

# Rice germplasm selection and production systems for the Northern Territory.

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## Abstract

The soil and water resources of the Northern Territory provide an opportunity for increased agricultural development. Rice has long been envisaged as a suitable crop in this region, but previous attempts failed due to a multitude of constraints. There is resurgent interest in rice production in northern Australia and identification of rice germplasm for different production systems is the foundation for industry development. More than 50 rice cultivars were assessed between 2009 and 2012 at three locations, in upland and lowland conditions, and in wet season and dry season production systems. Results for time to maturity, grain yield, stover yield and harvest index, varied between varieties and between seasons. The international standard cultivar IR64 required 106 days and 146 days to harvest for the wet and dry seasons respectively, illustrating the effect of seasons. A newly introduced cultivar from Vietnam produced grain yields greater than 11t/ha under a dry season lowland production system at the Adelaide River site, which was higher than all other cultivars, including IR64, and Australian varieties Quest and Illabong. There is potential to further increase annual yields through cropping again in the wet season. Agronomic practices including timing of nitrogen application, water management and establishment techniques need to be further optimised for each production system. More generic obstacles such as pest control, seed availability, market procurement, land tenure, and water allocation will also need to be addressed to fully avail of the opportunities for rice industry development in the Northern Territory.

## Key words

Agricultural development, *Oryza sativa*, paddy rice, aerobic rice, cattle intensification

## Introduction

There have been numerous attempts at agricultural development in northern Australia, and this is likely to continue. Water scarcity in other regions of Australia and the proximity to emerging market opportunities in Asia, has focussed policy makers and commercial interests to the relatively undeveloped soil and water resources of north Australia (Cook 2009). The extensive seasonally-flooded lands along the Adelaide River in the Northern Territory (NT) have long been considered for potential rice production. Early Chinese immigrants grew subsistence rice in the late 1800s, and development of a rice industry has since been attempted on numerous occasions. This included the much maligned example of the failure of the rice project at Humpty Doo by Territory Rice Ltd in the 1950s, and at least 250 man-years of rice production research in the Adelaide River region from the late 1950s to late 1960s (Chapman et al 1985). A concerted research effort commenced again in the 1980s (McDonald 1985), concluding within a decade without any significant industry development. The reasons for these failures included poor agronomic practices, difficulties in water management, unsuitable varieties, a range of vertebrate pests, and inconsistencies in markets (Chapman and Basinski 1985). Rice production in the NT epitomises 'Capturing Opportunities and Overcoming Obstacles'.

Recent interest in rice production in the NT was stimulated by Peanut Company Australia (PCA) to identify a suitable rotation crop, so a small trial was established at Katherine to evaluate upland (aerobic) varieties. Increasing pressure on water resources in traditional rice growing areas of southern Australia further increased interest in northern Australia.

A rice industry in the NT could encompass four production systems; upland and lowland (paddy) over both dry (winter) and wet (summer) seasons. The potential to overcome obstacles from previous attempts, through the identification of suitable varieties adapted to specific production systems, and the existence of export, niche domestic, and intensive cattle feeding markets, have re-ignited interest in development of a rice industry in the NT. This paper presents a preliminary assessment of rice germplasm in both upland and lowland production systems in the northern NT.

## Method

### *Experimental design*

Experiments were conducted at three locations in the NT from 2009 to 2012, encompassing both wet and dry seasons, and upland and lowland production systems. Seed was from Biloela Genetic Resource Centre, IRRI (International Rice Research Institute) and SunRice. The number of rice cultivars, the production system, the

dates of sowing and harvest, and experimental layout are presented in Table 1. Results will be discussed for the Katherine Dry Season (DS), and the Tortilla Wet Season (WS) and DS sites only because of uneven plant establishment at the Katherine 2009-10 WS site (Hussie 2010), and harvest was not completed at Coastal Plains at the time of paper submission. However, all sites are integral to the overall germplasm and production system evaluations so are listed here.

