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Rice Research and its Prospect of Production in Arid Regions of Saudi Arabia
II. First Trial of double Croppings in Gassim

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Introduction

In Gassim Province, there are lots of vast low-lying areas called the Great Nafud Sedimentary Basins where soils are characterized by heavy-textured sandy clay, low percolation and high accumulation of salts.(2) The ground water for irrigation usually have high salinity but low sodium hazard(11). Most of the low lands are still idle due to the inherent problems of soil texture and salinity. For crop cultivation on these soils, various reclamation practices are needed. Rice is regarded as the most suitable reclamation crop, although varieties differ in adaptability(1).

Furthermore, as reported by the International Rice Research Institute(9), the unit yield of rice in an arid zone is much higher than that of humid tropics, if adequate irrigation and drainage systems are provided.

The objective of this experiment is to determine the optimum sowing and transplanting time of rice cultivation in spring and summer seasons in Gassim area.

Materials and Methods

Spring crop:

Three long-grain indica rice varieties, one local Amberbook and two from Taiwan NTU 306-2-2 and Sipi 201602 were tested. They were subjected to 4 treatments of sowing and transplanting-time combinations as follows:

Treatment	Date of sowing	Date of transplamting
1	Jan. 28	Mar. 8
2	Feb. 6	Mar. 15
3	Feb. 16	Mar. 22
4	Feb. 26	Mar. 29

A split plot design with sowing transplanting time treatments as main plots and varieties as sub-plots with 4 replications was adopted. The sub-plot size was 1.5×4m.

Seedlings were raised in both ordinary seed-beds and seed-boxes to ensure enough number of seedlings for transplanting. Seedling were protected with PVC film from cold injury during the nursery period according to the temperaturess and seedling ages. After salt-leaching treatments were made twice, seedlings were transplanted into the experimental plots, at a spacing of 25×20cm with 8-10 seedlings per hill. N-P-K fertilizers used were at a rate of 150-75-20 kg/ha, with N-fertilizer applied in 5 splits. Replanting for missing hills was made about 7 days after trans-

planting. Growth performance, grain yields and yield components were recorded.

Summer crop:

Amberbook and NTU 306-2-2 were subjected to 5 treatments of sowing and transplanting time combinations as follows:

Treatment	Date of sowing	Date of transplamting
1	May. 30	Jun. 20
2	Jun. 15	Jul. 5
3	Jun. 30	Jul. 20
4	Jul. 15	Aug. 5
5	Jul. 30	Aug. 20

A split plot design with 5 sowing-transplanting time treatments as main plots and varieties as sub-plots with 4 replocations was adopted. The main plot size was 2.5×9m, while that of the sub-plot was 1.25×9m.

Seedlings were raised in seed-boxes and transplanted at the 3-leaf after all the plots were treated with two times of salt-leaching. Transplanting was done at the spacing of 30×15cm with 3-5 seedlings per hill, equivalent to the amount by power transplanting. N-P-K fertilizers used were 160-80-0 kg/ha with N-fertilizer applied in 5 splits. Each main plots was seperated by soil levees. All plots were continuously flooded since transplanting till one week before harvesting except drainage was made while top-dressings and at the maximum tillering stage. Growth performance, grain yields and yield components were recorded.

Results and Discussion

Spring crop:

1) Seedling growth:

NTU was most tolerant to cold and dry weateher, followed by Sipi. Amberbook was least tolerant in seedling stage and after transplanting. The symptoms of cold injuries (leaf withering) appeared from the 2-leaf stage.

It was observed that the earlier the sowing/transpalting time, the slower the growth rate of seedlings due to the prevailing low temperature in the early season. Neverthless, the earlier planted showed taller and thicker seedlings in both nursery and the field.

