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CHANGES IN INPUT USE AND GRAIN YIELDS IN LOWLAND RICE FARMS IN THREE PHILIPPINE PROVINCES

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CHANGES IN INPUT USE AND GRAIN YIELDS IN LOWLAND RICE FARMS IN THREE PHILIPPINE PROVINCES[1]

ABSTRACT

Modern rice technology and more irrigation are expected to change rice farming systems and increase production. This paper discusses changes in farmer use and management of inputs, adoption of improved technology, and varying grain yields in Nueva Ecija, Laguna, and Camarines Sur provinces of the Philippines from 1974 to 1982. Those changes are compared with predetermined high input levels chosen to estimate potential farm yields.

Farmers applied more fertilizer N in dry season (DS) and application rate generally increased over time. Foliar insecticides were more commonly used than granular formulations.

Farmers' yields in the study areas rose as fertilizer use increased. From 1974 to 1980, the yield gap in Laguna decreased from 2.6 to 0.6 t/ha in DS and from 2.0 t/ha to zero in wet season (WS).

In Nueva Ecija and Camarines Sur, the contribution of high fertilizer levels to DS and WS yield gaps increased with time. Fertilizer contribution in Laguna decreased in DS. In WS it increased from 1974 to 1977, then decreased.

Results indicate that farmers increased grain yields by adopting and improving farm-level technology.

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CHANGES IN INPUT USE AND GRAIN YIELDS IN LOWLAND RICE FARMS IN THREE PHILIPPINE PROVINCES

Modern rice technology and better irrigation have increased rice yields and production in the Philippines and other Asian countries. In 1966, when IR8 and other improved technologies were introduced, average yield in the Philippines was 1.3 t/ha. It was 2.3 t/ha in 1981. However, that increase does not reflect the yield potential researchers achieved with the same technology in farmer fields, resulting in a yield gap. De Datta et al (1979) wrote that in Nueva Ecija, the yield gap was 2.0 t/ha in DS and 1.0 t/ha in WS. A very large yield gap is, however, subject to scrutiny. In general, farmers try to maximize profits instead of yield.

In any country, some farmers hesitate to shift to modern rice farming techniques, but others rapidly adopt technological advances. Farmers in two irrigated villages in Nueva Ecija began accepting modern varieties (MVs) sooner than farmers in a nearby rainfed village (IRRI 1975), but within 4 yr farmers had adopted them. In Leyte and Cotabato, rapid adoption of MVs was accompanied by sharply rising insecticide and herbicide use. However, fertilizer application rate and yields remained low. Huke et al (1982) reported that in one village in Tarlac Province, adoption of modern rice farming techniques was rapid and produced striking economic changes. Morooka et al (1979) reported that after land reform and technological changes, some Camarines Sur farmers began to change their production system from *aliwalas* (a traditional system where rice is transplanted and harvested with very little during-crop cultivation) to intensive year-round rice farming.

This paper summarizes data from farm-level constraints research conducted by IRRI Agronomy, Agricultural Economics, Statistics, and Irrigation and Water Management Departments from 1974 to 1982 in Nueva Ecija, Laguna, and Camarines Sur. We sought to examine changes in farmer use and management of inputs, record the extent of adoption of modern rice technology and quantify its effect on rice yields, and determine if adoption of modern rice technology has narrowed the yield gap in farmer fields.

PROCEDURE

The concepts and approaches in the identification and quantification of the major yield constraints at the farm level were discussed by Gomez 1977, De Datta et al 1979, Gomez et al 1979, and De Datta 1981.

We used three sets of treatments in complete factorial, minifactorial, and supplemental trials to quantify yield gap. Complete factorial trials consisted of treatments equal to 2^n, where n is the number of test factors. Minifactorial trials consisted of treatments equal to two more than the number of factors being tested: one treatment with all factors at high level, one with all factors at farmer level, and others with each having all-but-one factor at the high level. Supplemental trials had a minimum of one plot with all factors at high level. Farmer yields were measured by crop-cutting.

Test factors were fertilizer, and insect and weed control. The two levels of each factor were tested in factorial combinations. The high level of each factor was established before the experiment began. The farmer level was determined by observing actual farmer operations throughout the growing season. This is the *comparable paddy* technique. All management and cultural practices but the test factors were standard farmer practice. Farmer input levels and practices were recorded and carefully simulated.

The experiments were in farmer fields, and a researcher lived in each study area to carefully monitor cultural practices and farm conditions.

The farmer selection procedure placed farmers in low, medium, and high yielding groups, based on data collected in the preliminary survey. An equal number of farmers was selected from each group.

To obtain a study area with uniform agroclimatic conditions and a manageable number of test sites, a small area and few sites were chosen. These sites, therefore, may not adequately represent the diverse farming conditions in the test provinces.

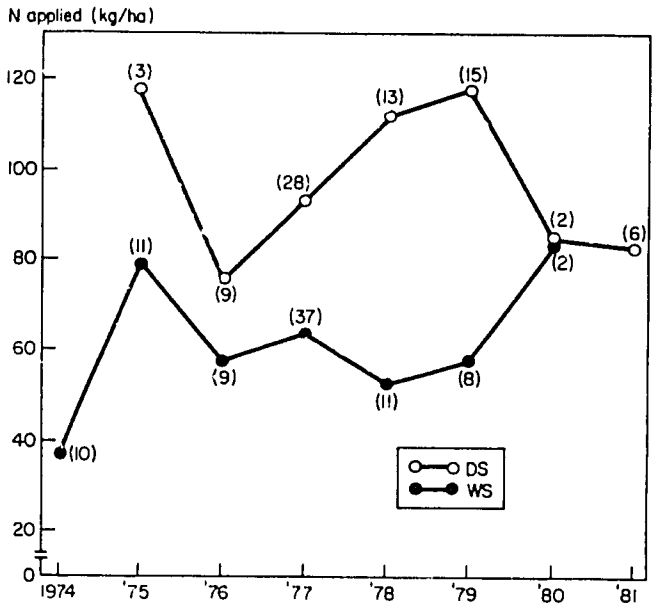
The discussion of results emphasizes changes in farmer input levels and yields from 1974 to 1982 rather than the predetermined high levels chosen to estimate potential farm yields.

NUEVA ECIJA PROVINCE

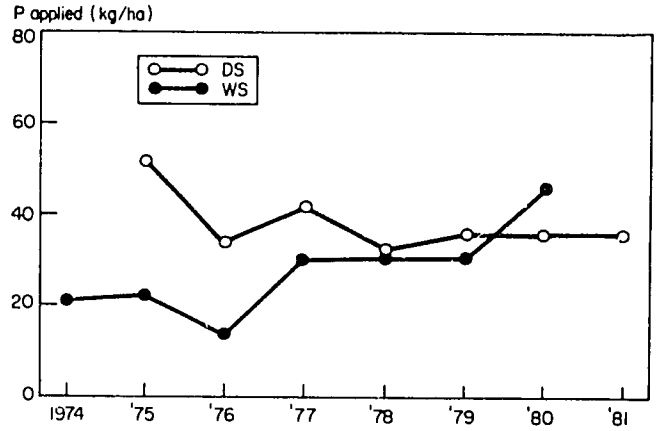
Data on changes in input use and varieties in Nueva Ecija Province for 1974-80 follow.

