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A Progress Report

AN EMPIRICAL ASSESSMENT OF ALTERNATE FIELD-LEVEL RICE POST-PRODUCTION SYSTEMS IN NUEVA ECIJA, PHILIPPINES

by

Z. Toquero, C. Maranan, L. Ebron and B. Duff

June 1976

· AGRICULTURAL ENGINEERING DEPARTMENT ·
THE INTERNATIONAL RICE RESEARCH INSTITUTE
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WORKING PAPERS

The Department of Agricultural Engineering at the International Rice Research Institute has undertaken a series of empirical studies designed to examine and assess the economic and technical characteristics of the rice post-production industry in the Philippines and other countries of Southeast Asia. As a part of this project, the department is issuing a series of preliminary working papers reporting the results of studies of selected aspects of the post-production industry. The papers listed below represent those which have been issued to date.

74-02 AE Zenaida Toquero and Bart Duff, "Survey of Post-Production Practices Among Rice Farmers in Central Luzon", IRRI Saturday Seminar, September 1974.

75-02 AE Zenaida Toquero, Bart Duff, Tessa A. Lacsina and Yujiro Hayami, "Estimating the Elasticities of Home Consumption and Marketable Surplus for a Subsistence Crop: Rice in the Philippines", (Separate versions appear in the American Journal of Agricultural Economics and the Philippine Economic Journal).

75-03 AE Zenaida Toquero, "A Survey of Rice Milling Practices in Central Luzon", IRRI Department of Agricultural Engineering, August 1975.

75-04 AE Bart Duff and Zenaida Toquero, "Factors Affecting the Efficiency of Mechanization in Farm Level Post-Production Systems", paper prepared for presentation at a Workshop on Farm Tenure and Mechanization, UPLB Center for Policy and Development Studies, July 1975.

76-02 AE Zenaida Toquero and Bart Duff, "A Profile of the Rice Post-Production Industry in Camarines Sur", paper prepared for presentation at a Regional Workshop on Rice Post-Production Technology sponsored by the National Grains Authority, National Food and Agriculture Council, Bicol River Basin Council, University of the Philippines at Los Baños, February 5-7, 1976, Naga City, Philippines.

A Progress Report

AN EMPIRICAL ASSESSMENT OF ALTERNATE FIELD-LEVEL RICE POST-PRODUCTION SYSTEMS IN NUEVA ECIJA, PHILIPPINES

Introduction

With increased field yields resulting from the use of improved varieties and cash inputs such as fertilizers, pesticides, herbicides and supplemental irrigation water, the magnitude and importance of quantitative field losses has also increased. The economic value of a 15 percent loss may seem relatively unimportant when yields are only 2 tons per hectare. A similar loss with a 5-ton yield is, however, of considerably greater significance.

The problem of determining the magnitude and source of losses in the post-production sequence of operations is an important and complex issue. The interdependency of operations, both at the field and processing stages of the post-production system, makes evaluation of discrete operations difficult and the results often inconclusive in pinpointing the nature and characteristics of such losses. The technique employed, the timing of each operation, and the environmental conditions under which they are carried out all contribute to the quality and quantity of paddy farmers ultimately sell or retain for home consumption. Harvesting, handling, threshing, drying and storage each conditions the size of the crop which is ultimately made available for consumption.

This report summarizes the results of a series of village-level trials undertaken in Central Luzon during the period from August 1975 to February 1976. The evidence presented is not comprehensive nor complete, but does illustrate the nature of the problem, presents some preliminary findings, and lists some of the difficulties encountered in attempting to measure the impact of alternative technologies on benefits and costs in post-production systems.

Objectives

The post-production field trials were confined to farm-level operations which affect the level of output and grain quality. In particular, attention was focused on the timing of harvest, the method of handling paddy, the method of threshing, and the technique of drying.

The objectives of the study were: a) to measure the magnitude of quantitative and qualitative losses which occur at each stage in the sequence of field operations using various systems of post-production technology and management, b) to compare the benefits resulting from improvements in individual operations within each system and, c) to evaluate and compare the overall technical and economic performance of each system. The field trials focused principally on threshing and drying, two operations which farmers had identified in earlier surveys as priority problems.1/

1/B. Duff and Z. Toquero, "Technical and Economic Factors Affecting the Efficiency of Post-Production Systems," Agricultural Engineering Dept., IRRI, 1975, 31 pp.

Methodology

Five systems involving alternative combinations of technology and management were utilized in the pilot trials. All five systems are described in fig. 1.

System I exemplifies the traditional technology commonly used by farmers throughout the study area. Threshing was entirely a manual operation with the operator using a threshing frame or "hampasan". Threshed paddy was then solar-dried prior to storage or milling. System I acted as a control against which results obtained from the other systems were compared.

In System II threshing was also performed manually, but a twin-bed batch dryer was used to remove moisture prior to storage. Under System III the IRRI-designed axial flow thresher was utilized immediately following harvest, although paddy was dried using traditional solar techniques.

In System IV paddy was threshed with the axial-flow thresher and subsequently dried in the twin-bed batch dryer. The same set of technology was used in System V but the paddy was harvested on three alternative dates to determine the effect of harvest date.

Depending on the minimum yield requirement per system, one or more fields were used in each post-production system. Systems I and V required a minimum of 10 cavans[2/] each while 25 cavans each were needed for Systems II, III and IV. When more than one field were needed for a particular system, every attempt was made to use only those with uniform variety and planting dates under one system.

[2/] One cavan weighs 50 kg.

The area of the field(s) selected for a given system were measured and identified with individual tags. Farm maps for all fields included in the trials were also prepared to serve as guide in planning each farm operation.

Crop-cut samples were taken in each post-production system to measure the potential yield at the field level. Further yield assessments were made following threshing (but before drying) and following drying to obtain actual area yields. Paddy samples were also taken at each stage of the operational sequence to determine changes in quality which occurred as a result of using particular treatments. These samples were subjected to a careful analysis at the National Grains Authority laboratory to determine paddy quality and milled rice characteristics resulting from each combination of techniques. All yield and weight measurements were corrected for moisture content and impurities.

Labor employed for each operation within individual systems, the costs incurred to perform each operation, and the time required to complete an entire sequence of operations were recorded. In addition, the quantitative and qualitative measurements necessary to impute relative benefits and costs for each system were also analyzed.