2) Growth after transplanting:

Follwing a spell of fine weather after May, with increasing solar energy, sunshine and warm temperatures togakher with fertilizers and irrigation, the rice plants showed magnificient growth. The earlier planted plants were taller and had more tillers than late ones. However, the plants in treatment 1 were damaged by low temperatures after transplanting. During the vegetative growth phase, NTU was most tolerant to drought, cold and heat, followed by Sipi, and Amberbook was the least in terms of leaf-drying. However, during and after flowering, Sipi was most tolerant to heat followed by NTU, and Was Amberbook the least in terms of sterility.

3) Rates of fertilizers and plant growth:

The initially planned fertilizer dosage was 150-75-20 N-P-K kg/ha. However, due to low temperatures prevailing during the vegetative growth period associated with intensive solar energy and barren soil, the planned fertilizer rate was found insufficient to maintain normal plant growth. Furthermore, potassim fertilizers were not readily available from the local market. Therefore the fertilizer rate was modified to 200-80-0 kg/ha. This resulted in excellent growth and yield performance.

4) Growth duration:

The growth durations of three rice varieties in the nursery (sowing to transplanting), vegetative and reproductive growth period (transpalnting to heading) and ripening period (heading to harvesting) are shown in Fig. 1.

The plants sown on January 28 required 39 days (Treatment 1) for nursery growth whereas those sown in February needed 31 days only (Treatment 4), indicating that the earlier the sowing, the slower the seedling growth. The same trend was seen for vegetative and reproductive period, but it was not clear in the ripening period. In spite of the wide difference in transplanting time, the differences in heading and harvesting dates were much smaller, although the earlier transplantings resulted in earlied heading and harvesting, Sipi was the earliest variety and was hervested on July 28, August 6, 9 and 12 in treatments 1, 2, 3, and 4, respectively. NTU was harvested on August 7, 12, 16 and 18, and Amberbook was the latest, harvested on August 27, 28, 31 and September 2, respectively.

5) Grain yield:

Table 1 shows the marked differences in yielding capacity among the three varieties. NTU outyielded local varieties Amberbook as much as 128%, and Sipi 86%. Treatments 2 and 3 apparently gave higher yields than treatments 1 and 4. A slight diference was found between treatments 2 and 3, being in favor of the former.

Table 1. Yields of three rice varieties under different planting time

Treatment	Variety			
	NTU	Sipi	Amberbook	Mean (Index)
	t/ha	t/ha	t/ha	t/ha
1	8.63	6.03	2.48	5.71 (100)
2	9.50	8.43	5.00	7.64 (134)
3	10.32	7.55	4.19	7.35 (129)
4	7.87	7.64	4.29	6.60 (116)
Mean	9.08	7.41	3.99	
(Index)	(228)	(186)	(100)	

Table 2 shows that differencesin yield due to the sowing / transplanting time treatments and varieties were highly significant. But the interaction between sowing / transplanting time treatment and variety was insignificant.

