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AN APPRAISAL OF THE PACKAGE OF PRACTICES APPROACH IN ADOPTION OF MODERN VARIETIES

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INTRODUCTION

Much of the research and extension effort in India in connection with the development and release of modern varieties (MV's) since the mid-1960's has revolved around the concept of a "package of practices". Farmers have generally been extolled to adopt the MV's of crops like paddy, wheat, bajra, jowar and maize along with vastly increased amounts of fertilizers, pesticides, insecticides, etc. to gain maximum benefit from the new technology. The implication which farmers and others seem to derive from the literature on MV's is that unless they include all parts of the input package at their "recommended" levels, then MV technology will not be of any benefit.

According to the Programme Evaluation Organization of the Planning Commission [14, pp. 159-160] the proportions of Indian farmers adopting all four recommended practices in the 1968-69 rabi season was 9.43, 16.62 and

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We have benefited from the comments of B.A.Krantz, M.J.T.Norman, N.S.Jodha, [illegible] Kanwar, H.P.Binswanger, A.H.Kassam, J.M.Green and B.C.Wright on an earlier draft. They of course are absolved of any remaining sins of omission and/or commission.

55.84 per cent for wheat, paddy and jowar, respectively.[1] One might have expected those percentages to be in the reverse order, with wheat, the most successful green revolution crop, having a higher proportion of farmers adopting all four practices.[2] The percentage of participants using some type of fertilizer in the high yielding variety programme was 77, 90 and 71 per cent for wheat, paddy and jowar, respectively [14, pp.161-162]. The proportions adopting the recommended levels of chemical fertilizers were 54, 61 and 64 per cent in the three crops, respectively [14, p.30]. In another study, Gowda and Jalihal [5] found that no paddy farmer in the IADP district of Mandya in Karnataka adopted all eight recommended practices. Almost two thirds of them adopted only three or less.

The fact that there are such differences between the numbers of participants in the high yielding variety programme who adopt parts versus the complete package of recommended practices, particularly with wheat and paddy, suggests that the "package" approach may not be entirely appropriate in all instances. How much it has been responsible for non-adoption of the simplest part of the package - namely a change to the MV of seed and nothing else - can only be guessed at. If this simple change is itself profitable, then the

1) The four practices were seed treatment, use of chemical fertilizers, plant protection and inter-cultural operations. The percentages refer to proportions of selected farmers who participated in the high-yielding varieties programme in six states of India. Unfortunately, important practices like reduced depth of planting and shifting to early and late irrigations were not evaluated in the quoted study. It is likely that, especially in the case of wheat, adoption of these two practices would have been high. However, they represent minimum cost changes in management, rather than large input increases.

2) It has been suggested by B.A.Krantz (private communication) that, three of the chosen recommended practices for wheat in the Planning Commission's study, namely seed treatment, insect control and inter-culture, were generally not required in practice.

opportunities foregone in extending the complete package approach might be significant. It is possible that many farmers are deterred from just trying the new variety while still using their other traditional practices. They could be encouraged to adopt practices in a sequential manner, rather than in all - or - nothing type of framework. Each part of the package might be looked upon by farmers as a less risky activity than the complete package in terms of what the farmer could lose if crop failure resulted. If this were true, then this sequential approach might increase adoption of MV's in the longer-run. The ancillary inputs in the package could be added according to their relative profitability, and as working capital was accumulated from introductions of previous parts of the package.

In this paper we compare the likely benefits from adoption of three different packages of technology using extensive crop-fertilizer response data from a number of sources, most of which were derived from experiments conducted in farmers' fields. The three packages involve a change from growing the traditional local variety (LV) with zero nitrogen fertilizer to

(A) a MV of the crop with fertilizer nitrogen kept at zero;

(B) an increase in the quantity of nitrogen fertilizer from zero to the derived economic optimum level for the traditional LV;

(C) a MV of the crop and an increase in the quantity of nitrogen fertilizer from zero to the derived economic optimum level for the MV.

Practice A might be looked upon as the simplest change in technology and C the most complex of the three, involving also the largest increase in costs. Practice B might be regarded as an intermediate technology. We want to examine whether farmers have to change all other input levels (in this case only fertilizer, due to data limitations) in order to reap the advantages of MV's.

