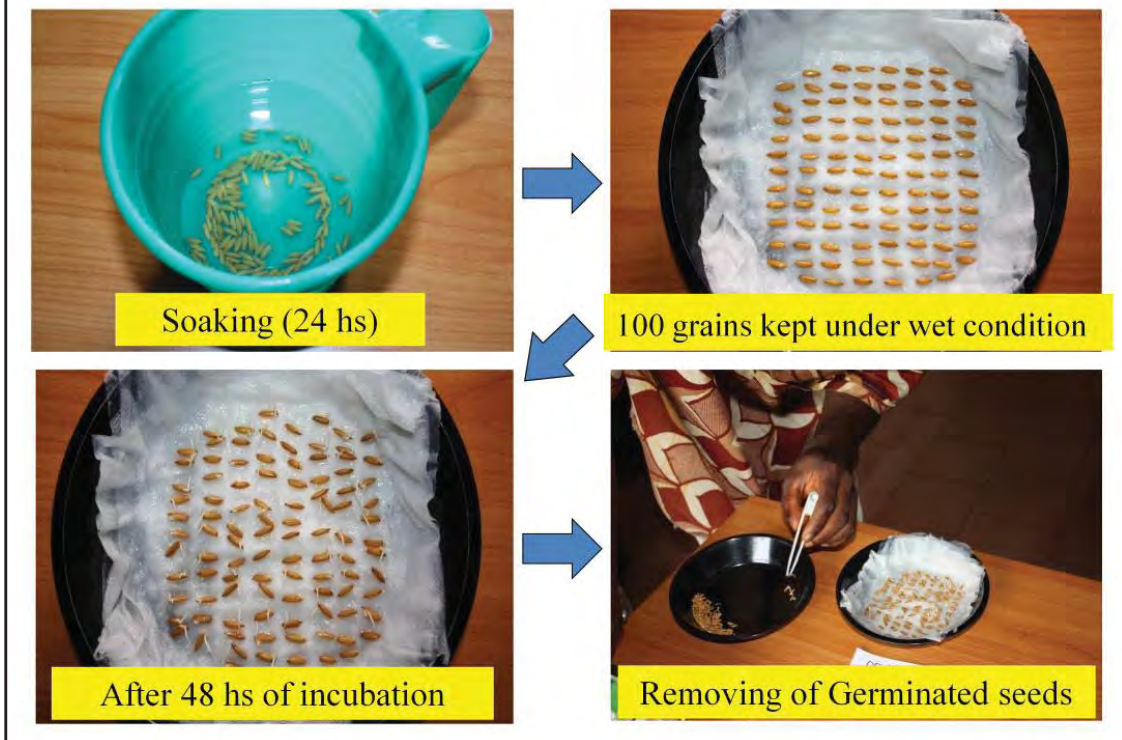


Off-Type

Plant height



## Implement Germination Test before sowing



**Why conducting germination test before sowing is important ?**

**Because germination rate needs to be grasped before sowing.**

**If germination rate is less than 80%, the amount of seed must be increased !**



**Germination Rate (100 - 7 = 93%)**

**More than 80% is OK**

**How about 93% ?**



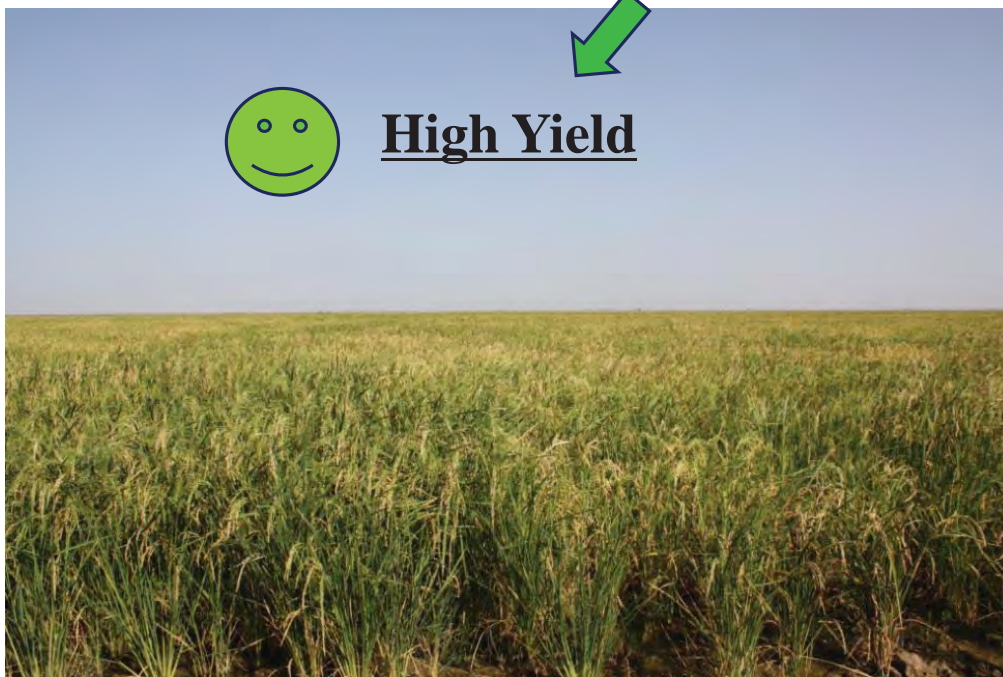
**93% is more than 80%  
and very good rate,  
no need to increase the seed !**

## ② Good Land Preparation (Leveling)



**Good leveling is indispensable for irrigating water uniformly in the field.**

**Good Land Leveling → Uniform Growth**



**High Yield**



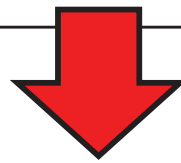
## Land Preparation (Leveling)