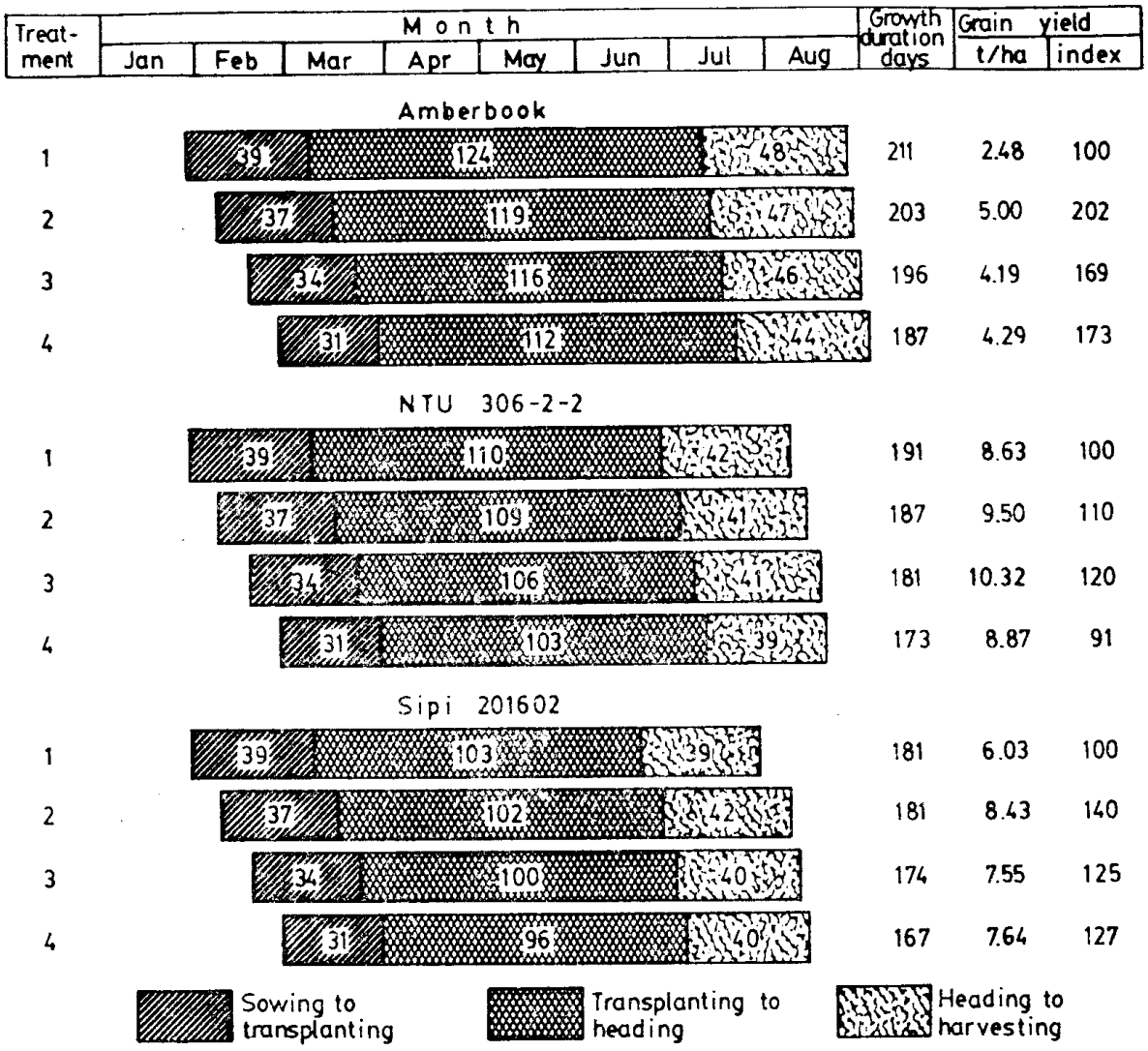

Fig 1: Comparison of growth durations and grain yield between timings of sowing/ transplanting of three rice varieties, spring crop, 1978.

Table 2. Analysis of variance for grain yield data (spring crop, 1978).

Source of variation	Degree of freedom	Mean square	F
Replication	3	19,041,08	
Time (T)	3	2,235,516.08	15.48**
Error (a)	9	144,481.75	
Variety (V)	2	26,960,410.75	105.62**
T x V	6	518,411.81	2.03n.s.
Error (b)	24	255,257.10	

*, ** Significant at 5% and 1% levels, respectively.

Table 3 shows the significant differences in yields between Treatments. Treatment 2 giving the highest yield was significantly different from treatments 4 and 1. Treatment 3, the second also differed significantly from treatments 4 and 1. The data suggested that the optimum sowing time in the spring was February 6 to 16, and transplanting time being March 15 to 22.

Table 3. Grain yield differences between dates of sowing/transplanting (Spring crop, 1978)

Treatment Sowing/Transplanting	Grain yield (Plot total)	Comparison ($gm/60M^2$)		
1. Jan 28/Mar 8	34266			$LSD_{0.05} = 4212*$
4. Feb 26/Mar 29	39602	5336*		$LSD_{0.01} = 6052**$
3. Feb 16/Mar 22	44110	9844**	4508*	
2. Feb 6/Mar 15	45849	11583**	6247**	1739

Table 4 shows the grain yield differences between varieties.