Land preparation consisted of 1-3 rotary hoe cultivations depending on soil condition at each site. Basal fertiliser was applied prior to sowing using a twin-box drill seeder at 30cm row spacing, consisting of 200 kg/ha urea (46:0:0) at 8cm depth, and 200 kg/ha NPKS blend (4:12:7:9) at 3 cm. Seed was sown in 30cm rows using a single row vegetable drill. Stam® (480 g/L propanil) was applied for weed control at the Tortilla sites 1 month after sowing, and permanent flood irrigation applied within two days. Hand weeding was conducted at the Katherine site, and overhead solid set irrigation was applied daily. Urea was hand spread at mid-tillering (45 kg/ha) and again prior to panicle initiation (65 kg/ha). Insect infestation was sporadic, so chlorpyrifos was applied as necessary. All sites were under bird netting.

**Table 1. Description of sites for rice germplasm assessment conducted over the dry season (DS) and wet season (WS) across 3 locations from 2009 to 2012. Results are presented for the 3 sites in bold type.**

Location	Katherine Research Station, (14°27'55"S, 132°18'39"E)		Tortilla Flats, Adelaide River (13°05'15"S, 131°13'43"E)		Coastal Plains, Adelaide River (12°34'29"S, 131°19'04"E)
Season	WS 2009-10	<b>DS 2011</b>	<b>WS 2010-11</b>	<b>DS 2011</b>	WS 2011-12
Production System	Upland	<b>Upland</b>	<b>Lowland</b>	<b>Lowland</b>	Upland
Sowing date	10Dec 2009	<b>18May 2011</b>	<b>15Dec 2010</b>	<b>31May 2011</b>	21Dec 2011
Harvest period	30Mar–23Apr	<b>25Oct-28Nov</b>	<b>10Mar–28Apr</b>	<b>10-31Oct</b>	16Mar–2May
Design, plot size	Varied depending on seed quantity available	<b>RCB 4 replicates 11 m<sup>2</sup></b>	<b>RCB 3 replicates 23 m<sup>2</sup></b>	<b>RCB 2-3 replicates 24 m<sup>2</sup></b>	RCB 4 replicates 17 m <sup>2</sup>
No of Cultivars	52	<b>10</b>	<b>17</b>	<b>15</b>	16 (plus 13 cultivars of single row)

RCB=Randomised Complete Block

### Measurements

Data on seedling establishment, time of 50% panicle emergence, and harvest measurements of tiller number, plant height, grain yield and stover yield were recorded from a 4 row x 1m sub-plot. The remainder of the plot was harvested for seed. Sub-plot grain and stover yields are presented here. An ANOVA was conducted on appropriately transformed data, and pairwise comparisons were assessed using Tukey HSD test.

## Results and Discussion

### Maturity and growing season

Maturity as determined by days after sowing (DAS) to harvest, and grain and stover yields for the three selected sites are presented in Table 2. There was a significant effect of cultivar on maturity ( $P < 0.001$ ) for all sites. Baseline cultivars can be used to illustrate the effect of season and site. Rice reached maturity more quickly in the wet season than the dry season at Tortilla (106 DAS extended to 146 DAS and 111 DAS extended to 147 DAS for IR64 and NTR426 respectively). This effect was more pronounced by the colder conditions at Katherine (data not shown) which significantly lengthened time to maturity over the dry season to 176 DAS for IR64 and to 194 DAS for NTR426.

Physiological development and maturity needs to suit the length of growing season and the time of temperature extremes in proposed production areas. Cultivars with a longer growing season are required for WS production to ensure grain maturity occurs into the start of the dry season. A shorter growing season is required for cultivars for DS production so that grain is mature prior to the onset of the wet season. Results so far suggest that Viet4 and Takanari are promising for DS production, and that the two NTR lines are promising for WS production. The NTR cultivars are a result of selection of over 1000 lines obtained through IRRI during the 1980's NT rice breeding program.