The threshers and dryers used in the experiment were purchased through an amendment to the Agrarian Reform Project Agreement for fiscal year 1975. Under this agreement, the United States Agency for International Development (USAID) provided a ₱100,000 grant fund to the Integrated Development Project of Nueva Ecija (IDP/NE) to be used to purchase threshers, dryers and other farm equipment. The IDP/NE was empowered to sell the quipment to Farmer Barrio Cooperatives (FBC) and

Samahang Nayon (SN). Arrangements were made to amortize the costs of the machines over a period of not more than 5 years at 8 percent annual rate of interest. Under the agreement between IDP/NE and the FBC/SN, 40 percent of the gross income derived from use of the equipment was to be applied toward amortization and 60 percent was to be retained by the FBC/SN to defray labor, fuel and maintenance costs, etc. The agreement provides that a fee of 5 sacks of paddy be charged for each 100 sacks threshed. This threshing fee is comparable to that charged by large commercial McCormick-type threshers (locally called "tilyadoras"). For drying, the fee was to be 4 percent of the total weight of paddy dried. The drying fee turned out to be unrealistic since high-moisture paddy requires more time and fuel to dry than low-moisture paddy. It was therefore felt that a graduated scale of drying charges based on initial moisture content would be a better alternative.

In addition to the above terms, the Samahang Nayon or Farmer Barrio Cooperative was also required to sign a promissory note and chattel mortgage.

Results

The field trials were initiated during the 1975 wet season harvest and continued through the dry season. Three villages in the province of Nueva Ecija were included in the project: Soledad, Sta. Rosa; Malapit, San Isidro; and Polilio, Cabanatuan City. Five farmer-cooperators were recruited from the Soledad Samahang Nayon, 6 from the Tagumpay Farmers Cooperative in San Isidro, and 4 farmer-members from the Samahang Nayon of Polilio (Table 1).

Labor requirements

Of the total manpower required in all post-production operations, 70 percent was used for harvesting, 23 percent for threshing, and 7 percent for drying.

Harvesting in this study covers the time required to cut and gather the paddy, including bundling and stacking in the field or along the road in preparation for threshing. Threshing is defined as the separation of the grain from the stalks. Under the traditional system (System I), threshing includes cleaning or winnowing to separate the grain from immature kernels and foreign materials. The time required for drying includes the handling of threshed paddy in preparation for drying, management of the drying system, and the collection and bagging of the dried materials.

The number of persons performing each operation and the net time required to complete the work were carefully recorded. Rest periods and breaks for snacks and meals were not included in computing the total man-hours utilized in each operation and/or system.

The total labor required to harvest, thresh and dry a hectare of paddy ranged from 133 to 421 man-hours (Table 2). On a per-ton basis, it ranged from 41 to 244 man-hours (Table 3). As expected, labor inputs were reduced considerably with the introduction of mechanical threshing in Systems III, IV and V. An average of only 32 m-h/ha or 12 m-h/t was utilized in mechanical threshing. In contrast, farmers using manual threshing methods required an average of 131 m-h/ha or 46 m-h/t.

In a similar though less significant way, the introduction of the batch dryer in Systems II, IV and V also reduced the amount of labor by

about one-half, both on a per-hectare and a per-ton basis. Using both the thresher and dryer in combination (as exemplified in Systems IV and V), reduced total labor requirements by one-half compared to the traditional system (System I).

The wide variability in total man-hour requirements among and within each of the three project sites was brought about by differences in land and labor productivity, the nature of traditional post-production practices and customs relating to labor use, the number and topography of field plots per system,[3] and local environmental conditions.

Labor productivity

The productivity of labor expressed in kilograms per man-hour or dollars per man-hour increased more than proportionally with the decrease in manpower requirements because there was a quantitative increase in output using the improved systems (Table 4). Increased yields resulting from use of improved techniques and their effect on post-production labor requirements bear directly on the importance of timeliness in post-production operations. The evidence from the pilot trials shows clearly that delays at any point in this sequence of operations increases loss, regardless of the techniques used. Although this issue is important under a single-cropping pattern, particularly during the wet-season harvest, it becomes even more critical as cropping systems are intensified. In intensified cropping, not only does the post-production system begin to act as a constraint but also the land preparation and planting operations for subsequent crops.

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[3] More labor was utilized in collecting and stacking paddy in systems involving more than one field at different elevations.

Grain loss

Through a series of crop-cut samples and yield data taken at various stages in each post-production system, it was possible to determine the nature of losses for individual elements of the system as well as the magnitude of such losses. A comparison of yield levels between systems at comparable stages permits the determination of the relative levels of technical efficiency for particular operations within each system. It also permitted an overall comparison between the performance and costs of each system.

Quantitative loss. Potential harvest yield was calculated using a series of 1-sq m crop-cuts replicated twice for all plots included in a given system. Threshing yield, on the other hand, was based on the weight of the cleaned paddy following threshing. Finally, drying yield was measured using the weight of the paddy after drying. All the yield and weight measurements were corrected for moisture content and impurities.

Table 5 shows the percent grain loss incurred for different post-production operations. The introduction of the axial-flow thresher saved an average of 2 to 11 percent in the amount of total paddy lost after threshing. This figure could have been higher had full cooperation and interest been obtained during the implementation of the experiment. In many instances, threshing was delayed for 2 to 4 days due to the unavailability of the thresher or the lack of funds to finance its operation. Moreover, unfavorable weather, particularly during the wet season harvest affected the timeliness of the threshing operation.

In the case of drying, data limitations resulting from minimal use of the batch dryer make statements regarding its effects very tentative

and inconclusive. Some farmer-cooperators sold their paddy immediately following threshing because of an immediate need for cash. Others did not dry their crop because they believed it was already suitable for sale. The reluctance to use the batch dryer was also due to the lack of suitable price and quality incentives for properly dried paddy. Moreover, good weather, especially during the dry season harvest, provided very little incentive for the cooperators to use the equipment outside the experiment.

Improved post-production technology (as practiced in System IV) exhibited lower total grain loss at all three field sites as compared to the traditional system (exemplified by System I). System V, which also employed mechanical threshing and drying, considered the effect of alternative harvest dates on quantitative and qualitative loss levels. It was hypothesized that paddy harvested at maturity would give the least loss compared to paddy harvested too early or too late. The results of the field trials were, however, contrary to our expectations. System V_a which was supposed to be harvested 5 days before maturity had the lowest grain loss ranging from 14 percent in Cabanatuan to 28 percent in Sta. Rosa. Conversely, System V_b which was harvested at maturity incurred the highest grain loss ranging from 22 percent in San Isidro to 43 percent in Sta. Rosa. One possible explanation was the degree of accuracy in estimating the date of maturity. It could be possible that the dates considered by the farmers to be too early or too late was actually the right time to harvest paddy. Moreover, the five days interval before and after maturity might be too short for a more effective and meaningful comparison.