Tabe 4. Comparison of differences between varieties (Spring crop, 1978)

Variety	Grain yield (Plotsvtotal)	Comparison ($gm/80M^2$)		
Amberbook	31895			$LSD_{0.05} = 5899*$
Sipi	59301	27406**		$LSD_{0.01} = 7994**$
NTU	72631	40736**	13330**	

6) Agronomic traits and their correlation analysis:

Regarding plant height at maturity, the earlier the planting date, the shorter the stems in NTU and Sipi, but the trend was reversed in Amberbook (Table 5). In all three varieties, earlier planting gave more panicle number per hill. Single panicle weight, panicle length, grain number per panicle, percentage of unfilled grains, and 1000-grain weight were not affected by planting time.

The correlation analysis revealed that the grain yields of NTU and Sipi were highly correlated with panicle number and 1000-grain weight.

Table 5. Effects of planting time one the agronomic characteristics of varieties and their correlation to grain yields. (Spring Crop, 16978, Gassim) (n=16)

Variety	Treatment	Plant ht. cm	Tiller No./ hill	Panicle Wt. gm/pa	Panicle 1th. cm/pa	Grain No./ panicle	No. of unfilled grains %	1000-grain weight gm
Amberbook	1	109	27.7	1.17	23.4	104.7	28.3	16.5
	2	111	32.7	1.50	23.1	100.0	18.4	17.5
	3	107	27.1	1.31	23.2	83.3	40.9	16.0
	4	102	28.3	1.60	16.5	114.0	26.8	23.5
	r	.25	.50*	.64**	–.00	.06	–.29	.45
NTU	1	67	34.5	1.57	18.9	76.8	19.8	23.0
	2	70	46.7	1.14	17.0	71.6	15.8	23.0
	3	72	41.2	1.52	17.4	75.5	26.6	23.0
	4	71	30.8	1.54	19.0	85.9	20.7	21.0
	r	.30	.74**	–.10	–.40	–.43	.42	.76**
Sipi	1	61	28.6	1.29	18.9	78.2	24.0	2.1
	2	67	37.3	1.54	18.1	78.3	22.1	22.5
	3	69	35.8	1.26	18.8	81.6	23.8	21.0
	4	69	31.9	1.60	19.2	93.8	21.5	22.3
	r	.29	.80**	.38	–.04	.13	–.31	.74**

*,**, Significant at 5% and 1% levels, respectively.

In Amberbook the grain yield was correlated with panicle weight and panicle number per hill. This suggests that spring seedling at an optimum date may get more tillers and high 1000-grain weight that are necessary for obtaining maximum yield.

Summer crop:

1) Seedling growth:

NTU showed a high rate of germination and seedling vigor, whereas Amberbook was poorer and weaker. Raising seedlings in seed boxes was found very successful when sown in late May to mid-June, but unsucessful after late June, particularly in mid-July when temperature was the highest. It was noticed that the earlier the sowing time the more vigorous the germination and seedling growth, regardless of varieties.

2) Soil salts and leaching treatment:

Salts accumulation in the newly developed sandy clay soil varied greatly or hetergene-ously[(2)]. A few plots showed stunting after transplanting, even with 2 leaching treatments, particularly in those plots transplanted in mid-July, seeming to be associated with torrid dry weather.

3) Plant growth:

Similar to the spring trial, better seedling growth was found in earlier plantings; the worst was seen in treatment 4, followed by treatment 5, on account of the torrid dry weather prevailing during July and the increasing of high salinity in the soil due to lateral seepage from adjacent earlier planted plots.