**Improper leveling !**



**Proper leveling !**



**Keep in your mind the vital importance of  
land leveling;**

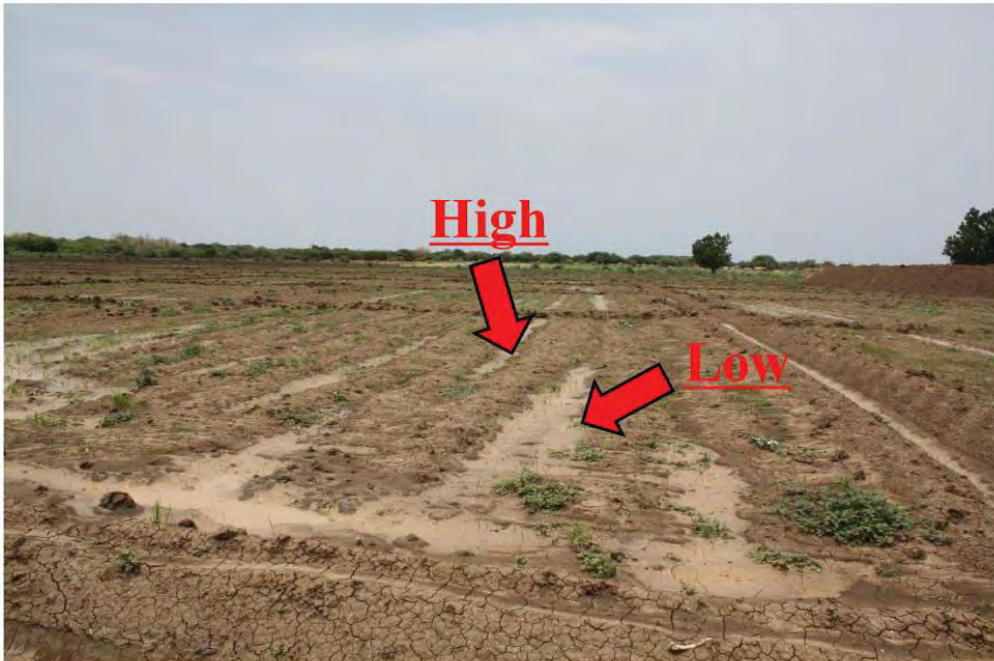
**Improper leveling creates high and low places  
in the field and causes the irreversible problems ;**

- 1) Rice is not able to grow well at the higher places because of insufficient water.**
- 2) The submerged water and high concentration of herbicide impede seedling emergence at lower places.**
- 3) Termites bred in the dry soil at the higher places feed root of rice and kill it.**
- 4) After sowing, re-leveling is impossible. Proper leveling must be conducted before sowing !**

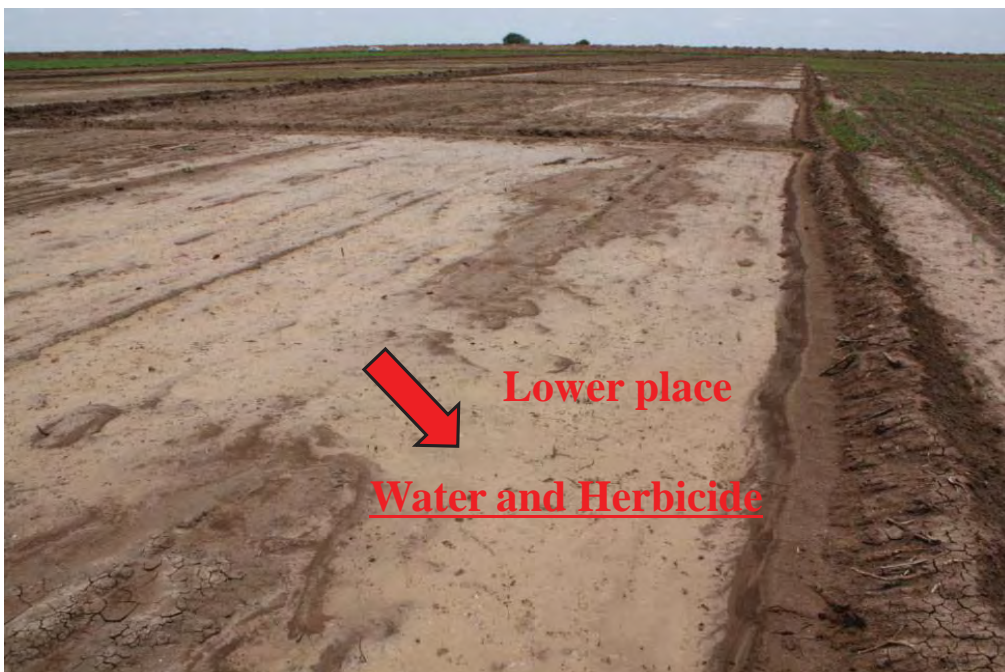


# (1) Problem caused by improper leveling

## ✘ Uneven Land Leveling (1)



## ✘ Uneven Land Leveling (2)





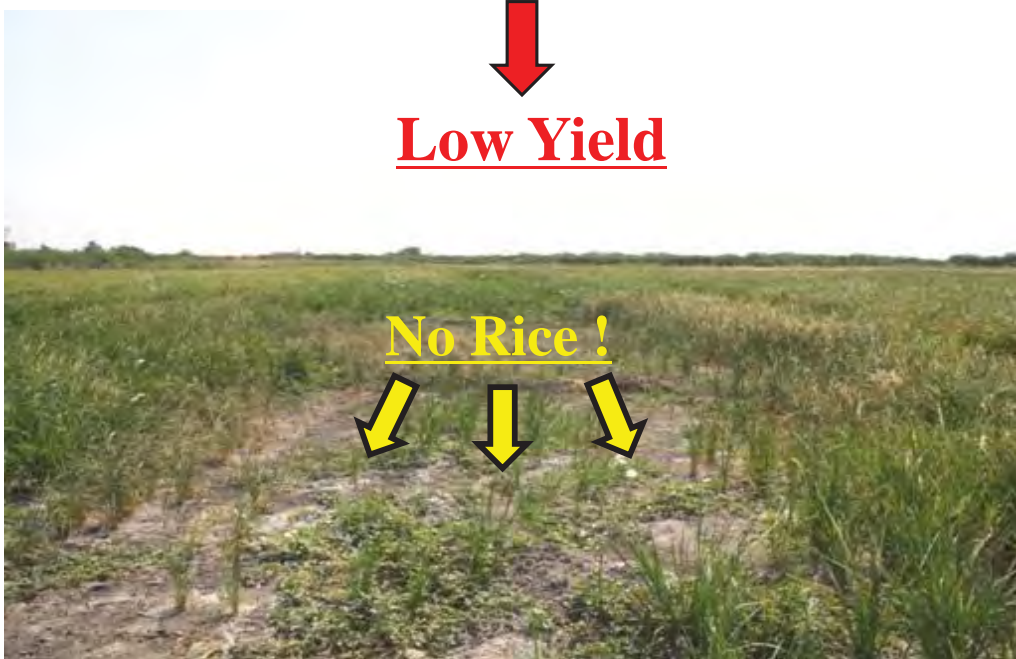
**Submerged water and high concentration of herbicide impede seedling emergence**