Table 6 illustrates the relationship between elapsed time from harvesting through drying and grain yield.[4/] In general, grain loss rose with increases in the time interval between harvesting and threshing when the grain remains unthreshed or undried or both. More significant, however, are the yield differences between traditional systems and those which used either one or both improved methods of threshing and drying. Using a dryer in System II increased grain yield by 12 percent over System I. Similar increases in yield were found in System III from use of the mechanical thresher. System IV, which employed both the thresher and dryer in sequence, increased output the most. Variability was high in the observations from each system, largely because of failure to control all variables that affected the performance of the systems. Rain after harvest but before threshing often damaged the grain that was stacked or bundled in the field. Subsequent operations could do little to rectify these effects. Better scheduling of operations for all systems would have reduced losses by cutting the time interval between harvesting and drying.

Qualitative loss. Differences in the quality of grain from each post-production system are shown in Table 7. Although overall recovery of milled rice increased only 4 to 6 percent using the improved systems, the percentage of broken, fermented, discolored and immature grains was significantly reduced, particularly where the grain dryer was used. An inverse relationship was also observed between elapsed time from harvesting to final drying and the percentage of head rice recovery (see Table 6

[4/] Analysis was based only on 51 paddy samples because the qualitative analysis for the other samples were not yet completed as of this writing.

and 7). A total elapsed time of 4 days from harvesting to drying resulted to only 77 percent head rice recovery. This was exhibited by the traditional system employing manual threshing and solar drying. Conversely, systems with a total elapsed time of only 2 days (as exemplified by mechanical threshing and drying and a combination of mechanical threshing and solar drying) gave 90 and 91 percent head rice recovery respectively.

Economic Implications

A series of cost estimates depicting the relative expenses in each system based on observed labor, fuel, and fixed investment requirements were computed for each of the three villages as well as an average for all three locations, designated in the table as Nueva Ecija. Costs were expressed in terms of dollars per ton to incorporate the loss differentials between alternative systems. No attempt was made to ascribe increased value to improvements in quality that resulted from the use of the mechanical system, although this would accentuate the differences.

Two different cost estimates were considered in analyzing the traditional method of harvesting and threshing. One was based on contractual harvesting and threshing fee paid in sacks of paddy while the other was based on actual labor utilized using an imputed wage rate of ₱1/h ($0.14/h).

Cost estimates based on contract labor. Traditionally, harvesting and threshing were performed using a contract arrangement in which the same people perform both the harvesting and threshing operations. Labor was paid a proportion of the crop at a rate of 1/6 of the gross production. Cash costs, which included fuel and oil as well as machine depreciation increased appreciably with the introduction of threshers and dryers.

In terms of total cost, however, the expenditure per ton of paddy in the traditional system was almost twice that incurred using the improved systems (Table 8).

A comparison costs among the alternative post-production systems showed that mechanized threshing and solar drying had the lowest cost at $10/t. This figure, however, should not be taken at face value since the amount of labor utilized to solar dry a ton of paddy was seriously underestimated thereby resulting to very low imputed solar drying cost. This problem resulted because most farmers in the area never solar-dry paddy to a storage moisture content of 14 percent. In fact most farmers sold their paddy immediately following threshing without the benefit of drying. This development made observations on solar drying practices difficult and unreliable.

Similar cost behavior was shown in the individual cost estimates for different project sites (Tables 9, 10, and 11). Variation in the cost figures among the three villages was due to differences in the efficiency of operating and managing the equipment, variations in the cost of fuel and oil and differences in farm yields and local practices.

Total returns per ton were based on the amount of paddy recovered after adjusting for the degree of measured grain loss for each post-production system. A price for paddy of P1/kg or $0.14/kg was used in these computations.

System II, which employed manual threshing and mechanical drying obtained the lowest net return of $81/t in Sta. Roa, $70/t in Cabanatuan, or an average of $73/t for all sites designated as Nueva Ecija (Table 12). The traditional system (System I) which incurred the highest percent grain

loss had a slightly higher net return than System II because of the underestimated solar drying cost. Conversely, systems using threshers and dryers incurred the lowest percent grain losses and the highest returns ($99/t in San Isidro and $104/t in Cabanatuan). This observation was the same for all project sites with the exception of Sta. Rosa where problems in the timing of operations were encountered. Net returns for System IV could have been higher than what was computed since solar drying expenses in Systems I and III were seriously underestimated.

Cost estimates based on actual labor inputs. The value of labor for traditional harvesting and threshing was computed using the average man-hours required to perform individual operations at a wage rate of P1/h ($0.14/h). For Nueva Ecija, the average man-hours utilized in the different post-production operations were as follows: 43 m-h/t for harvesting, 40 m-h/t for manual threshing, 10 m-h/t for mechanical threshing, 7 m-h/t for solar drying and 3 m-h/t for mechanical drying. These labor requirements varied within and among the three project sites.

Cost figures when based on actual labor inputs for traditional harvesting and threshing were reduced to almost one-half as shown in Tables 8 and 13. This reduction in cost was partly due to lower labor cost for harvesting and threshing when imputed at a wage rate of P1/h or $0.14/h. Fees based on contractual harvesting and threshing were much higher than the regular wages harvesters and/or threshers would receive because of the additional responsibility assumed by them. Under the contractual arrangement, the harvesters and/or threshers take care of the crop right after transplanting until harvest. The gross output is then shared between the owner and the harvesters and threshers at a ratio of

1:6. Underestimation of labor required for traditional post-production operations, particularly that used for solar drying, contributed further to this reduction in total cost.[5/]

The above conditions resulted in a slightly higher total cost for the improved systems when compared to systems using traditional technology. These cost estimates were in contrast to those shown in Table 8. With the exception of cost estimates in Sta. Rosa, the other two project sites exhibited the same cost behavior as the average obtained for Nueva Ecija (Tables 14, 15, and 16). Cost estimates in Sta. Rosa showed slightly higher total post-production costs for the traditional system than for systems using the thresher and the dryer because of higher labor requirement for harvesting.

Table 17 provides the results of the benefit-cost analysis using an imputed wage for actual labor utilized in the post-production operations. The same total return values shown in Table 12 were used in this analysis.