Treatments 1 and 2 gave excellent height growth and tillering after transplanting which lasted to the ripening stage (treatment 1) or to the heading stage (treatment 2) regardless of varieties. A rapid drop of air temperature occurred in October, with a mean daily minimum of 17.7 ℃.[2] The cold damage during the night was yellowing to bronzing of leaves with tip-drying in NTU but it was paling of leaves with tip-drying in Amberbook. These symptoms were seen in all planting time. The cold injury also caused incomplete development of embryos, particularly in treatment 2. In treatment 3, heading in October, the cold injury not only damaged leaves but also affected heading uniformity, flowering, pollination and embryos development. In treatments 4 and 5, height growth was seriously affected by the cold and no heading occurred at all.

4) Rates of fertilizers and plant growth:

In view of growth performance of the two varieties tested, a fertilizer dosage of 180-80-0 N-P-K kg/ha seemed to be needed for normal growth in summer.

5) Growth duration:

As shown in Fig. 1 and 2, the growth duration from sowing to harvesting in the spring was 187-211 days in Amberbook and 173-191 days in NTU; and in summer was only 148-161 days and 154-163 days in Amberbook and NTU, respectively. Seedlings grown in summer could be transplanted at about 20 day-old stage and required approximately two-third of growth duration from transplanting to heading and one third for heading to harvesting.

Amberbook showed not only thermo-sensitivity but also slightly photoperiod sensitive as it was late-maturing in spring planting but was early maturing in summer. It was noticed that Amberbook was very susceptible to low temperature in seedling stage but was more tolerant during the reproductive growth period as compared to NTU.

To sum up, the earlier the planting date, the shorter was the growth duration. The optimum date of sowing was before early June so as to be transplanted before late June. The harvesting time was before the end of October in Amberbook and before early November in NTU. The later planting showed marked extention of growth duration, and yield decreasing.

6) Grain yield:

Table 6 shows significant differences in yield among different treatments, and significant interaction between sowing/ transplanting time and varieties, but no significant difference between varieties.

7) Agronomic traits and correlation analysis:

Table 9 shows a remarkable influence of planting time on plant height. Plants in treatment 1 were tallest regardless of varieties, and those in treatment 4 were shortest.