Floret sterility was observed in some cultivars where flowering occurred during low temperatures in the DS, and in other varieties in the WS where flowering occurred during high temperatures and heavy rain periods during February. DS cold tolerance, WS heat tolerance and rice blast tolerance are criteria to be considered in cultivar selection in the NT. Blast and extreme temperatures were also found to be a constraint to rice production in the Ord River Irrigation Area (ORIA) (Sivapalan 2012).

#### Grain yields

The Tortilla 2011 DS site produced consistently higher grain yields than the previous WS crop and the corresponding DS upland site at Katherine. A more detailed interpretation of cultivar performance by environment will be conducted with the inclusion of 2012 data, consistent with studies conducted by Sivapalan et al (2007). However, initial trends of lowland grain yields greater in the DS than the WS are consistent with previous research in northern Australia (Chapman and Basinski 1985; McDonald 1985) attributed to increased solar radiation and better harvest indices. Incidence of lodging, and insect, disease and vertebrate pest pressure, were also less in the DS than the WS, water management was easier to regulate, and these factors all contributed to higher yields.

Field observations indicated substantial differences in grain yield between cultivars within all sites, supported as a significant effect of cultivar in the Katherine DS site ( $P < 0.01$ ). However, the effect was weaker at the Tortilla DS site ( $P < 0.05$ ), and no significant effect at the Tortilla WS site. Results for the Tortilla sites were confounded by inconsistencies in water levels and possibly nutrition, within different bays. Lodging, in conjunction with difficulties in water management, was a major issue, especially in the WS, resulting in lost or shot grain. Amount and timing of nitrogen application may have influenced degree of lodging. Viet4, a newly introduced cultivar from Vietnam, produced an average yield over 11t/ha in the DS, and will be targeted for seed increase.

Yunlu29 produced relatively high yields under upland conditions over the DS at Katherine and appears promising for NT upland production systems. This was consistent with the 2009-10 Katherine WS results (data not presented, Hussie 2010) and the ORIA trials in 2011 where it was the highest yielding cultivar under aerobic conditions (Sivapalan et al 2012).

**Table 2. Grain and stover yield, and days after sowing (DAS), for rice cultivars at three selected sites. Values are means across replicates within each site, listed in ascending order of grain yield.**

**IR64 and NTR426 are highlighted to illustrate comparison between sites.**

Cultivar	Tortilla WS			Cultivar	Tortilla DS			Cultivar	Katherine DS		
	Grain yield (kg/ha)	Stover yield (kg/ha)	DAS		Grain yield (kg/ha)	Stover yield (kg/ha)	DAS		Grain yield (kg/ha)	Stover yield (kg/ha)	DAS
Amber33	1752	-	110	Langi	6667	4792	141	Vandana	1735	2497	160
Yunlu29	2172	3975	103	<b>IR64</b>	<b>6889</b>	<b>5917</b>	<b>146</b>	<b>NTR426</b>	<b>2880</b>	<b>2259</b>	<b>194</b>
Azucena	2178	4698	102	Doongara	7167	5889	133	Azucena	3095	4080	175
Moroberekan	2190	8286	107	PW7 <sup>#</sup>	7167	8139	142	<b>IR64</b>	<b>3168</b>	<b>2580</b>	<b>176</b>
Basmati370	2759	-	111	Lemont	7611	5500	138	Lemont	3194	2049	182
Tachiminori	3149	3390	95	Fin	7778	6389	147	PSBRC9	3228	2312	181
IR66	3270	3327	103	<b>NTR426</b>	<b>8000</b>	<b>8667</b>	<b>147</b>	Takanari	3298	1903	175
PW7	3492	7448	106	Viet1	8278	8639	150	Tachiminori	3465	3288	168
IR72	3600	6159	106	NTR587	8417	6375	153	Yunlu29	3892	3872	162
<b>IR64</b>	<b>3917</b>	<b>5371</b>	<b>106</b>	Viet5	8833	7500	148	B6144FMR6	3961	2578	179
Muncul	4038	9753	132	IR72	8889	7056	149				
Vandana	4101	4190	88	Kyeema	8917	6792	140				
<b>NTR426</b>	<b>4105</b>	<b>5810</b>	<b>111</b>	Quest	9611	5806	133				
Milyang23	4340	5676	102	Illabong	9722	6361	140				
PW10	4394	9995	132	Viet4	11167	6167	143				
IR24	4571	6610	107								
Takanari	4749	4203	101								
LSD (5%)	NS	5560	9		4443	3413	3		1389	1142	2.59

<sup>#</sup>PW=Pandan Wangi. Stover yields were not measured for Amber33 and Basmati370 due to extreme lodging into standing water.