Changes in input use

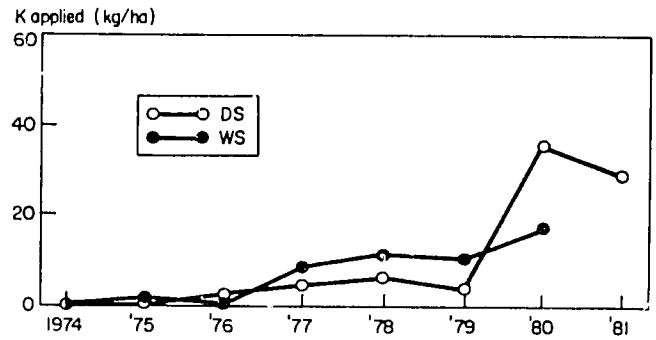
Fertilizer. Average farmer rate of N application varied from 76 to 118 kg/ha during DS and from 37 to 82 kg/ha in WS (Fig. 1). P application from 1974 to 1980 ranged from 32



1. Farmer N fertilizer level in Nueva Ecija, Philippines, 1974-81. Figures in parentheses indicate number of test sites.



2. Farmer P fertilizer level in Nueva Ecija, Philippines, 1974-81.



3. Farmer K fertilizer level in Nueva Ecija, Philippines, 1974-81.

to 52 kg/ha in DS and from 13 to 46 kg/ha in WS (Fig. 2). Dry season K application increased from 0 in 1975 to 29 kg/ha in 1981. In WS, it rose from 0 in 1974 to 18 kg/ha in 1980 (Fig. 3).

Insect control. In DS, foliar insecticide applications on the farmer level increased until 1978 and then decreased, averaging two sprays, which was similar to the high level (Table 1). Average granular insecticide application was lower than the high level. During WS, the average number of foliar sprays and granular applications was 1.6 and 0.7, both less than the high level. More farmers used foliar than granular insecticides (Table 2).

Weed control. Farmers used chemical and mechanical weed control, but the number of applications for both averaged less than one per season (Table 3). Hand weeding was the most common mechanical method and 2,4-D was the most common herbicide (Table 4).

Variety. Until 1975, Nueva Ecija farmers used medium-duration varieties such as IR20 and IR26 (Table 5). When they became susceptible to insects and diseases, farmers adopted newer, more pest-resistant varieties.

Adoption of new varieties in Central Luzon was rapid. In 1966, only traditional varieties were grown (Cordova et al 1981). In 1970, about 78% of the total area was planted to MVs and of that 51% was planted to IR5. In 1974, about 79% of the total area was devoted to MVs and IR20 was the dominant MV. By 1979, more than 95% of the total rice

Table 1. Farmer and high levels of insect control in Nueva Ecija, Philippines, 1974-81.

Insect control		Applications (no.)								
Level	Method	1974	1975	1976	1977	1978	1979	1980	1981	Av
						DS				
Farmer	Foliar	–	1.0	1.6	1.9	3.2	2.1	1.5	1.7	1.7
	Granular	–	1.0	0.4	0.6	0.5	1.2	0.5	0.5	0.7
High	Foliar	–	3.0	1.0	1.0	2.5	1.8	3.0	2.3	2.1
	Granular	–	2.0	4.0	4.0	4.0	3.0	4.0	2.0	3.3
						WS				
Farmer	Foliar	1.1	0.9	1.9	2.3	1.4	1.1	2.5	–	1.6
	Granular	0.4	0.4	0.4	0.7	0.4	0.4	2.0	–	0.7
High	Foliar	5.0	3.0	1.0	2.3	2.4	2.0	5.5	–	3.0
	Granular	3.0	2.0	3.0	3.0	3.0	3.0	4.0	–	3.0

Table 2. Insecticides commonly used by farmers in Nueva Ecija, Philippines, 1974-81.

Year	Sites[a] (no.)	Foliar		Granular	
		Most common	Users (no.)	Most common	Users (no.)
1974	10	MIPC	4	Gamma-BHC	3
1975	14	MIPC	3	Gamma-BHC	2
				Diazinon	2
				Gamma-BHC + MIPC	2
1976	18	Endrin	4	Carbofuran	3
				Gamma-BHC + carbaryl	3
1977	65	Chlorpyrifos + BMPC	31	Carbofuran	21
1978	24	Chlorpyrifos + BMPC	10	Carbofuran	6
1979	23	Monocrotophos	9	Carbofuran	7
1980	4	Monocrotophos	3	Diazinon	2
1981	6	Monocrotophos	3	Carbofuran	1

[a]Total no. of sites for DS and WS where experiments were conducted.

area was planted to MVs, with IR36 dominating. Herdt and Capule (1983) reported that in the Philippines, MVs were planted on 89% of irrigated riceland and 77% of the rainfed lowland rice area in 1979-80.

Changes in grain yields

Yield increases resulted from the adoption of MVs and associated technology, and increased year-around irrigation. DS yields with farmer inputs increased from 4.3 t/ha in 1975 to 6.3 t/ha in 1981 and WS yields increased from 1.8 t/ha in 1974 to 6.1 t/ha in 1980 (Fig. 4).

Changes in yield gap

Yield gap varied more and was higher in DS than in WS. DS yield gap was 2.5 t/ha with 76 kg N/ha in 1976 and 2.6 t/ha with 85 kg N/ha in 1980 (Fig. 5). In WS, yield gap varied from 0.5 to 1.6 t/ha.

Changes in contribution to yield gap

Fertilizer. The greater contribution of fertilizer to yield gap in DS, despite increased N application (Fig. 6), shows that

Table 3. Farmer and high levels of weed control in Nueva Ecija, Philippines, 1974-82.

Weed control		Applications (no.)								
Level	Method	1974	1975	1976	1977	1978	1979	1980	1981	Av
						DS				
Farmer	Chemical	–	0.3	0.4	0.5	0.8	0.7	0.5	1.0	0.6
	Mechanical	–	0.7	0.9	0.8	0.8	0.3	0	0	0.5
High	Chemical	–	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Mechanical	–	0	1.0	1.0	1.0	1.0	1.0	1.0	0.9
						WS				
Farmer	Chemical	0.3	0.4	0.3	0.4	0.4	0.2	1.0	–	0.4
	Mechanical	0.4	0.3	0.2	0.4	0.1	0.2	0	–	0.2
High	Chemical	1.0	1.0	1.0	1.0	1.0	1.0	1.0	–	1.0
	Mechanical	1.0	0	1.0	1.0	1.0	1.0	1.0	–	0.9

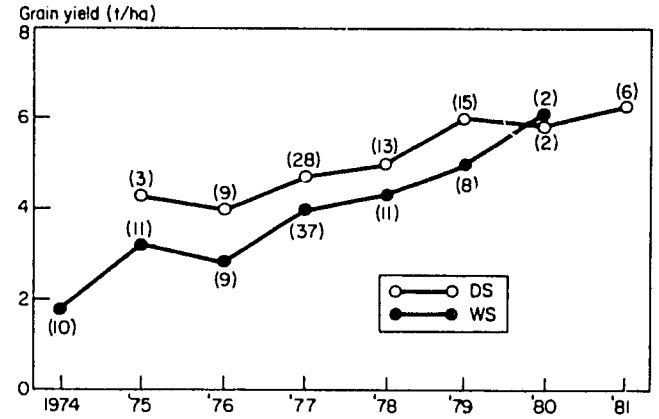
Table 4. Herbicides and mechanical weeding commonly used by farmers in Nueva Ecija, Philippines, 1974-81.