With the exception of Sta. Rosa, the highest net benefits at each site were obtained from the system employing mechanical threshing and drying; $99/t in San Isidro and $104/t in Polilio. An overall average increase in net returns of $12/t was obtained from the introduction of thresher and dryer over that of the traditional system. The overall results also revealed that a higher net gain was obtained from the system using mechanical threshing and solar drying when compared to manual threshing and mechanical drying. Underestimation in labor required for solar drying effected this difference between the two systems.

[5/] This is a reflection of a previous observation that most farmers do not dry paddy to 14 percent moisture content before sale when using traditional method.

Summary and Conclusions

Pilot trials were implemented in three villages of Nueva Ecija to test the farm level efficiency of alternate techniques and systems of harvesting, handling, threshing, and drying.

Improved systems of post-production technology substantially reduced the labor required for threshing and drying. The introduction of the axial-flow thresher in Systems III, IV, and V reduced threshing labor by about 99 m-h/ha or 34 m-h/t (the manual method utilized 131 m-h/ha or 46 m-h/t while mechanized system used only 32 m-h/ha or 12 m-h/t). In a similar, though less significant way, the use of the batch dryer in Systems II, IV, and V reduced labor requirements by about one-half, both on a per hectare and a per ton basis.

Labor productivity expressed in kg/m-h or $/m-h increased more than proportionally with the decrease in manpower requirements because of the increase in output resulting from the use of the improved system. Increased yields and their effect on total labor requirements are also linked with the issue of timeliness in post-production operations. The results of the pilot trials indicate that delays at any point in the sequence of post-production operations increase losses, regardless of the techniques used. More efficient and timely operations significantly reduced grain loss (by 14 percent) and consequently increased post-harvest yields by as much as 12 percent. Moreover, the use of the dryer and thresher substantially improved the quality and quantity of milled rice.

Two different cost estimates were considered in analyzing tra-

ditional methods of harvesting and threshing. The first was based on a contractual harvesting and threshing fee paid in paddy while the second was based on actual labor utilized using an imputed wage rate of P1/h ($0.14/h). Using the contractual harvesting and threshing fee, a total cost of $14/t was obtained for the improved system. This was $11/5 lower than the cost incurred using the traditional method. In like manner, the improved system, which incurred the lowest grain loss, had the highest net return of $104/t compared to $74/t for the traditional system.

The other cost estimate was based on the observed level of labor used in each of the post-production operations. An underestimation in the amount of labor utilized for the solar drying operations resulted in lower drying cost for those systems employing solar drying.[6/] A cost comparison between traditional and improved post-production systems showed a slightly lower total cost of $12/t compared to $13/t in the mechanized system. Expressed in terms of net benefits, however, the system using the mechanical thresher and dryer had the highest net return of $104/t compared to only $86/t with the traditional system.

The above findings indicate that improved mechanical technologies have a quantitative and qualitative impact on total output through more timely operations and reduced unit costs. An increase in the time interval between harvesting and threshing during which paddy remains unthreshed or undried or both, was accompanied by a proportional increase in grain losses.

[6/] This is a reflection of an observation that most farmers do not dry paddy to 14 percent moisture content before sale when using the traditional method.

Variability was high for observations from each system, largely because of failure to control all variables that affect the performance of the systems. One uncontrolled factor was timeliness in the use of the thresher. Threshing was usually delayed for 2 to 4 days because of poor scheduling and lack of funds to operate and maintain the equipment. Fuel and oil were usually purchased only when they were needed, resulting in delays in post-production operations. The IRRI team often advanced money to ensure timeliness and continuity in the project. Delays in the collection of threshing and drying fees contributed partly to inadequate operating capital.[7/] Unfavorable weather, particularly during the wet season harvest also affected the timing of the threshing operation.

There was difficulty in encouraging farmers to dry paddy to a safe 14 percent moisture content. They claimed the crop was dry enough for sale or for milling. Most farmers sold their paddy immediately after threshing to generate cash. Unfortunately, this was often before a complete record of the post-harvest operation was taken.

Finally, promoting use of the twin-bed batch dryer proved difficult. Farmers believe solar drying is still the most economical, if not the best method of drying. The problem was further aggravated by the lack of suitable price and quality incentives for properly dried paddy. The generally good weather condition in the area, particularly during the dry season, further contributed to the unpopularity of the batch dryer.

[7/] Fees were usually collected long after the operation was completed and when the paddy has already been sold by the farmer.

Table 1. Characteristics of three villages used in post-production pilot trials, Philippines, 1975-76.

Location	Season	Cooperators (no.)	Plots (no.)	Area (sq m/plot)	Yield[a] (t/ha)	Rices
						IR20
						IR26
Soledad, Sta. Rosa	Wet	5	80	771.4	3.3	IR1529
						IR1561
						IR26
						IR30
Malapit, San Isidro	Wet	6	46	1423.2	3.6	IR579
						IR1529
						IR1561
						IR26
Polilio, Cabanatuan	Dry	4	42	1242.3	3.1	IR30
						C4-63G
Total/average		15	168	1081.3	3.3	

[a] Final paddy weight after drying and adjusting for purity at 14% moisture content.

Table 2. Labor requirements per hectare using alternate post-production systems in three pilot areas, Nueva Ecija, 1975-76.

Item	Post-Production Systems[a]						
	I	II	III	IV	V_A	V_B	V_C
Labor requirement per hectare:			(m-hr/ha)				
Nueva Ecija (All sites)							
Harvesting[b]	139	144	136	142	136	128	139
Threshing	131	132	30	38	30	34	28
Drying	22	10	24	10	12	13	21
Total	292	286	190	190	178	175	188
Soledad, Sta. Rosa							
Harvesting	204	179	154	141	136	141	125
Threshing	164	127	28	28	24	28	21
Drying	53	8	43	7	9	12	24
Total	421	314	225	176	169	181	170
Malapit, San Isidro							
Harvesting	128	129	132	135	126	137	118
Threshing	140	150	37	58	38	50	36
Drying	18	12	23	12	14	16	16
Total	286	291	192	205	178	203	170
Polilio, Cabanatuan City							
Harvesting	110	126	116	152	149	96	175
Threshing	99	119	23	24	30	26	27
Drying	16	10	20	10	14	11	23
Total	225	255	159	186	193	133	225

[a] See text for description of alternative systems.

[b] Harvesting includes cutting, bundling, hauling and stacking of paddy ready for threshing.