METHODOLOGY

Data from crop-nitrogen response studies conducted on wheat, paddy, jowar, bajra and maize by Kanwar [8], Krishnamoorthy *et al.* [9, Table 4], Krishnaswamy and Patel [10, pp.76, 87], Mahendra Singh *et al.* [11, p.308], Murthy [12, p.151], Raheja *et al.* [15], Rao [16], Saxena and Sirohi [17, p.125] and Shah [18, p.164] were used to calculate the additional costs, additional yields, and additional net returns from the above three packages A, B and C.

To do this we assume the response function for a LV to nitrogen (N) to be:

(1) $Y_{LV} = a_{LV} + b_{LV} N - c_{LV} N^2$

where Y_{LV} = total yield of the LV,

a_{LV} = yield at zero N,

b_{LV}, c_{LV} = coefficients of the linear and quadratic terms, respectively;

and that for the MV to be:

(2) $Y_{MV} = a_{MV} + b_{MV} N - c_{MV} N^2$,

with terms as explained above for the LV.

The additional yield under practice A is given as ΔY, where:

(3) $\Delta Y = a_{MV} - a_{LV}$.

The additional yield under practice B is found first by determining the optimal level of N by equating the first derivative of equation (1) to the ratio of the price of nitrogen (P_N) to the price of the crop (P_{LV}):

(4) $dY_{LV}/dN = b_{LV} - 2c_{LV}N^* = P_N/P_{LV}$

The calculated optimum level of N^* in equation (4) is used in equation (1) to calculate the optimum yield Y^*_{LV} under practice B. The added yield under B is then calculated as:

(5) $\Delta Y_{LV} = Y^*_{LV} - a_{LV}$.

The added yield under practice C is calculated in a similar fashion to that in practice B. First, equation (6) is solved for N^{**}, the optimal level of N on the MV:

(6) $dY_{MV}/dN = b_{MV} - 2c_{MV}N^{**} = P_N/P_{MV}$.

Then N^{**} is substituted in equation (2) to derive Y^{**}_{MV} and then the change in yield (ΔY_{MV}) from the change involved in practice C is calculated as:

(7) $\Delta Y_{MV} = Y^{**}_{MV} - a_{LV}$.

Additional returns are calculated by applying the product prices in the appendix to the above yield data. Additional costs for MV seeds and fertilizers are also shown in the appendix. Prices used were those reigning in 1974. Additional labour costs were not included for applying extra fertilizer as this can be supplied by family labour. Additional labour costs for harvesting and threshing were also not included. No significant differences could be found between these latter costs per hectare on farms with different yields in a regression analysis performed on some paddy production data kindly supplied by Dr.Suryanarayana of Andhra Pradesh Agricultural University. Similarly, no significant difference in the labour requirement for harvesting and threshing local and hybrid jowar was reported by Venkataram and Ramanna [20], though there was a significant difference in yields. Desai and Mohan [3] found that in the Kaira District of Gujarat in 1967-68, hybrid bajra required about 14 man-days per hectare more to harvest than deshi bajra. Yield of the hybrids was 85 per cent more than the deshi varieties. Basu [1, pp.6-11] found for irrigated wheat, maize and bajra in Haryana and Bihar that the MV's required an additional five man-days per hectare, for harvesting and threshing compared to LV's.

On the basis of the lack of a clear picture of the added labour requirements for MV's from the above studies, it was decided not to allow for additional labour costs. The magnitude of any such costs would also be small and would in no way affect the conclusions drawn from the analyses later in the paper.

It is further assumed that all other management factors except levels of fertilizers, were similar between the LV's and the MV's. The various sources from which the fertilizer response data were taken did not indicate anything to the contrary.

Unfortunately, measures of the statistical significance of differential yield responses of LV's and MV's to fertilizers were not available. This was a deficiency in the data, although most of the response curves were derived over many locations, so hopefully they represent the differences one would observe in practice.

