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Timing of Nitrogen Applications for Rice Grown under Intermittent Flooding in the Coast of Peru[1]

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ABSTRACT

Seven timings of N applications of 180 kg N/ha as urea were tested on three rice varieties of different growth duration and plant type, in transplanted and direct seeding systems in a subtropical desert environment under conditions of alternate flooding and drying. Delaying basal or split applications until the panicle initiation stage increased grain yields by about 2000 kg/ha over applications at 0, 30 or 60 days after transplanting or direct seeding. In general, yields increased as N applications were delayed. Yield increases were related to a 25 per cent increase in the number of panicles/m², indicating that applications at the panicle initiation stage prevented the death of previously formed tillers. In spite of a growing season range of 125 to 228 days, no varietal differences in their response to timing were observed. Transplanting outyielded direct seeding due to suboptimal spacing of the latter. Under high nitrogen loss conditions caused by poor management, the optimum timing of nitrogen applications is substantially different from that recommended for constantly flooded situations.

Optimum water management in rice culture is normally understood as the maintenance of shallow flooding from the time the plants are able to survive it until a few weeks before harvest. Under such conditions, a basal application of an ammoniacal source of nitrogen incorporated in the topsoil before seeding or transplanting is usually sufficient to adequately supply the rice crop with N

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although in many circumstances optimum timing includes a second application broadcast at the panicle initiation stage (Evatt 1965 ; Matsushima 1965). Varietal differences in their response to timing exist and are related to their growth duration and lodging susceptibility (IRRI 1966, 1967 ; Sims *et al.* 1967 ; Hall *et al.* 1968).

Most of the timing-of-nitrogen-applications research on rice has been conducted under optimum water management. The vast majority of the world's rice area, however, depends on irregular rainfall or irrigation patterns which often cause several flooding and drying cycles during crop growth. Both soil and applied nitrogen losses are greatly accelerated under such conditions (Patrick & Wyatt 1964 ; Patrick *et al.* 1965). The northern coast of Peru is a high yielding rice area characterized by negligible rainfall, relatively low temperatures for its latitude (3 to 9°S), high solar radiation and fertile alkali soils. The tall, weak strawed and extremely late maturing rice varieties grown, usually receive a single broadcast application of 100 to 150 kg N/ha at about one month after transplanting. The recently introduced stiff-strawed varieties respond economically up to 320 kg N/ha (Sanchez & Calderon 1970a). The limited irrigation water supply is distributed in a way which prevents the maintenance of a constant flood and causes many flooding and drying cycles particularly at early growth stages when the valley's water table is relatively deep.

The result of over 14 years of experiments at the Lambayeque Agricultural Experiment Station (Calzada *et al.* 1959) suggest that delaying nitrogen applications until the panicle initiation stage has increased yields, although no explanations were supplied with the results.

EXPERIMENTAL

A direct seeding and a transplanted experiment were simultaneously established in adjacent fields at the Station farm in October, 1968 on a representative alluvial clay loam soil (pH 8.3, organic matter 1.7%, E.C. 1.0 mmho/cm., 17ppm Olsen P and 100ppm exch. K). A uniform rate of 180 kg N/ha as urea was applied at 0, 30 and 60 days after direct seeding or transplanting and at panicle initiation in 7 timing combinations to three rice varieties : the tall, weak-strawed extremely late maturing Minabir 2, (the main variety grown in Peru) ; the short, stiff strawed and medium late IR8, and the tall weak-strawed and early maturing Chiclayo variety. The experiments were arranged in a split plot design with four replications in 15 m^2 plots. Direct seeding was accomplished in rows 25 cm

apart with a seed rate of 96 kg/ha. Transplanting was spaced at 25 x 25 cm with six seedlings per hill. The basal application at seeding or transplanting was incorporated into dry or slightly puddled soil respectively. All topdressing applications were broadcast on a thin layer of water. The irrigation intervals averaged 8.5 days, most of which represented a full flooding and drying cycle. Planting dates were staggered in order for all treatments to reach their reproductive stage simultaneously. The different growth stages are shown in figure 1 plotted against the weather data which was considered better than average for Lambayeque. (Sanchez & Calderon 1970a). The growth durations varied from 125 to 228 days.