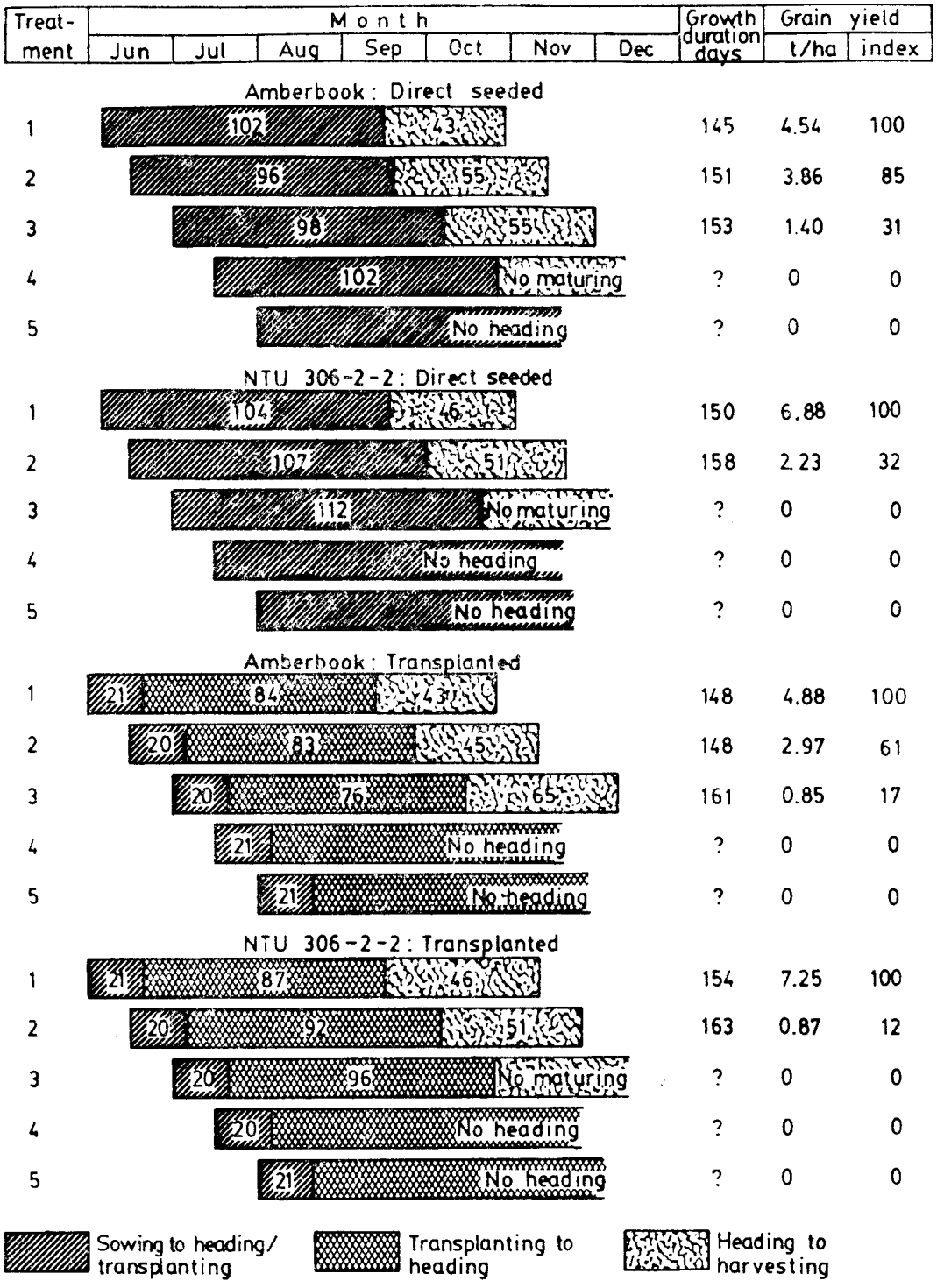

Fig 2: Comparison of growth duration and grain yield between treatments of sowing and planting times of two rice varieties, summer crop, 1978.

Table 6. Analysis of variance for grain yield in optimum time of sowing and transplanting experiment (summer crop, 1978, Gassim).

Source of variation	Degree of freedom	Mean square	F
Replication	3	881,807.03	
Time (T)	3	71,472,119.53	191.09**
Error (a)	9	374,016,75	
Variety (V)	1	182,257.03	0.75
TXV	3	8,253,752.86	34.04**
Error (b)	12	242,458.07	

*,** Significant at 5% and 1% levels, respectively

Fig. 2 indicates that Amberbook in treatment 1 yielded 4.88 mt/ha, nearly reaching the top-yield of 5.00 mt/ha by the same variety in spring crop. However, treatment 2 gave only 61 percent of the yield of treatment 1, and treatment 3 only 17 percent. NTU in treatment 1 yielded 7.25 mt/ha, which was lower than 7.87 mt/ha, the lowest yield given by the same variety in the spring in treatment 4 treatment 2 gave only 12 percent of the yield of treatment 1.

It may be concluded that Amberbook is more suitable for summer cultivation whereas NTU is more suitable in spring.

Table 7 shows that the differences between treatments 1 and 2 and those between treatment 2 and 3 were highly significant.

Table 7. Comparison of differences between dates of sowing/ transplanting (Summer crop, 1978).

Treatment Sowing/Transplanting	Grain yield (plot total)	Comparison (gm/86.4M^2)	
4. Jul 15/Aug 50	0		$LSD_{0.05}$ = 5533*
3. Jun 30/Jul 20	3660	3660	$LSD_{0.01}$ = 7950**
2. Jun 15/Jul 5	16665	16665**	13005**
1. May 30/Jun 20	52410	52410**	48750** 35745**

Table 8 indicates highly significant differences between NTU and Amberbook in treatment 1, between treatment 1 and 2 with Amberbook, and between Amberbook and NTU in treatment 2. The difference between Amberbook and NTU in treament 3 was also significant.