Year	Sites[a] (no.)	Chemical		Mechanical	
		Most common[b]	Users (no.)	Most common[c]	Users (no.)
1974	10	MCPA	3	HW	3
1975	14	MCPA	2	HW	4
		2,4-D L	2		
1976	18	2,4-D G	3	HW	10
		MCPA	3		
1977	65	2,4-D G	12	HW	36
1978	24	2,4-D G	6	HW	10
1979	23	Butachlor L	8	HW	5
1980	4	Butachlor L	3		
1981	6	2,4-D G	3		

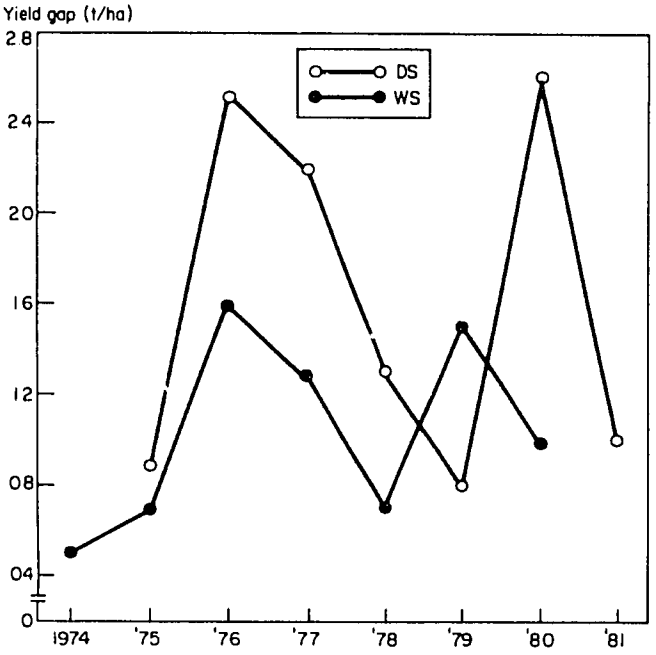
[a]Total for DS and WS where experiments were conducted. [b]L = liquid, G = granular. [c]HW = hand weeding.

Table 5. Most common varieties used by the farmers in Nueva Ecija, Philippines, 1974-81.

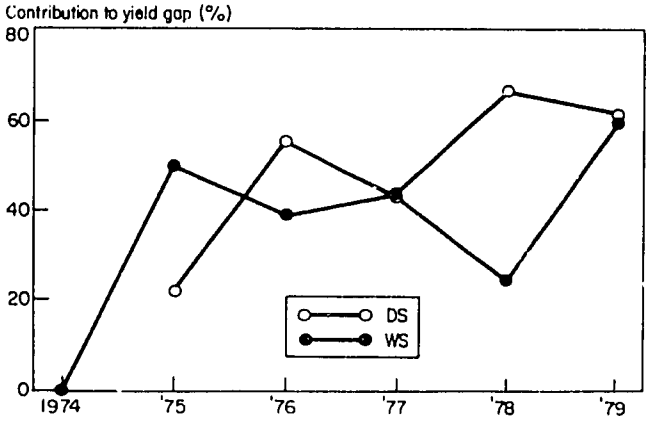
Year	Most common variety	
	DS	WS
1974	–	IR20
1975	IR26	IR26
1976	IR30	IR30
1977	IR36	IR36
1978	IR36	IR36
1979	IR36	IR42
1980	IR1561 (breeding line)	IR42
1981	IR36 and IR54	-



4. Variations in grain yields obtained with farmer inputs in Nueva Ecija, Philippines, 1974-81. Figures in parentheses indicate number of sites.



5. Variations in yield gap between farmer and high input levels in Nueva Ecija, Philippines, 1974-81.



6. Variations in contribution of high fertilizer level to the yield gap in Nueva Ecija, Philippines, 1974-79.

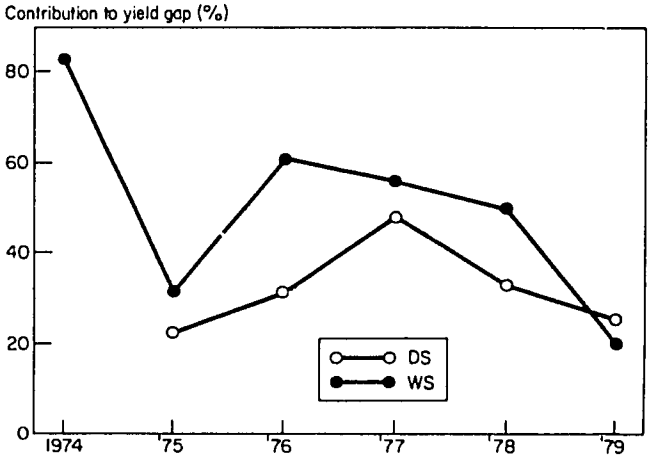
farmers' method and timing of N application were less efficient than those of the researchers. Garcia et al (1983) reported that in Nueva Ecija, farmers' timing of N application was inferior to researchers' timing in 15 of 17 DS trials. Fertilizer contribution to the WS yield gap tended to decrease. In 1974, fertilizer did not affect yield gap despite low farmer application rate because typhoons caused severe lodging in the high-fertilizer plots.

Insect control. In both WS and DS, the effect of high insect control to yield gap decreased (Fig. 7). Insect control contribution can further be substantially reduced if effective and inexpensive insecticides are available. Abilay (1978) reported that in Nueva Ecija, high levels of insect control added more to production cost than to value of yield in three seasons.

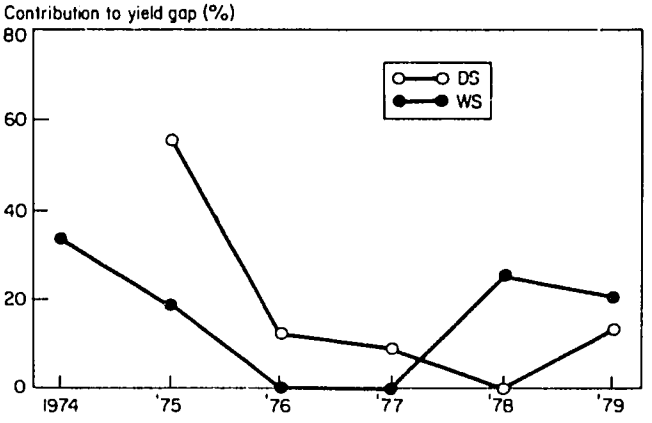
Weed control. The contribution of weed control to yield gap also decreased during the study (Fig. 8).