RESULTS AND DISCUSSION

The results of these analyses are presented in Tables 1-3. In Table 1 in the case of wheat, a simple shift from a LV to a MV (practice A) without applying nitrogen fertilizers resulted in marginal additional profits of around Rs.100/ha. But a combination of MV seed and the economically optimum level of nitrogen fertilizer (practice C) resulted in a substantial additional profits. Although in per hectare terms the additional

Table 1: Incremental Profits from Adoption of Package of Practices versus Adoption of Cing's Practice

Practice	Unit	WHEAT		PADDY	MAIZE		JOWAR				BAJRA
Data Source		a	b	a	a	c	a	d	e	f	a
No. of trials/centres	-	N.A.	13 centres (1964-65)	N.A	N.A.	17 trials (1961-63)	N.A	25 (1965-70)	8 locations (1968)	8 locations (1970-71)	N.A.
Irrigated or Unirrigated	-	Irrigated	Irrigated	Irrigated	Irrigated	N.A.	Irrigated	Unirrigated	N.A.	N.A.	Irrigated
Varieties compared		Kalyansona vs. C. 306	Sonara 64 vs. HP varieties	IR 8 vs. NDR 90	Hybrid vs. Local	Hybrid vs. Local	Hybrid vs. local	CSH1 vs local	CSH1 vs. local	CSH1 vs. local	HB. 1 vs. T. 55
A. Nil Nitrogen (N) fertiliser but change from local to HV:											
i) Additional cost	Rs/Ha.	168	168	80	15	15	100	100	100	100	28
ii) Additional yield	Kg/Ha.	227	214	420	422	352	1130	985	460	1050	670
iii) Additional profits	Rs/Ha.	127	109	99.2	491	407	1165	1033	429		669
iv) Additional profits per additional rupee of cost	Rs/Rs.	0.76	0.64	1.13	32.7	27.13	11.65	10.33	4.29	11.07	23.89
B. Increase from nil to economic optimum N fertiliser level on LV:											
i) Additional N fertiliser	Kg/Ha.	72	51	61	124	142	45	124	152	100	90
ii) Additional cost	Rs/Ha	314	222	274	540	617	196	540	661	435	392
iii) Additional yields	Kg/Ha.	1742	640	624	1412	1479	320	726	837	790	530
iv) Additional profits	Rs/Ha.	1951	610	301	1154	1158	126	295	299	471	159
v) Additional profit per additional rupee of cost	Rs/Rs.	6.20	2.70	1.39	2.14	1.88	0.64	0.55	0.45	1.09	0.41
C. Change from LV to HV and apply from nil to economic optimum N fertiliser:											
i) Additional N fertiliser	Kg/Ha.	254	97	124	139	206	84	142	137	150	170
ii) Additional costs	Rs/Ha.	1274	591	626	680	912	466	718	698	753	768
iii) Additional yield	Kg/Ha.	5439	1745	2409	2458	3059	1950	3021	1989	3090	2670
iv) Additional profits	Rs/Ha.	5797	1679	1441	2330	2759	1777	2756	1589	2800	2009
v) Additional profit per additional rupee of cost	Rs/Rs.	4.50	2.84	2.29	3.76	3.02	3.81	3.84	2.28	3.72	2.61

Sources: a) Kumar [8].
b) Saxena and Hironi [17, p. 125]
c) Shah [18, p. 164]
d) Singh *et al.* [11, pp. 15-33]
e) Murthy [12, p. 151].
f) Krishnamurthy *et al.* [9, Table 4

profit from practice C was about three times as large as the additional profits from applying the optimum level of nitrogen fertilizer to LV's (practice B), a comparison of additional gains per rupee of additional cost shows that practice B was more profitable than C for Kalyanasona and about the same for Sonara 63.

Slightly different results emerge from a regional analysis of the performance of MV's and LV's in hundreds of simple fertilizer trials conducted in farmers' fields in 1967-71, as reported by Rao [16], and shown in Table 2.[3/] The total additional profits per hectare for wheat were always greater for practice C, followed by B, then A in all four regions. This was also true using the additional profit per rupee of additional cost criteria in the case of the Indo-Gangetic and Western Regions. In the Northern Region, practice C rated first using this criterion, followed by A then B. In the Central Region the order was B. C, A.