Table 8. Comparison of differences between combinations of planting time and varieties. (Summer crop, 1978)

Combination	Grain yield (plot total)	Comparison (gm/43.2 M^2)				
T_3V_n	0				$LSD_{0.05}$ = 3501*	
T_3V_a	3660	3660*			$LSD_{0.01}$ = 4953**	
T_2V_n	3830	3830*	170			
T_2V_a	12835	12835**	9175**	9005**		
T_1V_a	21080	21080**	17420**	17250**	8245**	
T_1V_n	31330	31330**	27670**	27500**	18495**	10250**

The effects were greater in Amberbook than in NTU suggesting that their culm elongation is influenced by low temperatures in different manners. Possibly because of hot weather and soil salinity. For being affected in growth in the early stage, treatment 4 showed fewer tillers and panicles than other treatments.

The correlation analysis revealed that the grain yield of Amberbook was significantly correlated with panicle weight, plant height, number of grains per panicle, and 1000-grain weight, but was negatively correlated with sterility. It showed no correlation with panicle number and panicle length. The yield of NTU was correlated with panicle weight, and nearly significantly correlated with panicle length, and 1000-grain weight but showed no significant correlation with panicle number, number of grains per panicle and sterility.

8) Feasibility of direct sowing:

In the spring experiment, 100 upland rice varieties and lines from the IRRI were sown on March 8. The rates of germination under shallow flooding varied from 20 to 98%. However, they were entirely damaged by cold spell that attacked the plants on March 16. Resowing was made on March 31 but failed to germinated due to low percolation resulted in serious soil reduction after flooding for 3 weeks and cold weather at night[(2)]. For the safety in temperature, the optimum time of direct sowing seemed to be May.

In the summer, the same experiment as the above showed that germination and seedling growth after direct sowing were successful when salt-leaching was made twice by enough puddling and drainage and the land was well levelled and shallow irrigation was practiced. However, growth was not as uniform as that of transplanted, perhaps owing to heterogeneous salt accumlation. As shown in Fig. 2 the highest yield was obtained from treatment 1, the eariest sowing, which was 4.54 t/ha in Amberbook and 6.88 t/ha in NTU. The yields were slightly inferior to those from transplanting. Therefore, direct sowing is feasible but requires more precise management and may comsume water for 20 days more in the field.

Table 9. Effects of planting time on agronomic traits of varieties and their correlation with grain yield (Summer crop, 1978).

Variety	Treatment	Plant ht. cm	Tiller No./ m^2	Panicle Wt. gm/pa	Panicle 1th. cm/pa	Grain No./ panicle	No. of unfilled grains %	1000-grain weight gm
Amberbook	1	112	565	1.62	22.7	134.7	26.0	18.1
	2	111	691	1.15	22.2	122.2	33.7	17.5
	3	98	555	1.04	20.9	113.5	50.0	16.2
	4	57	427	–	–	–	–	–
	5	97	562	–	–	–	–	–
	r	.68*	.05	.80**	.40	.61*	–.64*	.65*
NTU	1	63	777	1.56	17.4	85.6	21.1	24.0
	2	62	702	1.02	17.6	85.9	54.8	23.3
	3	57	719	–	–	–	–	–
	4	42	647	–	–	–	–	–
	5	44	708	–	–	–	–	–
	r	.25	.05	.81**	.57	.50	–.03	.61

*,** Significant at 5% and 1% levels, respectively.

Conclusion

In Gassim, Saudi Arabia the optimum time of transplanting for spring rice was from March 15 to 22, and for summer rice was earlier than late June. Amberbook is suitable for late spring and/or early summer cultivation, whereas NTU for spring cultivation. The yields are quite high. Further studies on the date of planting are needed. Currently, double rice croppings on the same land are impossible because of the constraint of climatic conditions[(2)]. The optimum duration for growing seedlings in nursery is 40 days in spring and 20 days in summer.