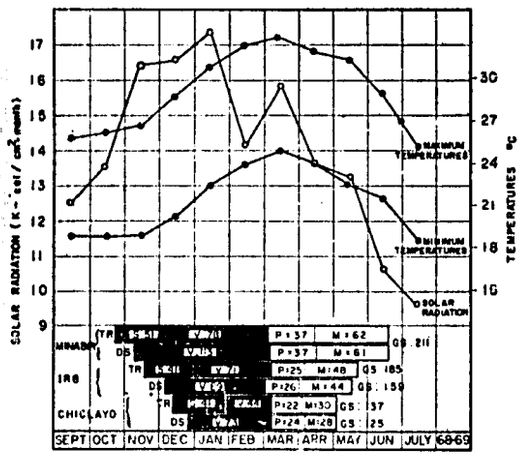

Fig. 1 Monthly weather summary in relation to the length (in days) of the different growth stages of variety-planting system treatment. TR: transplanted; DS: direct seeded; S: from seedbed seeding to transplanting; V: vegetative stage; P: from panicle initiation to 50% flowering; M: from 50% flowering to maturity; GS: total growth duration in days. Mean of 32 observation in days.

Plant height and tillering were determined at several growth stages. Dry matter and yield components from 4 hills or their direct seeding equivalent were chosen at random. Grain yields were obtained from a 5 m^2 central area and adjusted to 14% moisture. Plant nitrogen was determined according to the micro-Kjeldhal method.

RESULTS AND DISCUSSION

Grain yields are illustrated in figures 2 and 3 for each treatment. The planting system averages appear in table 1. Single or split appli-

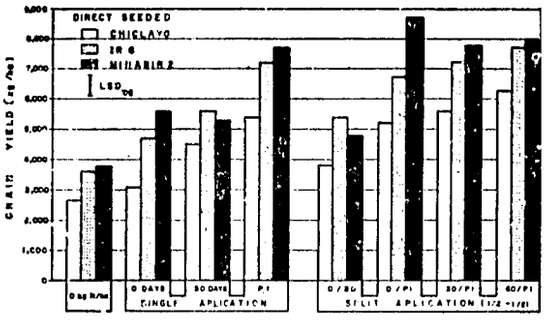

Fig. 2 Yield response to timing of N applications in three direct seeded rice varieties. Rate 180 kg N/ha. Mean of four replications.

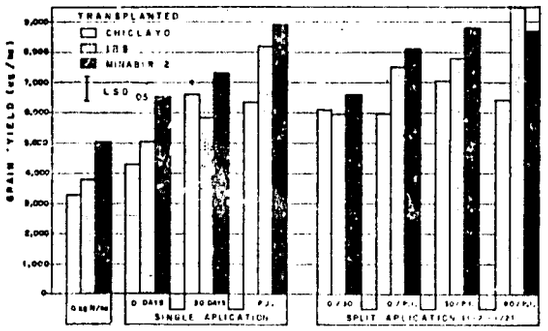

Fig. 3 Yield response to timing of N applications in three transplanted rice varieties. Rate: 180 kg N/ha. Mean of four replications.

cations at the panicle initiation stage significantly outyielded applications at earlier growth stages. The overall yield response for treatments with a single or split applications at the panicle initiation stage averaged 3703 kg/ha in contrast with earlier applications which averaged 1661 kg/ha. No significant differences were observed between single or split applications at the panicle initiation stage. The figures show a general trend with yields increasing as a result of delaying N applications. No varietal differences in their timing response were observed with the exception of the early maturing Chiclayo, where applications at 30 days produced similar results as at panicle initiation. Minabir 2 and IR8 performed similarly in spite of wide differences in plant type. Transplating outyielded direct seeding (Table 1) by an average of 1 ton/ha probably because of improper seeding density and spacing in the latter.

N uptake at harvest ranged from 34 kg N/ha in the check plots to a maximum of 107. The average by planting system, appearing in figure 4, shows a similar tendency as the grain yield data. The

TABLE 1

Influence of the time of N applications on grain yields, fertilizer efficiency and yield components. Mean of three varieties and four replications.
(TR : transplanting ; DS2 direct seeding ; PI : panicle initiation ; 0, 30, 60 : days after transplanting/seeding)