Hence, for wheat it seems clear that, while the package of MV seed plus optimum doses of nitrogen fertilizers generates the largest additions to yields and profits of the three practices examined, it also involves an extremely large additional cost to achieve this. In some

3) The results for practices B and C in Table 2 are not strictly comparable with those in Table 1 as the fertilizer levels in Table 2 are not necessarily the economically optimal levels.

Table 8. Incremental Profits from Adoption of a Package of Practices versus Adoption of Single Practice on Wheat and Paddy in Different Regions

Practice	Unit	WHEAT (1967-71) Regions[a]					PADDY (1967-71) Regions[b]							
							Kharif					Rabi irrigated		Rabi Un-irrigated
		North-ern	Indo Gangetic	Western	Central	Over all the regions	South-ern	North East-ern	Central	North-ern	Over all the regions	Southern	Over all the regions	South-ern
No. of trials: HV	No.	552	976	458	349	2235	502	180	119	146	947	416	626	308
LY	No.	116	654	539	134	1443	449	141	145	91	861	281	281	219
(1) Nitrogen (N) Fertiliser hut change from local to High Yielding Variety:														
i) Addl. costs	Rs/ha.	168	168	168	168	168	88	88	88	88	88	88	88	88
ii) Addl. yields	Kg/ha.	400	235	190	208	338	686	891	(-) 84	296	420	789	782	-805
iii) Addl. profits	Rs/ha.	352	305	79	95	271	950	629	(-)376.4	(-) 5.0	150	518	511	-488
iv) Addl. profit per addl. rupee of cost	Rs/Rs.	2.09	1.37	0.47	0.56	1.61	1.98	7.15	(-)4.28	(-)0.05	1.70	5.88	5.81	-6.9
Increase from Nil to $N_{60}P_{30}$ Level of Fertilisation on local variety:														
i) Additional fertilisers	Kg/ha.	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$
ii) Addl. costs	Rs/ha.	395	395	395	395	395	395	395	395	395	395	395	395	395
iii) Addl. yield	Kg/ha.	878	743	581	1273	759	1066	1847	1327	1189	1157	988	982	738
iv) Addl. profits	Rs/ha.	746	571	360	1260	986	726	704	998	853	820	573	573	775
v) Addl. profit per addl. rupee of cost	Rs/Rs.	1.89	1.44	0.91	3.19	1.48	1.83	1.78	2.53	2.16	2.07	1.45	1.45	1.96
Range from LY to HY and apply from Nil to $N_{60}P_{30}$ level of fertilisers:														
i) Addl. fertiliser	Kg/ha.	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$	$N_{60}P_{30}$
ii) Addl. cost	Rs/ha.	563	563	563	563	563	483	483	483	483	483	483	483	483
iii) Addl. yield	Kg/ha.	1879	1895	949	1619	1410	1965	2089	1143	1183	1305	1888	2047	511
iv) Addl. profits	Rs/ha.	1614	1180	665	1542	1270	1302	1425	609	841	797	1453	1462	8
v) Addl. profit per addl. rupee of cost	Rs/Rs.	2.86	1.99	1.18	2.73	2.25	2.86	2.95	1.25	1.33	1.57	3.01	3.03	0.005

a Consists of the following states: 1. Northern (Delhi, Haryana, Punjab); 2. Indo-Gangetic (Bihar, U.P., W. Bengal); 3. Western (Gujarat, Maharashtra, Rajasthan); 4. Central (Madhya Pradesh).

b Southern (Andhra Pradesh, Mysore, Tamil Nadu); North-Eastern (Bihar, W.Bengal); Central (Madhya Pradesh); Northern (Haryana, Uttar Pradesh); Eastern (Orissa).

Source: Single fertiliser trials on cultivators' fields 1967-71 as given in Ref [16, pp. 29,30]

instances it may be more desirable to apply fertilizers to LV's.[4] In situations where limited cash resources are available, as in the case of small farmers, a profitable yet low cost (comparatively) practice involving just a change to MV seed with zero fertilizer might be recommended initially. With the additional profits generated from this, in subsequent years they may invest in fertilizers and other complementary inputs. It may not always be true, as Kanwar *et al.* [7, 8] and others state, that fertilizer application is more profitable on MV's than LV's when criteria other than profits per hectare are considered.