Table 3. Labor requirements per ton using alternate post-production systems in three pilot areas, Nueva Ecija, 1975-76.

Item	Post-Production Systems[a]						
	I	II	III	IV	V_A	V_B	V_C
Labor requirement per hectare:	(m-hr/t)[b]						
Nueva Ecija (All sites)							
Harvesting[c]	49	51	55	40	52	51	54
Threshing	46	47	12	10	12	14	11
Drying	7	3	7	3	4	5	7
Total	102	101	74	53	68	70	72
Soledad, Sta. Rosa							
Harvesting	95	86	198	40	80	84	73
Threshing	76	61	36	9	14	17	12
Drying	12	2	10	2	5	6	11
Total	183	149	244	51	99	107	96
Malapit, San Isidro							
Harvesting	39	38	35	35	38	42	42
Threshing	43	44	10	15	2	15	13
Drying	5	4	6	3	4	5	4
Total	87	86	51	53	44	62	59
Polilio, Cabanatuan City							
Harvesting	40	43	40	47	49	30	55
Threshing	36	41	8	7	10	8	9
Drying	6	3	7	3	4	3	7
Total	82	87	55	57	63	41	71

[a] See text for description of alternative systems.

[b] Based on the final dried weight of paddy adjusted for purity and 14% MC.

[c] Harvesting includes cutting, bundling, hauling and stacking of paddy ready for threshing.

Table 4. Labor requirements and labor productivity using alternative post-production systems, Nueva Ecija, 1975-76.

	Post-production system	Yield[a] (t/ha)	Total labor requirement (m-hr/ha)	Labor productivity (kg/m-hr)	Labor productivity ($/m-hr)[b]
I.	Manual threshing & solar drying	3.3	291.7	10.0	1.4
II.	Manual threshing & mechanical drying	3.3	286.9	10.0	1.4
III.	Mechanical threshing & solar drying	3.6	189.7	18.8	2.7
IV.	Mechanical threshing and drying	3.6	189.2	19.1	2.7
V_A	Harvest 5 days before maturity	2.8	179.1	15.0	2.1
V_B	Harvest at maturity	2.8	175.9	14.7	2.1
V_C	Harvest 5 days after maturity	3.0	188.9	14.0	2.0

[a] Based on the final dry weight of paddy adjusted for purity and 14% moisture content.

[b] Paddy is valued at ₱1/kg ($0.14/kg).

Table 5. Percent grain loss in alternate post-production systems by site and operation, Nueva Ecija, 1975.

Item	Post-Production Systems[a]						
	I	II	III	IV	V_A	V_B	V_C
Grain loss by operation and area			percent				
Nueva Ecija (all sites)							
Harvesting to threshing	23	24	18	15	13	23	21
Threshing to drying	6	5	3	6	5	8	1
Total loss	29	29	21	21	18	31	22
Soledad, Sta. Rosa							
Harvesting to threshing	7	19	8	9	13	23	27
Threshing to drying	16	4	3	11	15	20	2
Total loss	23	23	11	20	28	43	29
Malapit, San Isidro							
Harvesting to threshing	29	23	22	19	13	17	16
Threshing to drying	1	1	3	2	5	5	2
Total loss	30	24	25	21	18	22	18
Polilio, Cabanatuan City							
Harvesting to threshing	30	29	26	15	13	28	19
Threshing to drying	1	2	1	3	1	2	b/
Total loss	31	31	27	18	14	30	19

a/ See text for description of alternative systems.

b/ Less than one percent.

Table 6. Relationships between elapsed time from harvesting to drying, grain loss and yield for laternate post-production systems, Nueva Ecija, 1975-76.

Item	Post-Production Systems			
	Manual threshing and solar drying	Manual threshing & mechanical drying	Mechanical threshing & solar drying	Mechanical threshing and drying
Elapsed time by operation (days)				
harvest to thresh	1	1	0	0
thresh to dry	1	0	2	2
harvest to dry	4	1	2	2
Percent grain loss (%)				
harvest to thresh	11.0	11.8	1.7	2.5
thresh to dry	15.3	1.2	11.4	8.2
harvest to dry	24.6	12.9	12.9	10.5
Yield per hectare (kg/ha)				
harvesting	3307	4088	4873	3929
threshing	2944	3605	4788	3831
drying	2492	3561	4244	3517

Table 7. Quality characteristics for milled rice from alternative post-production systems, 51 paddy samples, sixteen plots, Philippines, 1975.

System	Quality characteristics (%)			
	Head rice	Broken rice	Milling Recovery	
			Brown rice	Milled rice
Manual threshing and solar drying	77.4	20.2	63.0	59.3
Manual threshing and mechanical drying	84.5	14.1	67.4	63.4
Mechanical threshing and solar drying	90.6	818	70.5	65.6
Mechanical threshing and drying	89.9	9.2	68.4	64.4

Table 8. Cost estimates for alternate post-production systems, Nueva Ecija, 1975-76.

Expense	System: Manual threshing and solar drying	Manual threshing & Mechanical drying	Mechanical threshing & solar drying	Mechanical threshing and drying
	$/t (₱/t)[a]			
Harvesting expense				
Cash[b]			-	-
Non-cash[c]			6.14 (43.00)	6.14 (43.00)
Sub-total			6.14 (43.00)	6.14 (43.00)
Threshing expense				
Cash	23.81 (166.67)	23.81 (166.67)	1.86 (13.02)	1.86 (13.02)
Non-cash			1.43 (10.00)	1.43 (10.00)
Sub-total			3.29 (23.02)	3.29 (23.02)
Drying expense				
Cash	-	3.97 (27.77)	-	3.97 (27.77)
Non-cash	1.0 (7.00)	0.43 (3.00)	1.0 (7.00)	0.43 (3.00)
Sub-total	1.0 (7.00)	4.40 (30.77)	1.0 (7.00)	4.40 (30.77)
Total Post-Production expense				
Cash	-	3.97 (27.77)	1.86 (13.02)	5.83 (40.79)
Non-cash	24.81 (173.67)	24.24 (169.67)	8.57 (60.00)	8.00 (56.00)
Total	24.81 (173.67)	28.21 (197.44)	10.43 (73.02)	13.83 (96.79)

[a] Based on an exchange rate of $1 = ₱7.

[b] Includes the cost of fuel and oil and the depreciation of the machine.

[c] Cost of labor usually paid in kind.

Table 9. Cost estimates for alternate post-production systems, Soledad, Sta. Rosa, 1975-76.