Time of N application (days)	Grain yield (kg/ha)		Efficiency kg rice/kg N		Panicles/m²		Filled grains per panicle		100 grain weight (g)	
	TR	DS	TR	DS	TR	DS	TR	DS	TR	DS
Check (no nitrogen)	4059	3314	—	—	216	339	96	73	3.15	3.03
All at 0	5286	4450	6.8	6.3	234	373	103	79	3.04	3.01
All at 30	6606	4953	14.2	9.1	275	407	107	76	3.15	3.04
All at P.I.	7936	6763	21.5	19.2	345	552	118	74	3.07	3.05
Half 0 ; half 30	6118	4671	11.4	7.5	261	390	114	72	3.10	3.04
Half 0 ; half P.I.	7218	6885	17.6	19.8	289	466	118	91	3.17	3.10
Half 30 ; half P.I.	7864	6910	21.1	20.0	326	464	125	88	3.15	3.11
Half 60 ; half P.I.	8194	7350	23.0	22.4	354	460	107	86	3.20	3.16
Av. Planting System	6659	5664	14.4	13.1	287	431	111	80	3.13	3.07
Av. Chiclayo variety	5810	4589	18.0	10.6	320	445	94	64	2.88	2.90
Av. IR8 variety	6681	6044	16.0	14.0	268	445	132	74	3.19	3.15
Av. Minabir 2 variety	7498	6364	13.5	14.6	273	404	108	102	3.32	3.16
LSD 0.05	845		4.7		65		23		0.18	
LSD 0.01	1110		6.2		86		30		0.25	
CV (%)	9.9		10.0		13.1		17.2		4.2	

apparent N recovery, calculated without using N^{15}, ranged from 7.7 to 29.6 per cent, with the applications at panicle initiation showing almost twice the recovery as earlier applications. Another measure of efficiency, kg rough rice/kg N added, appears in table 1 and also shows that applications at panicle initiation were about twice as efficient as previous ones. Although it is common to obtain higher fertilizer recovery with delayed applications (IRRI, 1969), it is not common to have these figures directly related to yields as in the case of these data.

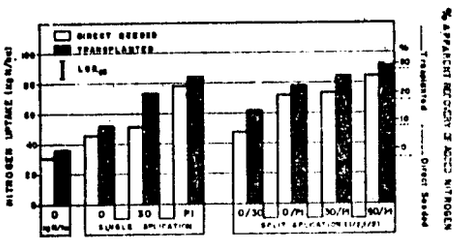

Fig. 4 Influence of timing N applications on N uptake at harvest and apparent recovery of added N. Mean of three varieties and four replications.

Yield components appear in table 1, with the exception of percentage sterility which was low and very uniform throughout the experiment due to favourable weather conditions. The number of panicles/m^2 in treatments with applications at the panicle initiation stage averaged 328 and 485 for transplanting and direct seeding, which represents a significant 25% increase over the average by earlier applications, 256 and 390 respectively. The number of filled grains per panicle and 100 grain weights were not significantly affected by timing treatments. These results indicate that the beneficial effect of delaying N applications until the panicle initiation stage is associated with a higher number of panicles/m^2 at harvest, which is totally contrary to the studies about timing of N applications in relation to yield components (Matsushima 1965). Fig. 5 shows the changes in tiller number at three growth stages for the Minabir 2—transplanted treatments. Although, as theory predicts, N applications at the tillering stage substantially increased tiller production, many of these tillers died at later stages probably because of N deficiency caused by the rapid N losses under alternate flooding and drying. Severe N deficiency symptoms were observed in such cases. Figure 5 shows that the applications at panicle initiation kept many of the previously produced tillers alive, which flowered and increased the panicle number component.

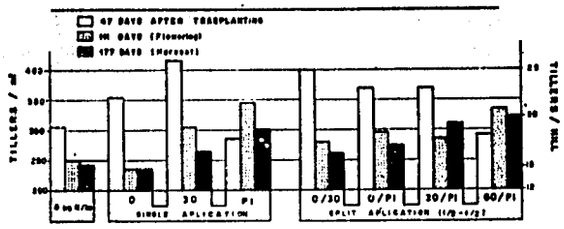

Fig. 5 Influence of timing of N applications on tiller production at different growth stages. Minabir 1, transplanted treatment. Mean of four replications.

The economic interpretation of these experiments using present market values in Peru and computed elsewhere (Sanchez & Calderon 1970b) indicates that with delaying N applications up to the panicle initiation stage, the benefit : cost ratio at the rate used was 9.7 : 1 or twice the profit than earlier applications which averaged 4.3 : 1.

The results have confirmed the previous Lambayeque work on the benefits of delaying N applications until the panicle initiation stage in order to maintain a large proportion of surviving tillers under field conditions of alternate wetting and drying. Since many soils may not have the high N supplying capacity of this one (35 kg N/ha), it is being recommended to farmers to split their applications at the beginning of tillering and at panicle initiation, but for those who insist on only one application, it should be at panicle initiation. This experiment also shows the extremely poor performance of basal applications properly incorporated into the soil before planting or transplanting. In order to improve local recommendations, timing schemes involving up to 5 frequencies of applications are being studied at different N rates. Although the specific results have only local value and may not be applicable to other intermittently flooded rice systems, the point that should be stressed is that the classic timing of N applications schemes developed under optimum water management conditions are probably irrelevant to the large majority of rice growing areas in the tropics.

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