**✘ Uneven Land Leveling**



**Low Yield**

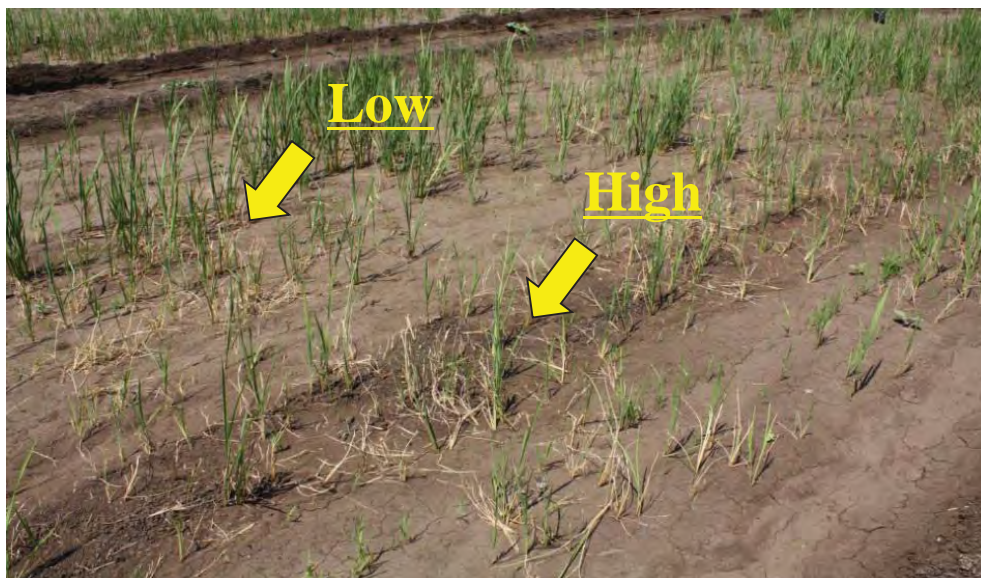


## (2) Problem caused by improper leveling

### Damage by termites (1)



### Damage by termites (2)



**Damage by termites can be minimized by keeping water, good land leveling is indispensable from this viewpoint.**

## Implements of Tractor for Land preparation



### **Chisel plow**

For drying soil easily and avoiding the field with bump and dent, but less effective compared with Disk plow in reversing soil ability

### **Disk plow**

For reversing soil easily under any condition, but less effective compared with Bottom plow in plowing depth and reversing soil ability



**Fertilization:**  
Basal Dressing (ex.TSP, NPK) must be applied before harrowing to mix with soil

### **Disk Harrow**

For crushing soil mass at deep level by rotating disks and implementing leveling at the same time





## Scraper (Leveler)

For executing soil leveling manually by technique of operator under correct understanding on field condition

## Laser Leveler

For conducting soil leveling automatically by utilizing emission and receiving device of laser beam



## Example of Perfect Land Leveling



Please implement leveling like this field !



# Fertilizer Application

## Example : Major chemical fertilizers and the content of elements

Name	Chemical formula	Content of elements (%)
<b>Nitrogen fertilizer (N)</b>		
Ammonium sulfate	$(\text{NH}_4)_2\text{SO}_4$	21(N) - 24(S)
Urea	$\text{CO}(\text{NH}_2)_2$	46(N)
Ammonium chloride	$\text{NH}_4\text{Cl}$	26(N)
<b>Phosphorus fertilizer (P)</b>		
Single superphosphate		18~20( $\text{P}_2\text{O}_5$ ) - 18(Ca) - 12(S)
Triple superphosphate		45( $\text{P}_2\text{O}_5$ ) - 14(Ca) - 10(S)
<b>Potassium fertilizer (K)</b>		
Potassium chloride	KCl	60( $\text{K}_2\text{O}$ )
Potassium sulfate	$\text{K}_2\text{SO}_4$	53( $\text{K}_2\text{O}$ ) - 18(S)
<b>Compound fertilizer (NPK)</b>		
14-14-14		14(N) - 14( $\text{P}_2\text{O}_5$ ) - 14( $\text{K}_2\text{O}$ )
12-12-12		12(N) - 12( $\text{P}_2\text{O}_5$ ) - 12( $\text{K}_2\text{O}$ )

## Fertilization in Demonstration Farms and Trial Field in 2013

### 1. Demonstration Farms

172.5-53.6-0 kg NPK kg/ha (69.0-22.5-0 kg NPK kg/fed)

DAS (Days After Sowing)

Fertilizer	Before sowing	3-4 weeks DAS ( 21-28 DAS )	6-7 weeks DAS ( 42-49 DAS )	9-10 weeks DAS ( 63-70DAS )
T.S.P (0-45-0)	125kg/ha (50kg/fed)	0	0	0
Urea (46-0-0)	0	125kg/ha (50kg/fed)	125kg/ha (50kg/fed)	125kg/ha (50kg/fed)

### 2. Trial Field

87.6-47.6-0 kg NPK kg/ha (36.8-20.0-0 kg NPK kg/fed)

Fertilizer	Before sowing	3 weeks DAS ( 21 DAS )	7 weeks DAS ( 51 DAS )
S.S.P (0-20-0)	250kg/ha (100kg/fed)	0	0
Urea (46-0-0)	0	100kg/ha (40kg/fed)	100kg/ha (40kg/fed)



**More effective, practical and economical fertilization such as type, time, amount, etc. will be provided through field trial and experiences on field activity.**

### ③ Proper Sowing Operation



1. Adjustment of tractor and seed drill machine for land condition is indispensable operation.
2. It is very important for machine operator to check soil condition before sowing and to modify driving/sowing technique based on soil condition. **No need to hurry !**



**Manual sowing  
with 'Karack'  
(a forked-rake for  
rice drill-planting)**





## Sowing Operation



**Sowing depth was deep !    Optimum sowing depth !**  
**Poor seedling emergence    Good seedling emergence**

### (1) Sowing depth (optimum: 2-3cm)

**Too deep (more than 4cm)**



**Poor seedling emergence !**

**Too shallow**



**Damage by birds, seed loss by irrigation water or rainfall and poor seedling emergence affected by herbicide !**





## Sowing Operation



Seed rate is extremely high.  
It causes poor growth and low yield !