Expense	System: Manual threshing and solar drying	Manual threshing & mechanical drying	Mechanical threshing & solar drying	Mechanical threshing and drying
	$/t (₱/t)[a]			
Harvesting expense				
Cash[b]			-	-
Non-cash[c]			8.00 (56.00)	8.00 (56.00)
Sub-total			8.00 (56.00)	8.00 (56.00)
Threshing expense	23.81 (166.67)	23.81 (166.67)		
Cash			1.79 (12.52)	1.79 (12.52)
Non-cash			1.29 (9.00)	1.29 (9.00)
Sub-total			3.08 (21.52)	3.08 (21.52)
Drying expense				
Cash	-	4.41 (30.89)	-	4.41 (30.89)
Non-cash	1.57 (11.00)	0.29 (2.00)	1.57 (11.00)	0.29 (2.00)
Sub-total	1.57 (11.00)	4.70 (32.89)	1.57 (11.00)	4.70 (32.89)
Total Post-Production Expense				
Cash	-	4.41 (30.89)	1.79 (12.52)	6.20 (43.41)
Non-cash	25.38 (177.67)	24.10 (168.67)	10.86 (76.00)	9.58 (67.00)
Total	25.38 (177.67)	28.51 (199.56)	12.65 (88.52)	15.78 (110.41)

[a] Based on an exchange rate of $1 = ₱7.

[b] Includes the cost of fuel and oil and the depreciation of the machine.

[c] Cost of labor usually paid in kind.

Table 10. Cost estimates for alternate post-production systems, Malapit, San Isidro, 1975-76.

Expense	System: Manual threshing and solar drying	Manual threshing & mechanical drying	Mechanical threshing & solar drying	Mechanical threshing and drying
	$/t (₱/t)[a]			
Harvesting expense				
Cash[b]			-	-
Non-cash[c]			5.28 (37.00)	5.28 (37.00)
Sub-total			5.28 (37.00	5.28 (37.00)
Threshing expense	23.81 (166.67)	23.81 (166.67)		
Cash			1.97 (13.80)	1.97 (13.80)
Non-cash			1.86 (13.00)	1.86 (13.00)
Sub-total			3.83 (26.80)	3.83 (26.80)
Drying expense				
Cash	-	3.74 (26.19)	-	3.74 (26.19)
Non-cash	0.86 (6.00)	0.57 (4.00)	0.86 (6.00)	0.57 (4.00)
Sub-total	0.86 (6.00)	4.31 (30.19)	0.86 (6.00)	4.31 (30.19)
Total post-production expense				
Cash	-	3.74 (26.19)	1.97 (13.80)	5.71 (39.99)
Non-cash	24.67 (172.67)	24.38 (170.67)	8.00 (56.00)	7.71 (54.00)
Total	24.67 (172.67)	28.12 (196.86)	9.97 (69.80)	13.42 (93.99)

[a] Based on an exchange rate of $1 = ₱7.

[b] Includes the cost of fuel and oil and the depreciation of the machine.

[c] Cost of labor usually paid in kind.

Table 11. Cost estimates for alternate post-production systems, Polilio, Cabanatuan, 1975-76.

Expense	System: Manual threshing and solar drying	Manual threshing & mechanical drying	Mechanical threshing & solar drying	Mechanical threshing and drying
	$/t (₱/t)[a]			
Harvesting expense				
Cash[b]			-	-
Non-cash[c]			5.86 (41.00)	5.86 (41.00)
Sub-total			5.86 (41.00)	5.86 (41.00)
Threshing expense	23.81 (166.67)	23.81 (166.67)		
Cash			1.79 (12.55)	1.79 (12.55)
Non-cash			1.14 (8.00)	1.14 (8.00)
Sub-total			2.93 (20.55)	2.93 (20.55)
Drying expense				
Cash	-	3.78 (26.44)	-	3.78 (26.44)
Non-cash	0.86 (6.00)	0.57 (4.00)	0.86 (6.00)	0.57 (4.00)
Sub-total	0.86 (6.00)	4.35 (30.44)	0.86 (6.00)	4.35 (30.44)
Total post-production expenses				
Cash	-	3.78 (26.44)	1.79 (12.55)	5.57 (38.99)
Non-cash	24.67 (172.67)	24.38 (170.67)	7.86 (55.00)	7.57 (53.00)
Total	24.67 (172.67)	28.16 (197.11)	9.65 (67.55)	13.14 (91.99)

[a] Based on an exchange rate of $1 = ₱7.

[b] Includes the cost of fuel and oil and the depreciation of the machine.

[c] Cost of labor usually paid in kind.

Table 12. Estimated costs and returns for alternate post-production systems, Nueva Ecija, 1975-76.

Item	I Manual threshing and solar drying	II Manual threshing & mechanical drying	III Mechanical threshing & solar drying	IV Mechanical threshing and drying
		$/t (P/t)		
Nueva Ecija (All sites)				
Returns	101.43 (710.00)	101.43 (710.00)	112.86 (790.00)	112.86 (790.00)
Costs	24.81 (173.67)	28.21 (197.44)	10.43 (73.02)	13.83 (96.79)
Net return	76.62 (536.33)	73.22 (512.56)	102.43 (716.98)	99.03 (693.21)
Sta. Rosa				
Returns	110.00 (770.00)	110.00 (770.00)	127.14 (890.00)	114.29 (800.00)
Costs	25.38 (177.67)	28.51 (199.56)	12.65 (88.52)	15.78 (110.41)
Net return	84.62 (592.33)	81.49 (570.44)	114.49 (801.48)	98.51 (689.59)
San Isidro				
Returns	100.00 (700.00)	108.57 (760.00)	107.14 (750.00)	112.86 (790.00)
Costs	24.67 (172.67)	28.12 (196.86)	9.97 (69.80)	13.42 (93.99)
Net return	75.33 (527.33)	80.45 (563.14)	97.17 (680.20)	99.44 (696.01)
Cabanatuan				
Returns	98.57 (690.00)	98.57 (690.00)	104.29 (730.00)	117.14 (820.00)
Costs	24.67 (172.67)	28.16 (197.11)	9.65 (67.55)	13.14 (91.99)
Net return	73.90 (517.33)	70.41 (492.89)	94.64 (662.45)	104.00 (728.01)

Note:

Returns have been adjusted using the observed figures on percent grain loss to adjust yield for each system by area. The price of paddy used was P1/kg ($0.14/kg).

Cost in the first two systems was based on the contractual payment for the harvesting and threshing operations.