Acknowledgement

The anthors are deeply indebted to HRH prince Naif, for his graciousness and generosity in providing private land and facilities for this research project. We also appreciate very much to Mr. S. AI-Oraier and Mr. A. A. M. Al-Sikhan, the former and the present Directors of Unayzah Agricultural Office, Gassim, for their unremitting and generous cooperation and assistance. Many thanks are given to Mr. S. T. Lin and Prof. C. I. Lin, the former and the present Leaders of the Chinese Agricultural Technical Mission to the Kingdom, of Saudi Arabia for their support of this experiment.

Summary

In 1978, the first trial of double croppings of rice in Saudi Arabia was made with three long-grain indica rice varieties, one being local Amberbook and the other two from Taiwan, NTU and Sipi (used in the spring only). The varieties were tested with 4 dates of sowing/transplanting, starting from January 30 through February 26 at 10-day intervals, as the spring crop,/and with 5

dates of sowing/transplanting, starting from May 30 through July 30 at 15-day intervals as the summer crop, in a sandy clay soil of Prince Naif's farm in Gassim basin of Saudi Arabia.

From the spring experiment, it was found that yield was the highest in February 2 seeding, reaching 5.00 t/ha in Amberbook and 8.43 t/ha in Sipi. However, the variety NTU gave the highest yield of 10.32 t/ha when seeded on February 16.

Too early planting suffered from serious cold damage in the seed-bed and in the early stage of growth after transplanting. Late planting showed decline in tiller number and grain yield.

1) The summer experiment showed that the eariest planting gave the highest yield, 4.88 t/ha in Amberbook and 7.25 t/ha in NTU.

2) The optimum seeding time was before early June, and about 20-day old seedlings were tranplanted.

3) Late plantings suffered from cold injury prevailing after October.

Double rice croppings on the same land in Gassim is impossible due to the constraint of weather. Amberbook is suitable for late spring and/or early summer cultivation, while NTU for spring cultivation.

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沙烏地阿拉伯旱區之稻作研究及其生產展望 II.卡新省双期稻作之初步試驗

張學錕　鐘三雄　廖明傳

爲探究沙烏地阿拉伯卡新省典型的王子農場盆地栽培双期水稻之可行性，於1978年間春作，用三個長粒型秈稻品種，一爲當種Amberbook，另二種由臺灣引進之NTU 302-2-2及Sipi 201602，自1月30日起至2月26日止，每隔10天播種及插秧一次，計4處理；在夏作用Amberbook及NTU兩品種，自5月30日至7月30日止，每隔15天種植一次計5處理。重複4次，裂區設計。土壤爲沙質粘土。其初步試驗結果如下：

春作：

1.收量最高之時期處理：NTU爲第3處理高達10.32t/ha，次爲Sipi及Amberbook之第2處理產量分別爲8.43及5.00t/ha。

2.播種最適宜時期，NTU在2月16日或中旬，Sipi及Amberbook均在2月6日或上旬，在播種後35～40天插秧。

3.過早種植，在秧田及插秧後會發生嚴重之冷害，但過遲栽培會減少分蘗及穗數，導致減產。

夏作：

1.產量最高之時期處理均爲種植最早者，NTU達7.25t/ha，Amberbook爲4.88t/ha。

2.夏作最適宜之播種時期，均顯示須在6月上旬之前，以20天苗插秧爲宜。

3.種植較遲時在10月間會遭嚴重的冷害，會導致嚴重的減產，或因抽穗不結實，甚至不會抽穗。

總之，在沙國卡新省之盆地，要在一年當中，同一塊土地上要種植双期水稻，因受氣候之限制，是根本不可行者。但如在適期栽培高產NTU品種產量極高，且很安定。當地Amberbook品種宜在晚春至初夏種植，NTU即在春季種植爲宜。