(2) Seed rate (optimum: 40kg/fed)

**Too high**



Due to competition for water, nutrient and light, plants can not grow and produce little !

**Too low**



Due to unused nutrient, water and light, plants produce low yield !



## Sowing Operation



Sowing space is narrow, not suitable for weeding !  
Weeding is difficult and low yield !

### (3) Sowing space (optimum: 30cm~)

**Too narrow**



**Due to close planting, poor growth and difficulty of weeding cause low yield.**

**Too wide**



**Due to inadequate plant numbers for the capacity of field area, yield becomes low.**

# Implement sowing operation properly !

**After sowing,  
it was rain or irrigation was started**

**Higher and lower places occurred in the field**



**Submerged water impede seedling emergence**

**No Rice**



## ④ Sowing at Optimum Time



**Sowing at optimum time allows rice to grow at proper level which can avoid damages caused by rain, lack of water at heading stage, high and low temperature, etc.**

## Optimum Sowing Time

If water is available, optimum sowing time is

Summer season : Before starting rain

➔ June

Winter season : Before starting low temperature

➔ October

**\* More accurate optimum time is under research especially for Northern part of Sudan.**



**There is heavy rain !**



**Please keep in your mind on sowing time;**

- 1) Influence caused by rainfall**
- 2) Influence caused by temperature (high or low)**
- 3) Damage by birds, especially, no crops around rice**



- Sowing time needs to be determined from several viewpoints such as rainfall, temperature, water availability, birds attack, etc.**
- In general, it is recommended that sowing should be finished 3 weeks before rainy season so that rice grows to enough height to avoid damage by rain.**
- There is a tendency that the yield of rice sown in the middle of September might be significantly lower than the one in middle of July.**

## **(1) Influence on rice growth by rainfall**



**It affected growth of rice plants.**

**Re-sowing seeds were not be able to germinate.**





## **(2) Influence on rice growth by temperature**



**To avoid/minimize 'heat damage' under high temperature, frequent irrigation and/or keeping water is important. Shifting time of sowing also needs to be considered.**

### (3) Influence on rice growth by birds

**✘** Damage by Birds   
(Just before Maturity stage)




**Serious damage !**                      **No damage !**  
Practical and Effective measures must be taken !

**★** Re-sowing is important operation for reducing missing hills to obtain good yield

Finish it short time ! 

To implement appropriate management, re-sowing must be completed within 2 weeks after germination of 1st sowing



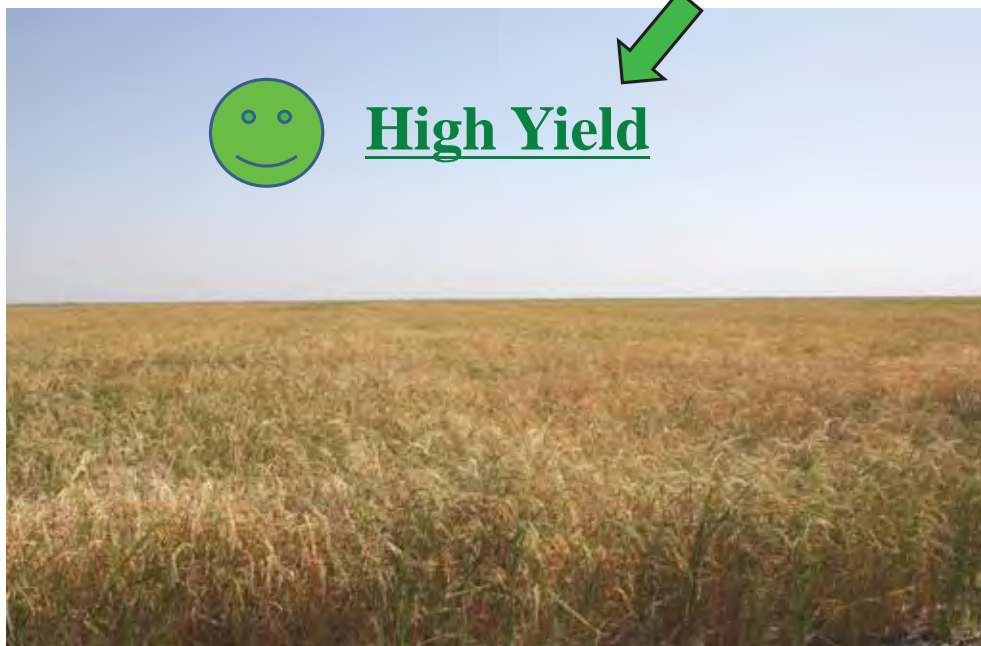
**Need fertilizer and water !**                      **No need fertilizer and water !**

## ⑤ Effective Weed Control



**Because of weakness of rice compared to weed on absorbing nutrient and water from soil, rice growth could be very much retarded by the growth of weeds.**

**Effective Weed Control → Without Weeds**







Weed Control  
(1 month after sowing)



**Weeds cover up the field ! Appropriate weed control !**



Weed Control (Heading stage)