LAGUNA PROVINCE

Data on inputs and grain yields for Laguna farmers for 1974-77 were collected by the IRRI Statistics Department



7. Variations in contribution of high insect control level to the yield gap in Nueva Ecija, Philippines, 1974-79.



8. Variations in contribution of high weed control level to the yield gap in Nueva Ecija, Philippines, 1974-79.

(IRRI 1975, 1976, 1977, 1978). Some of the published data were used in the following analyses.

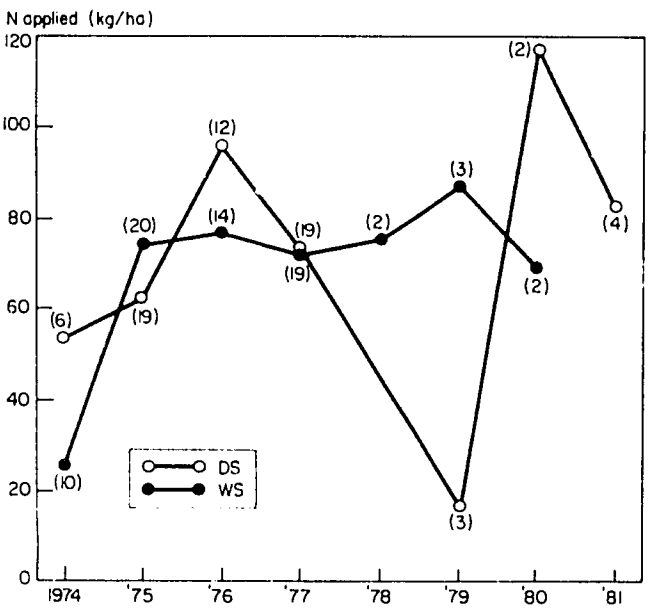
Changes in input use

Fertilizer. In DS, applied N fertilizer ranged from 54 kg/ha in 1974 to 118 kg/ha in 1980 (Fig. 9). In 1979, little N was applied because farmers lacked capital. N application in WS increased over time. Phosphorus application varied from 5 to 23 kg/ha in DS and 0 to 11 kg/ha in WS (Fig. 10), and potassium application ranged from 0 to 23 kg/ha in DS and 0 to 18 kg/ha in WS (Fig. 11).

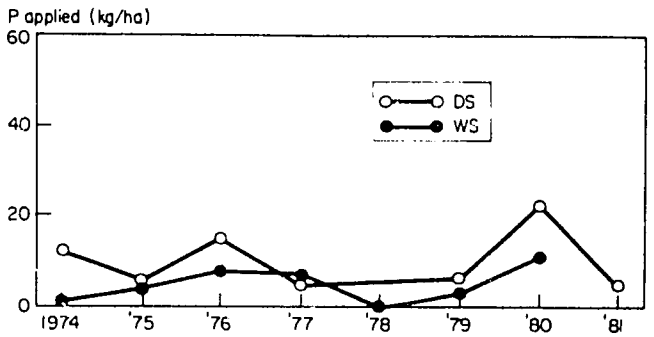
Insect control. Foliar insecticides were more popular than granular insecticides. In both seasons, foliar insecticide applications averaged two sprays and granular insecticide application was negligible (Table 6). The most common insecticides used by Laguna farmers are in Table 7.

Weed control. Farmers used mechanical weed control more than chemical weed control. In both seasons, mechanical weeding was done twice, but chemical weed control averaged less than one application (Table 8). Hand weeding was the most common weeding technique, except in 1976-78, when rotary weeding predominated (Table 9). From 1974 to 1980, liquid 2,4-D was the most common herbicide. In 1981 butachlor was the most commonly used.

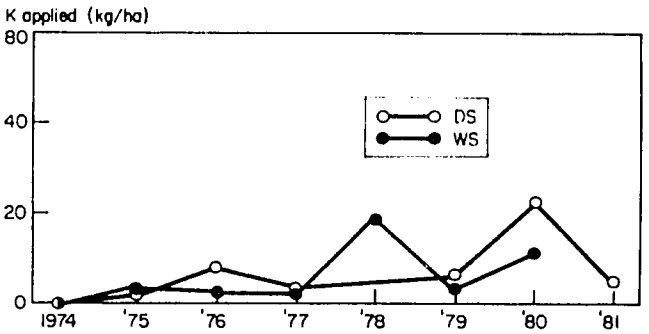
Variety. Farmers planted an IR1561 line in 1974 because it had high yield potential and short growth duration. In later years, they planted several other MVs irrespective of growth duration (Table 10).



9. Farmer N fertilizer level in Laguna, Philippines, 1974-81. Figures in parentheses indicate number of test sites.



10. Farmer P application level in Laguna, Philippines, 1974-81.



11. Farmer K application level in Laguna, Philippines, 1974-81.

Changes in grain yield

DS yields increased from 4.2 t/ha in 1974 to 6.3 t/ha in 1981, and WS grain yields increased from 3.2 t/ha in 1974 to 5.4 t/ha in 1980 (Fig. 12).

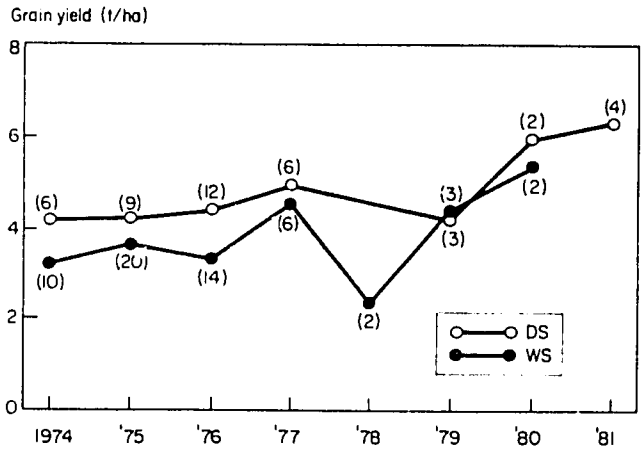
Table 6. Farmer and high levels of insect control in Laguna, Philippines, 1974-82.

Insect control		Applications (no.)								
Level	Method	1974	1975	1976	1977	1978	1979	1980	1981	Av
						DS				
Farmer	Foliar	2.0	2.3	3.5	1.4	–	1.0	2.5	1.5	2.0
	Granular	0	0.2	0.1	0.3	–	0	0	0	0.1
High	Foliar	12	3.0	2.0	4.8	–	1.0	3.0	2.0	4.0
	Granular	0	2.0	5.1	4.4	–	3.0	4.0	3.0	3.1
						WS				
Farmer	Foliar	1.2	2.3	3.3	1.5	1.9	2.3	2.0	0	2.1
	Granular	0	0.4	0.4	0.7	0.5	0.7	0	–	0.4
High	Foliar	7.0	3.0	2.1	1.9	1.0	1.0	3.0	–	2.7
	Granular	0	2.0	4.9	4.9	3.0	3.0	4.0	-	3.1

Table 7. Insecticides commonly used by farmers in Laguna, Philippines, 1974-81.