For paddy, Table 1 shows that a switch to MV seed gives about the same additional profits per hectare as in the case of wheat. The package of practices involved in C for paddy is extremely profitable at Rs.1441 per hectare, compared to Rs.381 for practice B. In terms of profits per rupee invested in the practices, Table 1 suggests that package C is the best, followed by B then A.[5] Table 2 shows somewhat different results. In the Southern and North Eastern paddy regions, a simple switch to MV

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4) While not shown in Table 1, we also examined the benefits of applying 20 kgs. of N per hectare to LV's, and 40 kgs. to MV's of wheat, on the grounds that it is the first few units of N which give the highest benefit/cost ratio. For LV's of wheat the additional profits per rupee of cost using 20 kgs. of N was about 80 per cent higher than using optimum N levels on LV's. For MV's of wheat, 40 kgs. of N gave about 20 per cent higher additional profits per rupee of cost than the optimum cost of N on MV's.

5) Application of 20 kgs. of N per hectare on LV paddy gave 70 per cent higher additional profits per rupee of cost than practice B. 40 kgs. of N per hectare on MV paddy gave 40 per cent higher additional profits per rupee of cost than practice C.

seed itself will be highly profitable, particularly in the rabi. Of course additional profits per hectare are greatest for practice C in these regions. However, on an additional profit per rupee of additional cost basis, practice A is well ahead of both C and B. For the Central and Northern Regions in the kharif, a switch to MV's of paddy without fertilizers is unprofitable. Applying fertilizers to LV's is also more profitable in these regions than applying it to MV's, whether using profits per hectare or profits per rupee of cost as the criterion.[6] These data no doubt help to explain the varying levels of adoption of MV's of paddy in different states and their popularity in the rabi season.

In the case of jowar as shown in Table 1, a simple switch to MV seed is highly profitable, with the marginal returns per unit of cost around ten and profits per hectare around Rs.1000 in most cases. Profits per hectare are greater if extra fertilizer is applied to MV jowar, but the profits per rupee of cost are much lower than practice A.[7] Applying fertilizer to LV's of jowar is not nearly as profitable as practices A or

Applying optimum levels of N fertilizer to MV's of maize generates extra profits per hectare of more than Rs.2000. This is five times more

6) It should be recalled that the levels of fertilizers being compared here are not necessarily the economically optimal ones. With optimal doses applied to both LV's and MV's the situations may be different.

7) Although the additional profits per rupee of cost from applying just 40 kgs. of N per hectare to MV's of jowar was about double that from the optimum levels of N.

profitable per hectare than just changing to MV seed, but the latter practice is ten times more profitable per rupee of additional cost. Applying optimum levels of N fertilizer to LV's of maize is also very profitable at some Rs. 1,100 per hectare, although it rates well below practice C on a profit per rupee of cost basis.[8/]

Applying optimum N fertilizer levels to MV bajra is also highly profitable, as was shown for jowar and maize, at around Rs. 2000 per hectare. The simple change to MV seed with no fertilizer generates only about Rs.700 of added profits per hectare. In terms of returns on additional costs though, the latter practice is ten times better than the former.[9/] Fertilizer applications to LV's of bajra are not very profitable by any criterion.

The question arises as to why the adoption rates for MV maize and MV jowar have not been as great as they have been for wheat, bajra and paddy in the light of the apparent large potential profits to be made from just trying the new seeds.[10/] No doubt the fact that wheat is

8) Additional profits per rupee of cost can be doubled by applying 20 and 40 kgs. of N per hectare to LV's and MV's respectively, compared to optimum N levels.

9) Again, the additional profits per rupee of cost can be more than doubled by reducing N fertilizer levels to 20 and 40 kgs. per hectare on LV and MV bajra, respectively.

10) According to Dalrymple [2, pp.48-51], the proportion of high yielding varieties of wheat and rice sown to the total areas of the crops in 1970-71 was 32.9 and 14.7 per cent, respectively. Rao [16, p.5] indicates that the equivalent percentages for bajra, maize and jowar in 1971-72 were 15.8, 8.7 and 5.4 respectively.

generally irrigated has a lot to do with its high adoption rate. Irrigation apparently has the effect of reducing the risk and enhancing the profitability of MV's and of the fertilizer applications on them. This is not so with bajra, which is largely unirrigated.