**A lot of weeds !**

**No weeds !**

**Field must be cleaned before this stage to avoid competition !**

## **Weed control is the main decisive factor of yield !**



### **Please keep in your mind on weed control ;**

- **Weeds are stronger than rice in terms of absorbing nutrient and water from soil. In case weeds and rice grow altogether in the same field, only weeds can grow but rice cannot grow at all eventually. It means that weeds can become bigger and bigger, but rice cannot grow properly and the fields will be covered by weeds.**
- **Implementing appropriate weed treatment such as pre-irrigation, plowing, ridging as well as cleaning field before sowing is vital importance.**
- **Proper application of pre-emergence type herbicide and sufficient weeding at necessary time in one month after sowing are also indispensable.**
- **If clean condition is maintained up to heading stage, rice can avoid competition on water and nutrient and it realize high yield.**
- **Removing weeds before flowering is important to limit weeds next season.**

## Weed Control Methods

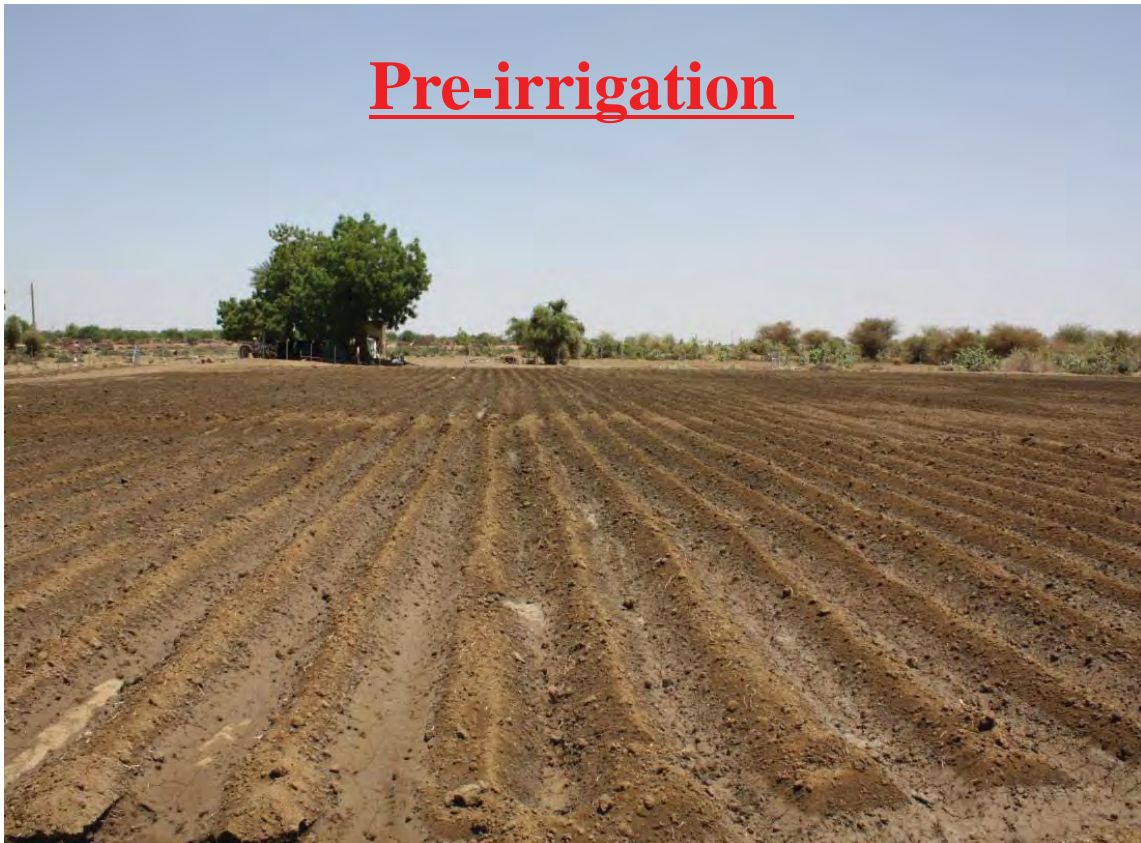
- Preventive, Cultural control
  - Land preparation, Pre-irrigation before sowing, Crop rotation, Plant spacing, etc
- Mechanical control
  - Hand weeding (hand, hand hoe, etc)
- Chemical (herbicide) control
  - Selective herbicide
  - Non selective herbicide
  - Pre-emergence (ex, Pendimethalin)
  - Post-emergence (ex, 2,4-D)