Year	Sites[a] (no.)	Foliar		Granular	
		Most common	Users (no.)	Most common	Users (no.)
1974	16	MIPC	8	Carbofuran	2
1975	29	MIPC	10	Carbofuran	3
1976	26	Chlorpyrifos + BPMC	16	Carbofuran	5
1977	38	Chlorpyrifos + BPMC	22	Carbofuran	9
1978	2	Monocrotophos	2	Carbofuran	2
1979	6	Chlorpyrifos + BPMC	2	Gamma-BHC + MIPC	1
1980	4	Chlorpyrifos + BPMC	2		
1981	4	MIPC	2		

[a]Total no. of sites for DS and WS where experiments were conducted.



12. Variations in grain yields obtained with farmer inputs in Laguna, Philippines, 1974-81. Figures in parentheses indicate number of sites.

Table 8. Farmer and high levels of weed control in Laguna, Philippines, 1974-81.

Weed control		Applications (no.)								
Level	Method	1974	1975	1976	1977	1978	1979	1980	1981	Av
						DS				
Farmer	Chemical	0	0	0.1	0.2	–	0.6	–	–	0.3
	Mechanical	1.0	1.0	3.2	2.4	–	1.7	–	–	2.1
High	Chemical	0	1.0	1.0	1.0	–	1.0	1.0	1.0	0.9
	Mechanical	4.0	0	2.6	1.3	–	1.0	1.0	1.0	1.6
						WS				
Farmer	Chemical	0.8	0.3	0.8	0.4	0.2	0.8	–	–	0.6
	Mechanical	1.2	2.4	2.3	2.5	2.5	2.0	–	–	2.2
High	Chemical	1.0	1.0	0.9	1.0	1.0	1.0	1.0	–	1.0
	Mechanical	1.5	0	2.3	1.7	1.0	1.0	1.0	–	1.2

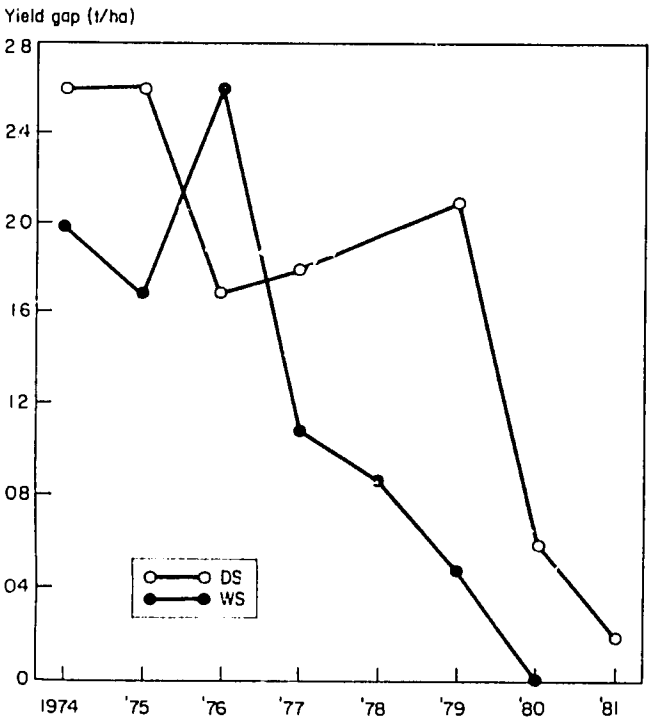
Table 9. Herbicides and mechanical weeding commonly used by farmers in Laguna, Philippines, 1974-81.

Year	Sites[a] (no.)	Chemical		Mechanical	
		Most common[b]	Users (no.)	Most common[c]	Users (no.)
1974	16	2,4-D L	1	HW	14
1975	29	2,4-D L	4	HW	29
1976	26	2,4-D L	8	RW	24
1977	38	2,4-D L	10	RW	36
1978	2			RW	2
1979	6	2,4-D L	4	HW	6
1980	4	2,4-D L	3	HW	3
1981	4	Butachlor L	3	HW	3

[a]Total no. of sites for DS and WS where experiments were conducted. [b]L = liquid. [c]HW = hand weeding, RW = rotary weeding.

Table 10. Most common varieties used by farmers in Laguna, Philippines, 1974-81.

Year	Most common variety	
	DS	WS
1974	IR1561 (breeding line)	IR1561
1975	IR26	IR26
1976	IR26	IR26
1977	IR36	IR36
1978	–	IR36, IR42
1979	IR36, IR40, IR1561	IR36
1980	IR36, IR42	IR42, IR44
1981	IR40	–



13. Variations in gap between yields obtained with farmer and high input level in Laguna, Philippines, 1974-81.

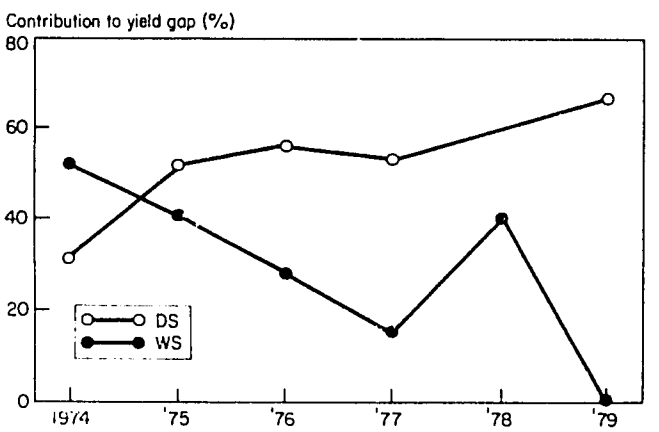
Changes in yield gap

Dry season yield gap decreased from 2.6 t/ha in 1974 to 0.2 t/ha in 1981 and from 2.0 t/ha in 1974 WS to zero in 1980 (Fig. 13).

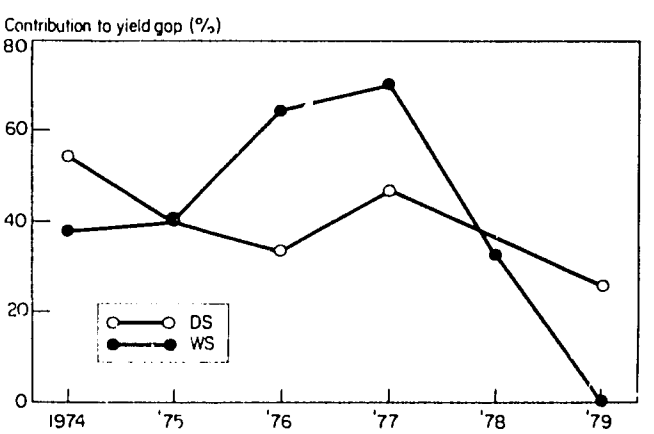
Changes in contribution to yield gap

Fertilizer. The contribution of high fertilizer application to DS yield gap increased from 1974 to 1979 (Fig. 14). Fertilizer contribution to yield gap was highest in 1979 when the farmers applied only 17 kg N/ha. Wet season fertilizer contribution decreased from 52% in 1974 to zero in 1979, when farmers applied the highest rate of N fertilizer.