Table 13. Cost estimates for alternate post-production systems, Nueva Ecija, 1975-76.

Expense	System			
	Manual threshing and solar drying	Manual threshing & mechanical drying	Mechanical threshing & solar drying	Mechanical threshing and drying
	$/t (P/t)[a]			
Harvesting expense				
Cash[b]	-	-	-	-
Non-cash[c]	6.14 (43.00)	6.14 (43.00)	6.14 (43.00)	6.14 (43.00)
Sub-total	6.14 (43.00)	6.14 (43.00)	6.14 (43.00)	6.14 (43.00)
Threshing expense				
Cash	-	-	1.86 (13.02)	1.86 (13.02)
Non-cash	5.71 (40.00)	5.71 (40.00)	1.43 (10.00)	1.43 (10.00)
Sub-total	5.71 (40.00)	5.71 (40.00)	3.29 (23.02)	3.29 (23.02)
Drying expense				
Cash	-	3.97 (27.77)	-	3.97 (27.77)
Non-cash	1.00 (7.00)	0.43 (3.00)	1.00 (7.00)	0.43 (3.00)
Sub-total	1.00 (7.00)	4.40 (30.77)	1.00 (7.00)	4.40 (30.77)
Total post-production expense				
Cash	-	3.97 (27.77)	1.86 (13.02)	5.83 (40.79)
Non-cash	12.85 (90.00)	12.28 (86.00)	8.57 (60.00)	8.00 (56.00)
Total	12.85 (90.00)	16.25 (113.77)	10.43 (73.02)	13.83 (96.79)

[a] Based on an exchange rate of $1 = P7.

[b] Includes the cost of fuel and oil and the depreciation of the machine.

[c] Cost of labor usually paid in kind.

Table 14. Cost estimates for alternate post-production systems, Sta. Rosa, Nueva Ecija, 1975-76.

Expense	System: Manual threshing & solar drying		Manual threshing & mechanical drying		Mechanical threshing & solar drying		Mechanical threshing and drying	
	$/t (₱/t)[a]							
Harvesting expense								
Cash[b]	-		-		-			
Non-cash[c]	8.00	(56.00)	8.00	(56.00)	8.00	(56.00)	8.00	(56.00)
Sub-total	8.00	(56.00)	8.00	(56.00)	8.00	(56.00)	8.00	(56.00)
Threshing expense								
Cash	-		-		1.79	(12.52)	1.79	(12.52)
Non-cash	9.29	(65.00)	9.29	(65.00)	1.29	(9.00)	1.29	(9.00)
Sub-total	9.29	(65.00)	9.29	(65.00)	3.08	(21.52)	3.08	(21.52)
Drying expense								
Cash	-		4.41	(30.89)	-		4.41	(30.89)
Non-cash	1.57	(11.00)	0.29	(2.00)	1.57	(11.00)	0.29	(2.00)
Sub-total	1.57	(11.00)	4.70	(32.89)	1.57	(11.00)	4.70	(32.89)
Total post-production expense								
Cash	-		4.41	(30.89)	1.79	(12.52)	6.20	(43.41)
Non-cash	18.86	(132.00)	17.58	(123.00)	10.86	(76.00)	9.58	(67.00)
Total	18.86	(132.00)	21.99	(153.89)	12.65	(88.52)	15.78	(110.41)

[a] Based on an exchange rate of $1 = ₱7.

[b] Includes the cost of fuel and oil and the depreciation of the machine.

[c] Cost of labor usually paid in kind.

Table 15. Cost estimate for alternate post-production systems, San Isidro, Nueva Ecija, 1975-76.

Expense	System			
	Manual threshing and solar drying	Manual threshing & mechanical drying	Mechanical threshing & solar drying	Mechanical threshing and drying
	$/t (₱/t)[a]			
Harvesting expense				
Cash[b]	-	-	-	-
Non-cash[c]	5.28 (37.00)	5.28 (37.00)	5.28 (37.00)	5.28 (37.00)
Sub-total	5.28 (37.00)	5.28 (37.00)	5.28 (37.00)	5.28 (37.00)
Threshing expense				
Cash	-	-	1.97 (13.80)	1.97 (13.80)
Non-cash	6.29 (44.00)	6.29 (44.00)	1.86 (13.00)	1.86 (13.00)
Sub-total	6.29 (44.00)	6.29 (44.00)	3.83 (26.80)	3.83 (26.80)
Drying expense				
Cash	-	3.74 (26.19)	-	3.74 (26.19)
Non-cash	0.86 (6.00)	0.57 (4.00)	0.86 (6.00)	0.57 (4.00)
Sub-total	0.86 (6.00)	4.31 (30.19)	0.86 (6.00)	4.31 (30.19)
Total post-production expense				
Cash	-	3.74 (26.19)	1.97 (13.80)	5.71 (39.99)
Non-cash	12.43 (87.00)	12.14 (85.00)	8.00 (56.00)	7.71 (54.00)
Total	12.43 (87.00)	15.88 (111.19)	9.97 (69.80)	13.42 (93.99)

[a] Based on an exchange rate of $1 = ₱7.

[b] Includes the cost of fuel and oil and the depreciation of the machine.

[c] Cost of labor usually paid in kind.

Table 16. Cost estimates for alternate post-production systems, Cabanatuan, Nueva Ecija, 1975-76.

Expense	System			
	Manual threshing and solar drying	Manual threshing & mechanical drying	Mechanical threshing & solar drying	Mechanical threshing and drying
	$/t (P/t)[a]			
Harvesting expense				
Cash[b]	-	-	-	-
Non-cash[c]	5.86 (41.00)	5.86 (41.00)	5.86 (41.00)	5.86 (41.00)
Sub-total	5.86 (41.00)	5.86 (41.00)	5.86 (41.00)	5.86 (41.00)
Threshing expense				
Cash	-	-	1.79 (12.55)	1.79 (12.55)
Non-cash	5.43 (38.00)	5.43 (38.00)	1.14 (8.00)	1.14 (8.00)
Sub-total	5.43 (38.00)	5.43 (38.00)	2.93 (20.55)	2.93 (20.55)
Drying expense				
Cash	-	3.78 (26.44)	-	3.78 (26.44)
Non-cash	0.86 (6.00)	0.57 (4.00)	0.86 (6.00)	0.57 (4.00)
Sub-total	0.86 (6.00)	4.35 (30.44)	0.86 (6.00)	4.35 (30.44)
Total post-production expense				
Cash	-	3.78 (26.44)	1.79 (12.55)	5.57 (38.99)
Non-cash	12.15 (85.00)	11.86 (83.00)	7.86 (55.00)	7.57 (53.00)
Total	12.15 (85.00)	15.64 (109.44)	9.65 (67.55)	13.14 (91.99)

[a] Based on an exchange rate of $1 = P7.