One might be led to conclude that the data in Tables 1 and 2 do not really express the relative riskiness of adopting new practices. For example, Kanwar *et al.* [7] showed quite clearly by individually analysing the hundreds of experiments in farmers' fields which Rao [16] also used, that in about three out of every four fertilizer experiments on MV jowar, the profits from fertilizer applications were negative. In MV maize less than one in ten gave negative profits in most areas, and in MV bajra the figures were about one in two in unirrigated experiments and one in four in those irrigated. MV jowar adoption may hence be insignificant partly due to the inherent riskiness of the new MV's, even at low levels of fertilizers. The additional returns per rupee of additional investment in MV seed for jowar is also much lower than for MV maize and bajra from Table 1. This could be another factor in explaining poor adoption of MV jowar. Data from the Indian Institute of Management study in the Bellary District of Mysore State in 1972-73, show that a shift from LV's to improved local varieties of jowar had a much higher pay-off per rupee of additional investment than a shift from LV's to MV's.[11/] The

11) In this study the values of by-products were also included. This was not done in Tables 1 and 2 as the data were not available.

Table 3. Addition in Costs, Yields and Returns Per Hectare from Change from One Variety to Other and Adopting Different Levels of Package of Practices in Jowar in Bellary District of Karnataka, Kharif, 1972[a]

Item	Unit	Shift from: Local to Improved Local Variety	Local to Hybrid (non-programme)	Local to Hybrid (Programme)	Improved local to Hybrid (non-programme)	Improved local to Hybrid (Programme)	Hybrid (non-programme) to Hybrid (Programme)[b]
Seed	Rs/ha.	0	32.5	42.5	32.5	42.5	10.0
Farmyard Manure	"	5.0	12.5	20.0	7.5	15.0	7.5
Fertiliser	"	15.0	55.0	272.5	40.0	257.5	217.5
Pesticides	"	0	2.5	15.0	2.5	15.0	12.5
Human Labour	"	- 5.0	12.5	10.0	17.5	15.0	-2.5
Bullock Labour	"	- 7.5	2.5	7.5	10.0	15.0	5.0
Other Variable Costs	"	2.5	2.5	10.0	0	7.5	7.5
Total Variable Cost	"	10.0	120.0	377.5	110.0	367.5	257.5
Additional Yields	Kg/ha.	165	440	705	275	540	265
Additional Profits	Rs/ha.	147.5	222.5	162.5	75	15	-60
Additional Profits per rupee of additional cost	Rs/Re.	14.7	1.85	0.43	0.68	0.04	-0.23

a Source: Krishnaswamy and Patel (10, p.76, Table 4.1, p.87, Table 4.7).

b Hybrid (Programme) means the cultivation of the crop under the full package of practices as recommended by the action programme working groups under the supervision of the lead bank agricultural officers. Hybrid (non-programme) means cultivation of the crop as done by the cultivator.

improved local varieties are generally still classified as "local" when estimates are being made of the rate of adoption of high-yielding varieties.

MV bajra may be more popular because the probability of a profitable fertilizer response is much greater than that of MV jowar as shown by Kanwar *et al.* [7].[12/] But MV maize apparently has the greatest probability of a profitable fertilizer response according to the same authors, yet its adoption percentage is about half that of MV bajra. The explanation for this may be in the inferior consumer characteristics of the new maize varieties or in unavailability of seeds etc. However, the latter problem would not appear to be peculiar to the MV's of maize alone. It has apparently been a general problem in the high yielding varieties programme.[13/]

12) Furthermore, it may be more critical in the case of MV jowar to follow all other practices such as seed treatment, plant protection, intercultivation etc., than in other crops. The fact that more than 50 per cent of participants in the "package programme" investigation by the Programme Evaluation Organization of the Planning Commission [14, pp. 159-168] adopted all four recommended practices, compared with about 9 and 17 per cent in wheat and paddy respectively, might suggest this.

13) See for example Programme Evaluation Organization, Planning Commission [13, p.38].