Insect control. The contribution of high DS insect control decreased from 1974 to 1979 (Fig. 15). During WS, the contribution of insect control to yield gap was highest in 1977 when farmers applied foliar insecticides twice and granular insecticides once. In 1977, high insect control consisted of two foliar sprays and five granular applications. Contribution was zero in 1979 when farmers sprayed more than twice and applied granular insecticides once. The high level consisted of one foliar spray and three granular applications.



14. Variations in contribution of high level of fertilizer to the yield gap in Laguna, Philippines, 1974-79.



15. Variations in contribution of high insect control level to the yield gap in Laguna, Philippines 1974-79.

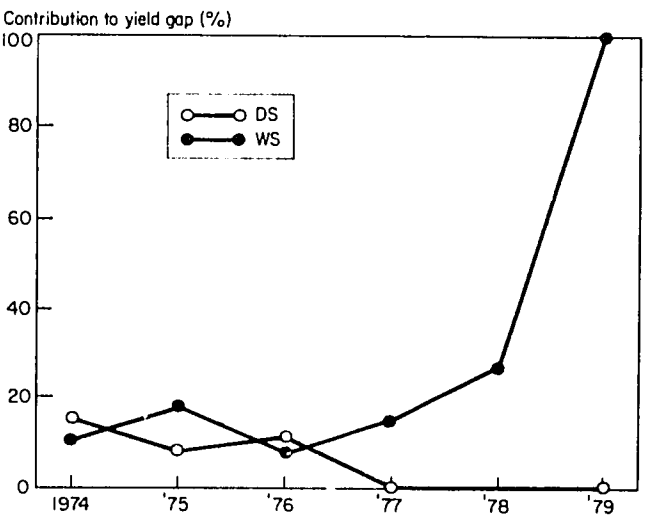
Weed control. The contribution of high weed control decreased to zero in 1977-79 DS. It increased in WS after 1976 (Fig. 16). High weed control accounted for the entire 1979 yield gap.

CAMARINES SUR PROVINCE

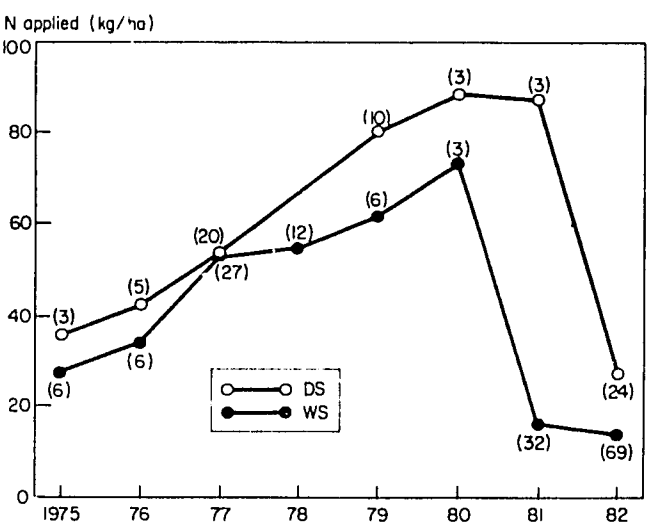
Farm-level constraints research in Camarines Sur began in 1975. Our data are through 1982.

Changes in input use

Fertilizer. The rate of N fertilizer applied by farmers in DS steadily increased from 36 kg/ha in 1975 to 87 kg/ha in 1981 (Fig. 17). Farmers in the new test sites in the 1982 DS applied only 27 kg N/ha. WS fertilizer rates also increased over the years and in 1981 and 1982 farmers in the new test sites applied less than 20 kg N/ha. In both seasons, P applications tended to decrease and were generally low,



16. Variations in contribution of high weed control level to the yield gap in Laguna, Philippines, 1974-79.



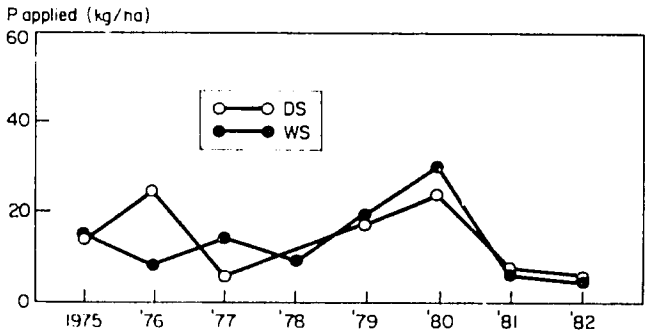
17. Farmer N fertilizer level in Camarines Sur, Philippines, 1975-82. Figures in parentheses indicate number of test sites.

averaging less than 20 kg/ha (Fig. 18). Potassium application rates decreased over the years except in 1980 when application rates increased in both seasons (Fig. 19). Earlier studies (De Datta and Gomez 1975) suggest that Camarines Sur farmers should apply about 18 kg P to get high yields; however, farmers in the study area applied mainly N fertilizer.

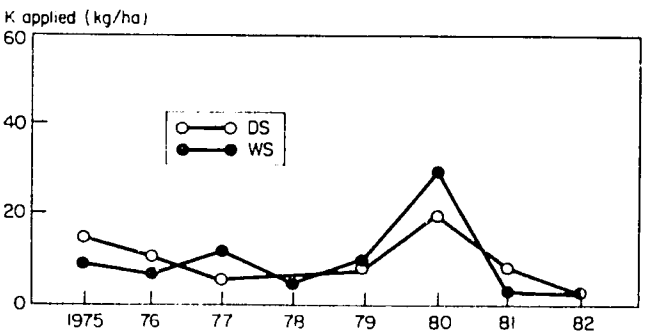
Insect control. Farmers applied an average of two foliar insecticide treatments in DS and more than two in the WS (Table 11). In both seasons, farmers' granular insecticide applications were negligible. Endosulfan and azinphos ethyl were the most common foliar insecticides (Table 12).

Weed control. Farmers used an average of one herbicide and one mechanical weed control method in DS (Table 13), which was similar to that in WS. Rotary weeding was the most common mechanical method. From 1975 to 1978, 2,4-D liquid, applied postemergence, was the most common herbicide used (Table 14). From 1979 to 1982, the farmers used liquid butachlor, applied preemergence. They shifted from 2,4-D to butachlor because of increasing weed problems and because butachlor controls grasses. In 1981 and 1982, more farmers used herbicides than mechanical methods because they broadcast-seeded on mud, which makes hand weeding difficult. Smith and Gascon (1979) showed that in Laguna, herbicide price has fallen with respect to labor price, which also helps explain the shift from hand weeding to herbicides. Increased herbicide use efficiency, as farmers shifted from postemergence (20 to 25 days after transplanting [DT]) to preemergence (4 DT) application, also encouraged the shift from hand weeding to herbicides.

Variety. Camarines Sur farmers planted early-maturing rice varieties. IR747, although not named as a variety, gained acceptance (Table 15) because it has short growth duration and high yield potential. In later years, when more MVs were released, farmers adopted only the early-maturing rices like IR36 and IR50.



18. Farmer P fertilizer level in Camarines Sur, Philippines, 1975-82.



19. Farmer K fertilizer level in Camarines Sur, Philippines, 1975-82.

Changes in stand establishment

Broadcast seeding on puddled soil has become popular in Camarines Sur. Mandac et al (1982) reported that the

Table 12. Insecticides commonly used by farmers in Camarines Sur, Philippines, 1975-82.