**Type, Amount, Concentration, Time should be considered**

### Weed control method (1)

#### Pre-irrigation



## **Weed control method (2)**

### **Mechanical control Hand weeding (hand, hand hoe, etc)**



## **Weed control method (3)**

### **Chemical (herbicide) control Application of herbicide**






**PendiMight 500EC  
(Pendimethalin)  
(Pre-emergence type)  
(dosage: 1.5L/fed)**

**Follow exactly  
the instruction of  
product (herbicide) !**




**If you do not follow ...**





**Herbicide injury  
(Phytotoxicity)**

**Symptom of  
herbicide injury  
(Phytotoxicity)**



**No rice plants due to  
improper application  
of herbicide !**



## Pre-emergence type

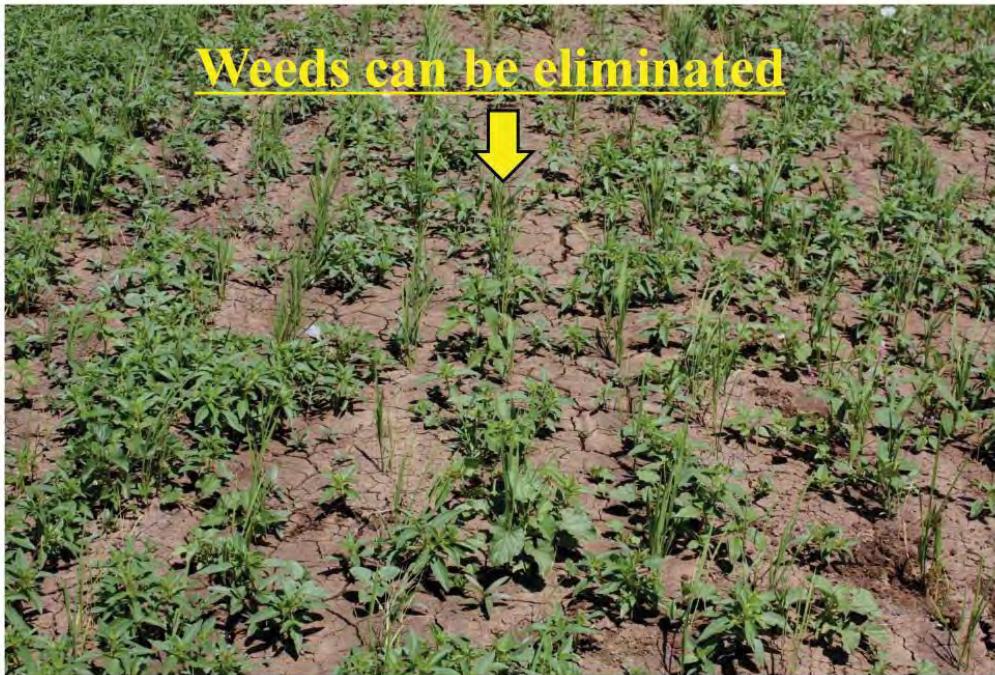


## Post-emergence type



**Please start weeding at early stage !**

**Weed control at early stage is essential**



**If you do not start weeding...**



**Weed control is difficult at this stage**





**If you do not start weeding yet ...**



**Weed control is more difficult at this stage**



**And, eventually...**



**Weeds cover up the field**



**No Yield**





**Weed Control Trial at the field of MoA, Gezira in 2013**  
**(T-1[Treatment -1] = No Weed Control)**



**We must do our best to develop effective weed control method.**  
**At present, number of weeding operation is not key point.**  
**The most important point is whether there are weeds or not.**

**The photo indicates that without weed control,  
rice can not be obtained at all !**



**The number of weeding operation  
is not key point.**



**The most important point is  
whether there are weeds or not !**

**Intensive weeding is indispensable on weed control !**



**Intensive weeding operation is :  
for example,**



**3 persons × 10 days**



**30 persons × 1 day**

**Intensive weeding enables removing weeds completely  
in a short time and conducting next operation timely !**

<b>4th Day</b>	<b>3rd Day</b>	<b>2nd Day</b>	<b>1st Day</b>

**It takes 4 days = Poor operation**



<b>2nd Day</b>		<b>1st Day</b>	

**It takes 2 days = Fair operation**



	<b>1st Day</b>		

**It takes 1 day = Good operation !**

# Yield result of weed control trial in 2013

## The Yield Result of Weed Control Trial

	R			Unit: kg/ha	Weeding Control
	1	2	3	Ave.	
1	98	1037	1991	1042	Control
2	3208	9564	9691	7488	Herbicide (Pre-emergence) +Herbicide (Post-e)
3	2195	8304	8465	6321	Herbicide (Pre-e) +Hand weeding (42DAS)
4	6775	8623	6201	7180	Herbicide (Pre-e) +Hand weed. (42DAS+56DAS)
T 5	2907	3771	10105	5594	Hand weeding (21DAS)
6	2585	6624	7977	5729	Hand weed. (21DAS+30DAS)
7	6569	10966	10978	9504	Hand weeding (21DAS+30DAS+56DAS)
8	2059	7580	10838	6826	Hand weed. (21DAS+30DAS) +Herbicide (Post-e)



### Recommendation

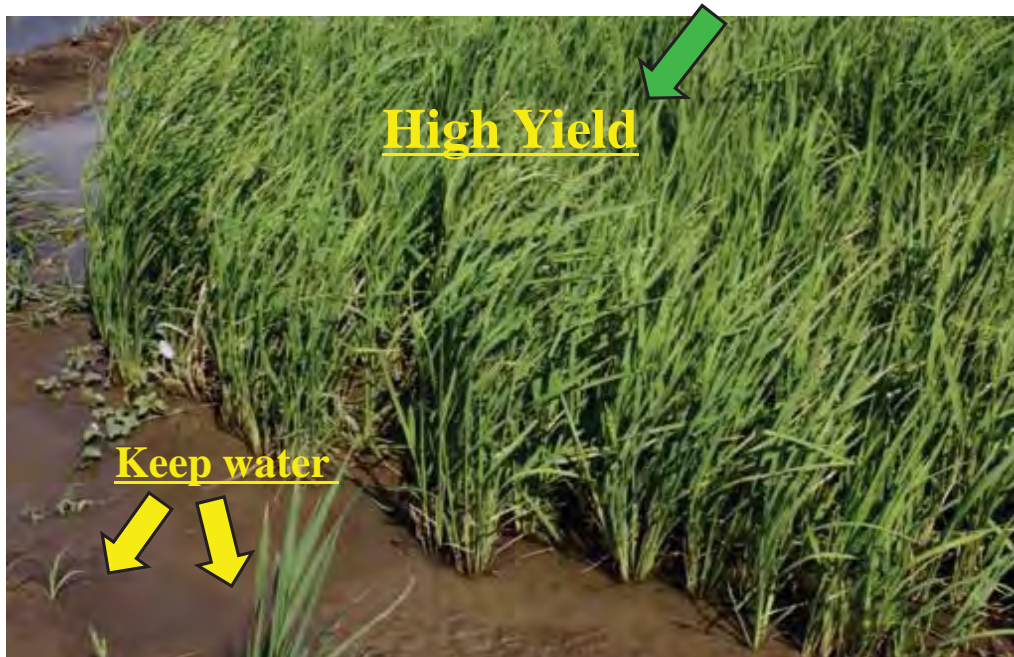
- Hand weeding of 3times is most effective from yield (9.5t.ha) and statistical analysis (1%).
- Utilizing herbicide is indispensable in large scale field. Application of herbicide is effective from yield and statistical analysis (5%).
- As a result, application of pre-emergence herbicide is effective and even if herbicide is not utilized, by 2times hand weeding during one month after sowing, weeds can be removed and allows later weeding easier.
- **The important point is that application of herbicide must be done at optimum time, in proper amount and concentration. This information is imperative for farmers for good control. And, to implement weeding at early stage is important so that weeds can be eliminated easily. If clean condition is maintained up to heading stage, rice can avoid competition on water and nutrient and it realize high yield. Removing weeds before flowering is important to limit weeds next season.**