### *Stover yields*

Cultivars at the two Tortilla sites produced greater stover yields than the corresponding cultivars at Katherine, as would be expected in comparing lowland to upland production systems. Cultivar significantly affected stover yield within all three sites ( $P < 0.001$ ). Muncul and Pandan Wangi10 produced high stover yields within the Tortilla WS site, consistent with the longest growing season, but this did not translate to the highest grain yields. Upland cultivars such as Vandana, Azucena and Moroberekan were expected to have a much lower harvest index ( $(\text{grain yield} / (\text{grain} + \text{stover yield})) * 100\%$ ) than traditional lowland varieties such as IR64, consistent with field observations.

The majority of floodplain land-type suitable for rice production in the NT is on pastoral lease with extensive cattle production the dominant enterprise. Rice stubble provides the opportunity to northern Australian pastoralists for the intensification of cattle grazing, so stover quantity and quality is an important consideration.

### **Conclusion**

Potentially suitable cultivars such as Takanari, Viet4, NTR lines, and Yunlu29, were identified for a range of rice production systems in the NT. DS lowland rice production produced relatively higher yields and easier management than other systems, suggesting this should be the basis of a northern rice industry. This may be the case for the ORIA which has established irrigation infrastructure, but suitable water availability for DS rice production is a significant constraint in the NT. Other major obstacles include the procurement of commercial quantities of seed of these cultivars, and favourable market evaluation for their quality characteristics. Further development of specific agronomic practices such as nutrition, sowing technique and water management are also still necessary. Overcoming these obstacles will form the basis of grasping the opportunity that rice production presents to growers in the NT.

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### **References**

Chapman AL and Basinski JJ (1985). Coastal Plains Research Station. The Northern Challenge. A History of CSIRO crop research in the northern Australia. JJ Basinski, IM Wood and JB Hacker. Brisbane, Australia, CSIRO Division of Tropical Crops and Pastures: pp 91-114.

Chapman AL, Dasari NR, Delane RJ, Mayers BA (1985). Rice. Agro-research in the semi-arid tropics: north-west Australia. RC Muchow. University of QLD Press: pp 209-226.

Cook G. (2009). Historical perspectives on land use development in northern Australia: *with emphasis on the Northern Territory*. Northern Australia Land and Water Science Review. Chapter 6: 1-30.

Hussie, D. (2010). Evaluation of rice cultivars grown under aerobic conditions in the 2009-10 wet season, Katherine Research Station. NT Government Department of Resources. Primary Industries Annual Research Report 2009-10. pp.136-139.

McDonald DJ. (1985). Review of Floodplain Cropping (Rice) Research and Industry Development in the Northern Territory. NT Government Department of Primary Production. 54 pages.

Sivapalan S, Batten G, Goonetilleke A, Kokot S. (2007). Yield Performance and Adaptation of some Australian-grown rice varieties through multi-variate analysis. Australian Journal of Agricultural Research **58**: 874-883.

Sivapalan S, Goldsmith P, Warmington M, Snell P and Ford R. (2012). Effect of low night temperatures on growth and grain yield of 20 rice varieties grown in the Ord Valley. DAFWA Proceedings of the Agribusiness Crop Updates Conference, 28-29<sup>th</sup> Feb, Perth, pp. 271-276.

Sivapalan S. (2012). Rice in the Ord: Opportunities and threats. Proceedings of the 16<sup>th</sup> ASA Conference, Armidale, Australia.