Year	Sites[a] (no.)	Foliar		Granular	
		Most common	Users (no.)	Most common	Users (no.)
1975	9	Endosulfan	3		
1976	11	Endosulfan	7	Carbofuran	1
				Gamma-BHC	1
1977	47	Endosulfan	25	Carbofuran	3
1978	12	Azinphos ethyl	8		
1979	16	Azinphos ethyl	8		
1980	3	Azinphos ethyl	2		
1981	35	Azinphos ethyl	14		
1982	93	Azinphos ethyl	53		

[a]Total no. of sites for DS and WS where experiments were conducted.

Table 11. Farmer and high levels of insect control in Camarines Sur Philippines, 1975-82.

Insect control		Applications (no.)								
Level	Method	1975	1976	1977	1978	1979	1980	1981	1982	Av
						DS				
Farmer	Foliar	1.3	3.0	2.5	–	2.1	1.0	1.6	0.9	1.9
	Granular	0	0.2	0	–	0	0	0	0.2	0.1
High	Foliar	3.0	1.0	1.0	–	2.6	4.0	2.0	1.0	2.1
	Granular	2.0	3.0	3.0	–	3.0	3.0	2.0	1.0	2.7
						WS				
Farmer	Foliar	3.3	3.0	2.0	2.3	3.0	2.3	1.6	2.0	2.4
	Granular	0	0.2	0.2	0.2	0	0	0.1	0	0.1
High	Foliar	3.0	1.0	1.0	1.8	2.1	3.7	2.4	2.7	2.3
	Granular	2.0	3.0	3.0	3.0	3.0	4.0	2.0	1.9	2.7

Table 13. Farmer and high levels of weed control in Camarines Sur, Philippines, 1975-82.

Weed control		Applications (no.)								
Level	Method	1975	1976	1977	1978	1979	1980	1981	1982	Av
						DS				
Farmer	Chemical	0.3	0.8	0.6	–	0.6	1.0	1.0	0.1	0.6
	Mechanical	1.0	0.8	0.8	–	0.9	1.0	1.0	1.0	1.1
High	Chemical	1.0	1.0	1.0	–	1.0	1.0	1.0	2.0	1.1
	Mechanical	0	1.0	1.0	–	1.0	1.0	1.0	3.0	1.1
						WS				
Farmer	Chemical	1.0	0.5	0.5	0.5	1.2	1.0	1.0	1.0	0.8
	Mechanical	0.5	1.3	0.9	1.2	0.7	1.0	1.0	0.5	0.9
High	Chemical	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.2	1.0
	Mechanical	0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.8

moisture status of the field and the introduction of more effective herbicides caused the shift in crop establishment method. Increased labor cost and lack of a timely labor supply for hand weeding also encouraged the shift to broadcast seeding as did availability of shorter-maturing rices with high yield potential. Weed control is difficult in broadcast-seeded rice; therefore, farmers used herbicides to minimize weed infestation.

The yield gap in broadcast-seeded rice was similar to that in transplanted rice but high fertilizer and weed control levels contributed more (Fig. 20) because of inadequate farmer N fertilizer application levels. Results also indicate that farmers have yet to learn how to control weeds in broadcast-seeded rice, despite currently available technology (De Datta 1981).

Changes in grain yields

Grain yields generally increased between 1975 and 1981, ranging from 3.9 to 5.6 t/ha in DS and from 3.6 to 4.2 t/ha in WS (Fig. 21). Mandac et al (1982) reported that higher fertilizer and pest management levels could increase grain yields more than 1.0 t/ha.

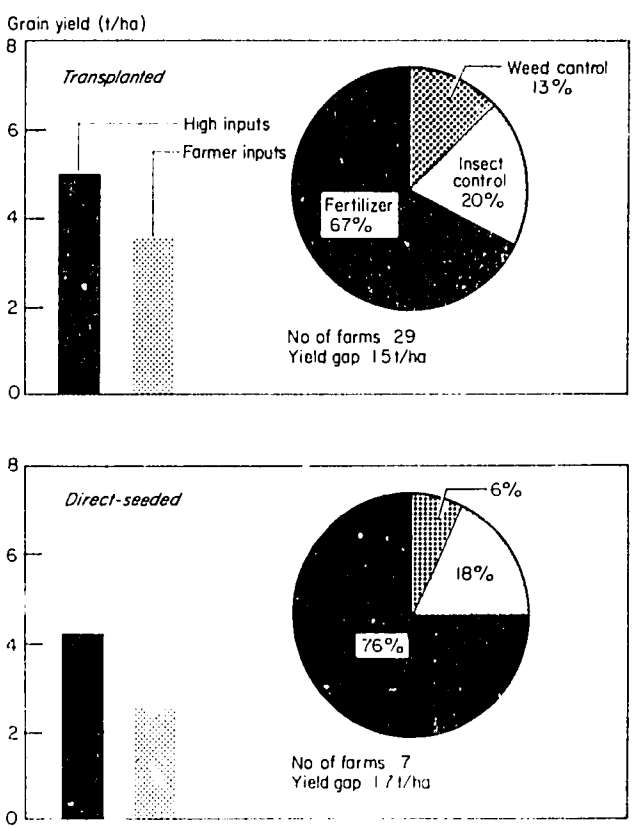
Table 14. Herbicides and mechanical weed control commonly used by farmers in Camarines Sur, Philippines, 1975-82.

Year	Sites[a] (no.)	Chemical		Mechanical	
		Most common[b]	Users (no.)	Most common[c]	Users (no.)
1975	9	2,4-D L	4	RW	7
1976	11	2,4-D L	7	RW	9
1977	47	2,4-D L	37	RW	38
1978	12	2,4-D L	4	RW	11
1979	16	Butachlor L	15	RW	16
1980	3	Butachlor L	3	RW	3
1981	35	Butachlor L	29	HW	10
1982	93	Butachlor L	42	HW	31

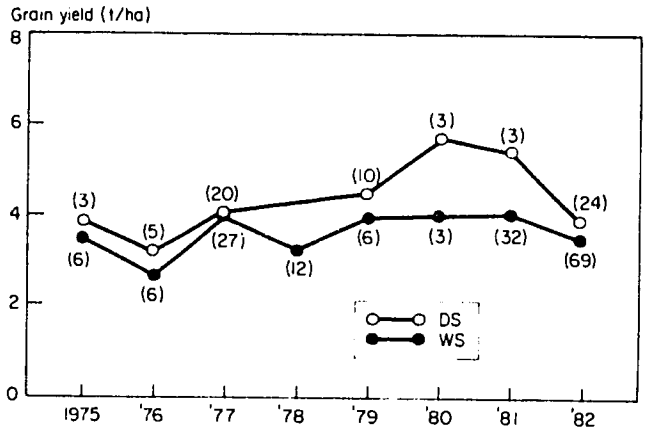
[a]Total for DS and WS where experiments were conducted. [b]L = liquid. [c]RW = rotary weeding, HW = hand weeding.

Table 15. Most common varieties used by farmers in Camarines Sur, Philippines, 1975-82.