## ⑥ Appropriate Irrigation



**From panicle initiation stage (50 days after sowing) to heading (flowering) stage, rice requires much water compared with other stage. Irrigate enough water and keep it in the field !**

**Appropriate Irrigation → Enough water**



## Water management (Heading stage)



**No water !**



**Enough water !**

**Field must be irrigated uniformly, especially at this stage !**



### Please keep in your mind on water management;

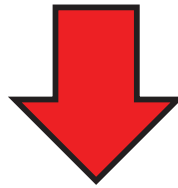
- **Insufficient water causes poor growth of rice.**
- **Submerged water after sowing impedes germination and emergence of seedling of rice due to lack of oxygen.**
- **Excessive irrigation water at early stage before panicle initiation possibly retards root development of rice.**
- **After rice starts to form panicle, it requires more water to have steady panicle growth compared with early stage. In particular, sufficient water is indispensable for rice at heading and flowering stage. In case irrigation water is not provided sufficiently at these stages, shortage of water causes empty or immature grains.**
- **In Sudan being high temperature, deficiency of water at/after panicle initiation stage, especially heading and flowering stage, causes empty grains at higher rate that results in low yield.**



**Just after sowing**



**Please reduce the amount of water !  
Just after sowing, no need to keep a lot of water.  
Excess stagnant water impedes germination  
and seedling emergence due to lack of oxygen !**

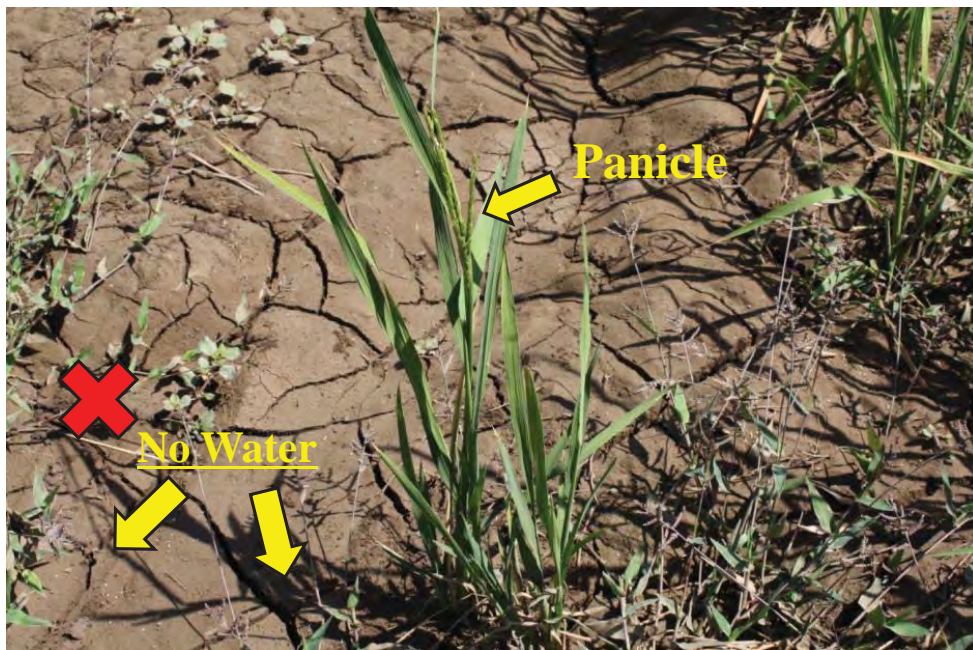


**Good seed emergence !**

## Rice requires water (1)



## Rice requires water (2)







**White Head**

**Why ?**



**Sterile panicle (grains)**

**Why ?**



**1) White head caused by**

**① Lack of water**

**② Damage by insects such as stem borers**



**(By Mr.Tsuboi)**

**2) Sterile panicle (grains) caused by**

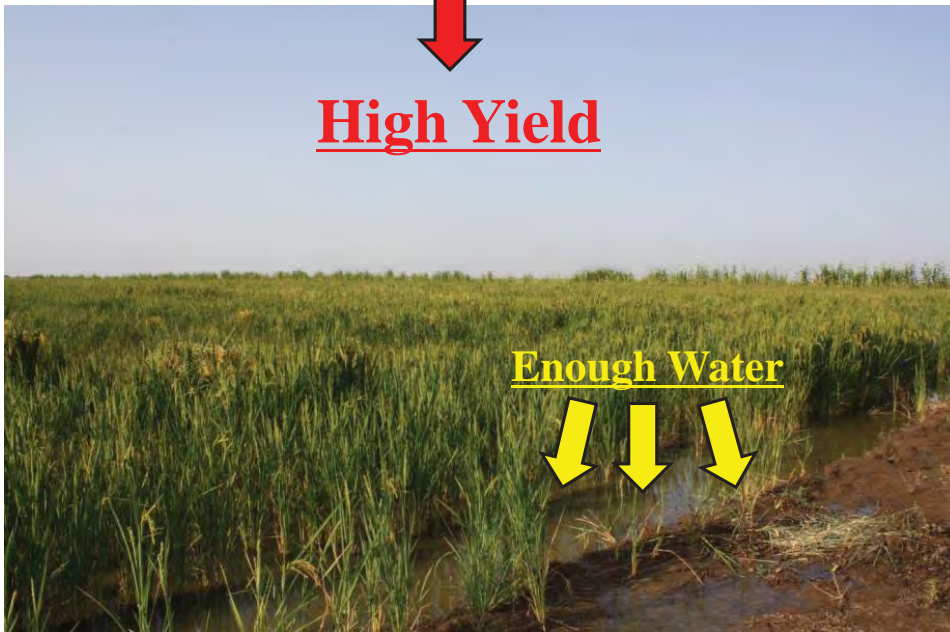
**Lack of water under high temperature condition  
from panicle initiation to heading( flowering)**