[b] Includes the cost of fuel and oil and the depreciation of the machine.

[c] Cost of labor usually paid in kind.

Table 17. Estimated costs and returns for alternate post-production systems, Nueva Ecija, 1975-76.

Item	I Manual threshing and solar drying	II Manual threshing & mechanical drying	III Mechanical threshing & solar drying	IV Mechanical threshing and drying
		$/t (₱/t)		
Nueva Ecija (All sites)				
Returns	101.43 (710.00)	101.43 (710.00)	112.86 (790.00)	112.86 (790.00)
Costs	12.85 (90.00)	16.25 (113.77)	10.43 (73.02)	13.83 (96.79)
Net return	88.58 (620.00)	85.18 (596.23)	102.43 (716.98)	99.03 (693.21)
Sta. Rosa				
Returns	110.00 (770.00)	110.00 (770.00)	127.14 (890.00)	114.29 (800.00)
Costs	18.86 (132.00)	21.99 (153.89)	12.65 (88.52)	15.78 (110.41)
Net return	91.14 (638.00)	88.01 (616.11)	114.49 (801.48)	98.51 (689.59)
San Isidro				
Returns	100.00 (700.00)	108.57 (760.00)	107.14 (750.00)	112.86 (790.00)
Costs	12.43 (87.00)	15.88 (111.19)	9.97 (69.80)	13.42 (93.99)
Net return	87.57 (613.00)	92.69 (648.81)	97.17 (680.20)	99.44 (696.01)
Cabanatuan				
Returns	98.57 (690.00)	98.57 (690.00)	104.29 (730.00)	117.14 (820.00)
Costs	12.15 (85.00)	15.64 (109.44)	9.65 (67.55)	13.14 (91.99)
Net return	86.42 (605.00)	82.93 (580.56)	94.64 (662.45)	104.00 (728.01)

Note:

Returns have been adjusted to reflect the quantity of paddy recovered after deducting grain loss incurred for each system at each project site.

Cost estimates for the first two post-production systems have been based on the amount of labor required to perform each operation with an imputed wage of ₱1/m-hr ($0.14/m-hr) which is the prevailing wage rate in the area.

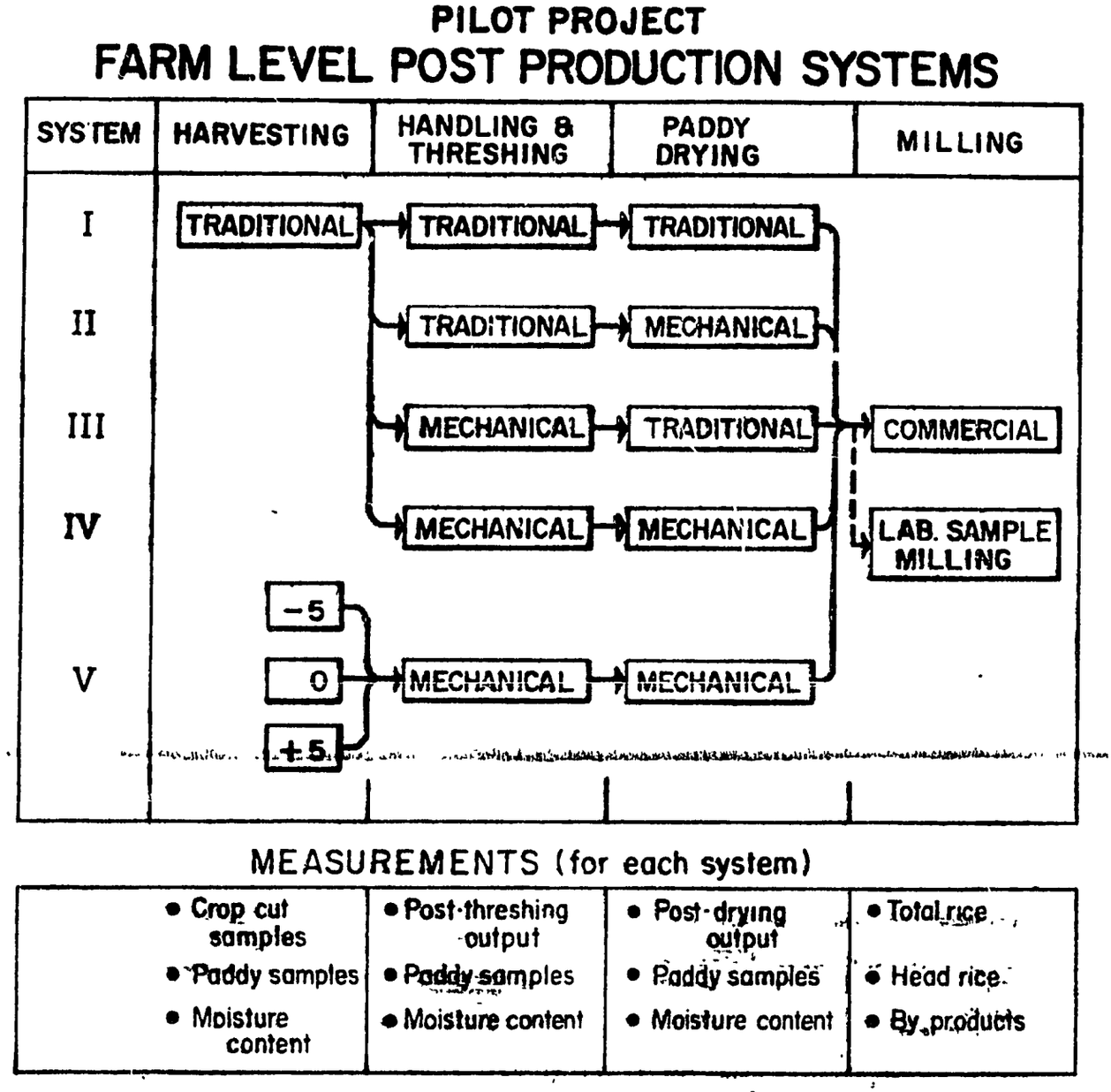

Fig. 1. Farm level post-production systems.