Year	Most common variety	
	DS	WS
1975	IR1561 (breeding line)	IR1561
1976	IR30	IR747
1977	IR36	IR36
1978	–	IR36
1979	IR36	IR36
1980	IR36	IR36
1981	IR36	IR36
1982	IR50	IR36, IR50



20. Relative contribution of fertilizer, weed control, and insect control to the improvement of transplanted and direct-seeded rice yields on rainfed farms in Camarines Sur, Philippines, 1982 WS.



21. Variations in grain yields obtained with farmer inputs in Camarines Sur, Philippines, 1975-82. Figures in parentheses indicate number of test sites.

Changes in yield gap

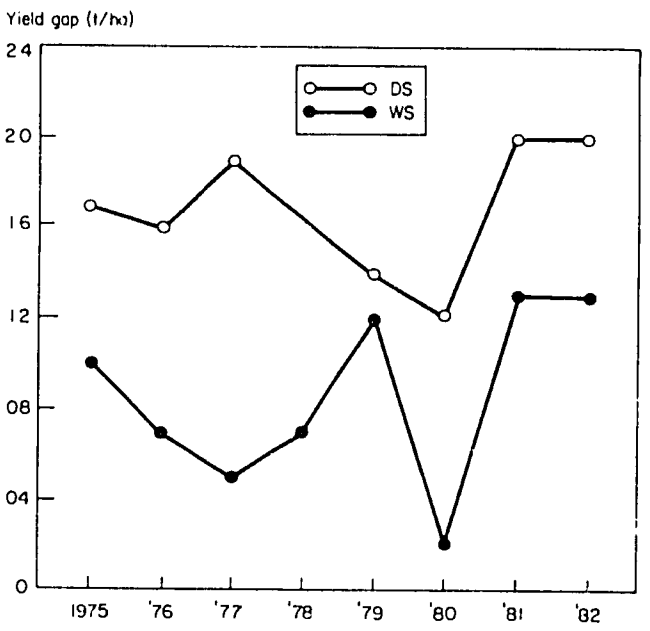
The yield gap decreased from 1.7 t/ha in 1975 to 1.2 t/ha in 1980 in DS and from 1.0 t/ha in 1975 to 0.2 t/ha in 1980 in WS (Fig. 22). The high 1981 and 1982 yield gaps were caused by the low N fertilizer levels applied by farmers.

Changes in contribution to yield gap

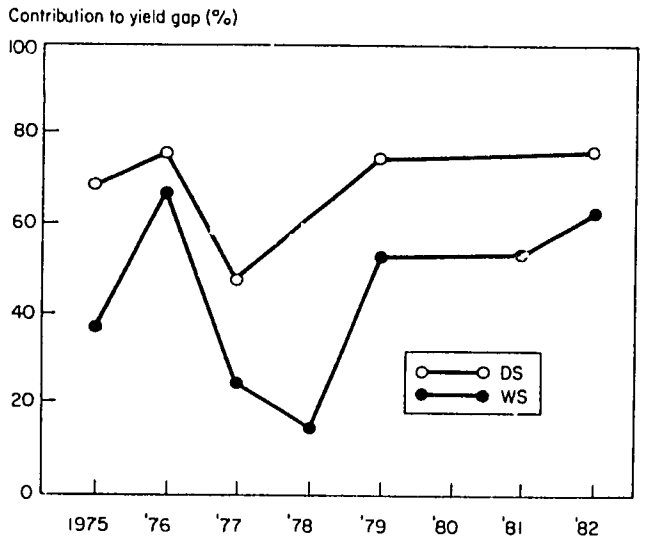
Fertilizer. In DS the contribution of high fertilizer to the yield gap did not decrease despite increased N fertilizer application by the farmers, which indicates the lower efficiency of the farmers' method and timing of application (Fig. 23). De Datta et al (1983) reported that in 3 study areas, researchers' timing of fertilizer application was as good as or more efficient than farmers' timing in 30 of 39 DS trials. Results suggest that rice yields can be considerably increased without added cost to the farmers by improved timing of application. In the WS, contribution to yield gap tended to decrease.

Insect control. In both DS and WS, the contribution of high insect control to yield gap decreased over time (Fig. 24). New varieties also minimized farmers' dependence on insecticides to control insects and vectors of virus diseases.

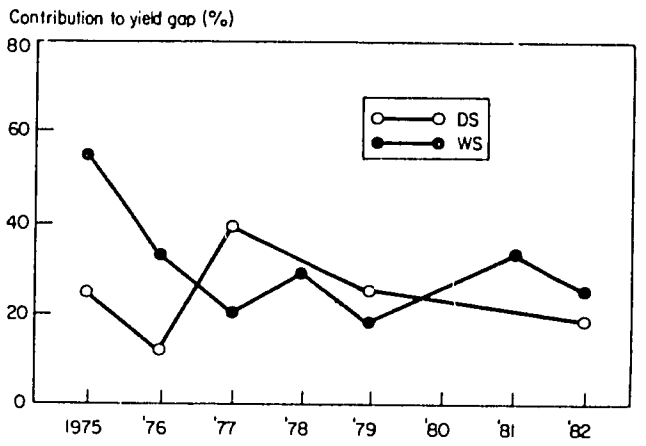
Weed control. The contribution of high weed control to yield gap decreased over time in DS (Fig. 25). In WS, high weed control accounted for 57% of the yield gap in 1978, but decreased in later years.



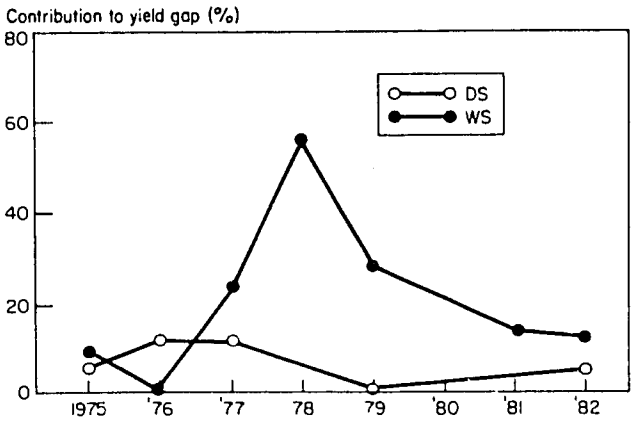
22. Variations in gap between yields obtained with farmer and high input levels in Camarines Sur, Philippines, 1975-82.



23. Variations in contribution of high fertilizer level to the yield gap in Camarines Sur, Philippines, 1975-82.



24. Variations in contribution of high insect control level to the yield gap in Camarines Sur, Philippines, 1975-82.



25. Variations in contribution of high weed control level to the yield gap in Camarines Sur, Philippines, 1975-82.

CONCLUSIONS

1. Farmers are adopting modern rice technology at a rate they find desirable under their farm conditions.
2. New varieties with high insect and disease resistance have substantially reduced farmers' dependence on insecticides to control insects and vectors of virus diseases.
3. Current rice yields can be considerably increased without added cost to the farmers by improved timing of N fertilizer application.
4. Farmers' adoption of modern rice technology increased grain yields in the three study areas in the Philippines and narrowed the yield gap in farmer fields in both DS and WS.

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