**Enough water from PI to Heading stage**



**High Yield**



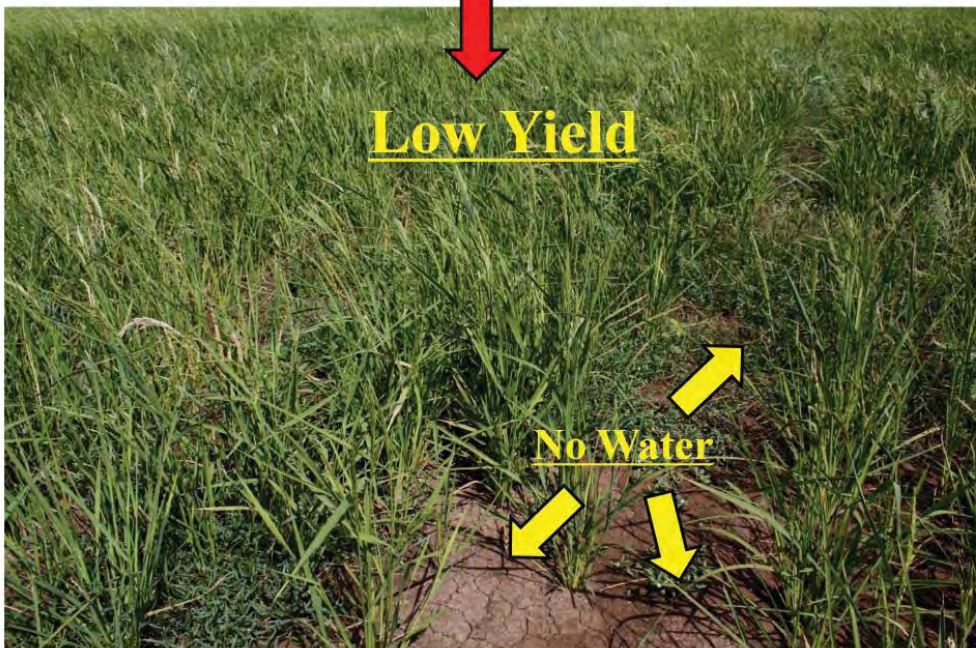
**Enough Water**



**Not enough water from PI to Heading stage**



**Low Yield**



**No Water**



**Only daily practical effort can produce good yield !**



**Re-sowing**



**Weeding**



**Weeding**



**Weeding**



**Weeding**



**Water management**



**Water management**



**Cleaning the field**

**You can realize high yield**  
**by implementing each operation properly.**

- ① Using Pure Seed
- ② Good Land Leveling
- ③ Proper Sowing Operation
- ④ Sowing at Optimum Time
- ⑤ Effective Weed Control
- ⑥ Appropriate Irrigation
- ⑦ Harvesting at Proper Time



**Daily practical management**



**Yield : 4.0t/ha (1.7t/fed) !**



## ⑦ Harvesting at Proper Time



**Harvesting at proper time is important to obtain head rice, not broken rice. Harvest must be started before moisture content of rice becomes less than 17% to prevent over drying.**



## Harvesting time



**Too late !**

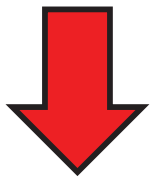


**Optimum time !**



## Rice Milling Machine

**After milling rice,  
how about rice ?**



**If you do not harvest at optimum time**



**A lot of broken rice  
due to late harvest  
(= over drying)**



**A lot of head rice  
because of good  
timing harvest**



# **Additional information**

## Rice in the world and the classification (1)

Rice planted area in the world: 157,500,000 ha (2012, Prof. ITO, Kyushu Univ.)

Rice production in the world: 720,000,000 t (2012, FAOSTAT)

Rice is eaten by half of the world population as staple food like Japan.

— *Oryza sativa* L. Indica → IR-64, Tox, WITA, etc.  
 (Asia Rice) Japonica → Koshihikari, Nihonbare, etc.  
 Javanica → Moroberekan, Lac etc.  
 (= tropical japonica)

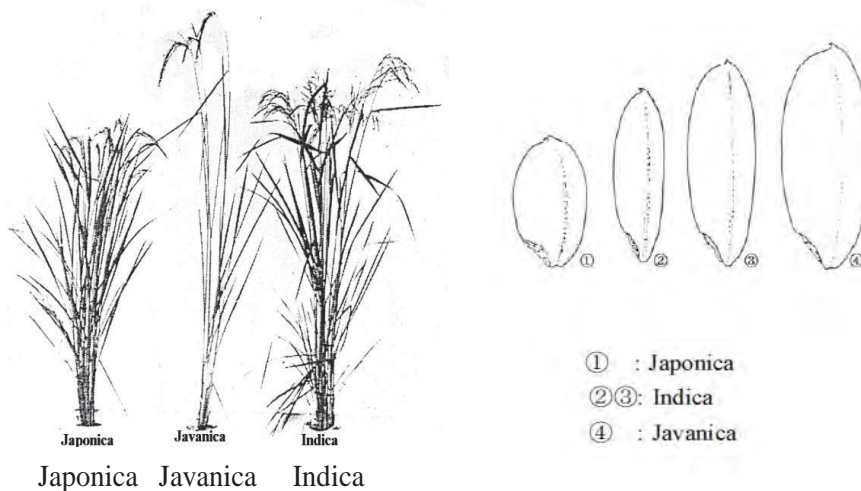
— *Oryza glaberrima* Steud.  
 (Africa Rice)  
 — *Oryza rufipogon* Griff.  
 — *Oryza nivara* Sharma et Shastry  
 — *Oryza longistaminata* A. Chev et Roehr.

↓  
 about 20 wild rice in the world.

Progenitor of *Oryza sativa* L. is *O. rufipogon*

Progenitor of *Oryza glaberrima* Steud is *O. barthii*

## Rice in the world and the classification (2)



### Classification of rice by amylose content

Non-glutinous rice: 10 to 25 % amylose + 90 to 75 % amylopectin

Glutinous rice: 100% amylopectin



## What is NERICA ?

NERICA = New Rice for Africa

NERICA is the product of interspecific hybridization between the cultivated rice species of Africa and Asia.  
( *O. Sativa* L. × *O. glaberrima* Steud.)

## Development of NERICA

♀ Asian rice



*O. sativa* L.  
WAB 56-104

×

♂ African rice



*O. glaberrima* Steud.  
CG 14

→



NERICA