CONCLUSION

It would seem that, on the basis of this admittedly rather limited amount of evidence, there is a case for closer examination of the current emphasis in research and extension on the "package of practices" approach. If we are aiming at increased levels of adoption of new technologies to improve the well-being of both farmers and consumers, the present analysis suggests that parts of the package alone can have a significant contribution.

This is not to deny the obvious advantages in complomenting parts of the package with other parts which have multiplicative rather than additive effects on yields and profits. These are the "synergistic effects" which Swaminathan speaks of [19, pp.29-30]. The data presented clearly show the superior profits per hectare which can be earned by combining optimum doses of nitrogen fertilizers with a change to a MV for all crops examined. The thrust of this paper was to indicate that significant yield and profit increases may still be generated by less radical changes in technology involving perhaps such minimum cost and minimum risk strategies as a change in the variety of seed used. Of course in some cases it may be a more economical use of limited extension resources to concentrate on the whole package in attempting to encourage adoption, rather than on parts of the package. This must be weighed up against the possible effect of this approach on non-adoption of parts of the package.

If, as seems plausible, many farmers in less developed countries are constrained by internal and/or external liquid capital rationing, then the return per unit of that limited liquid capital becomes an extremely important criterion governing decisions. Returns per hectare of land can be less relevant in making decisions under these circumstances. In most instances it is small farmers who are faced with this type of constraint. In the majority of the experiments analysed in this paper the additional profits earned per unit of expenditure on a practice involving a minimal change was equal to or greater than the benefits from the more complex and much more expensive packages. For dryland crops the minimal change (Practice A) generated much larger additional profits per rupee than the similar practice on irrigated wheat and paddy. It is only a guess as to how many small farmers might have adopted small portions of the package and reaped significant rewards on the way to possible complete adoption at some later time, had research and extension placed more emphasis on presentation of a "range of input options" rather than a "package of input practices". It is useful to distinguish here between changes in management practices involving little if any additional cost, and changes in use of expensive inputs such as chemical sprays and fertilizers. Management practices of course can be included in recommendations for MV's for virtually all farmers. When it comes to more expensive input practices, recommending options for different farmer constraint situations would seem appropriate. It is the latter which were the prime concern in this paper.

In this respect it is heartening to see the approach being taken by the International Rice Research Institute in determining the separate and combined effects of various management practices and input levels on rice yields in farmers' fields.[14] These experiments involve evaluation of recommended practices such as insect control, water management, fertilizers, weed control, seed source and seedling management, compared with farmers' existing practices in a factorial experimental design. Single and interaction effects are measured and economic analyses performed to determine which practice(s) generate the highest returns. This approach is commended to all research workers as a model for emulation. It is this type of approach which we hope to eventually develop in collaboration with our colleagues here at ICRISAT and in the various national programmes.

14) See the papers by Gomez *et al.* [4] and the International Rice Research Institute [6]. Similar work on maize is being done by E. Baker and his colleagues at the Institute of Agricultural Research at Samaru in Northern Nigeria (A.H.Kassam, personal communication).

REFERENCES

[1] Basu, N., *Employment Potential in Agriculture*, Progressive Agro-Industrial Consultants for National Commission on Agriculture, Government of India, March 1973.

[2] Dalrymple, D.G., *Imports and Plantings of High Yielding Varieties of Wheat and Rice in the Less Developed Nations*, United States Department of Agriculture, Foreign Economic Development Service, FEDR-14, February, 1972.

[3] Desai, M.D., and K.K.Mohan, "Green Revolution and Farm Labour Use : The Case of the Kaira District", *Artha-Vikas*, 51-59, July, 1970.

[4] Gomez, K.A., D.Torres and E. Go, "Quantification of Factors Limiting Rice Yields in Farmers' Fields", International Rice Research Institute, Philippines, Saturday Seminar, Statistics Department, November 24, 1973 (mimeo.).

[5] Gowda Channe, M.B., and K.A.Jalihal, "Adoption of Package of Practices by Paddy Farmers of Mandya District in Karnataka", *Mysore Journal of Agricultural Science*, 8(2): 276-282, 1974.

[6] International Rice Research Institute, "A Proposed International Rice Agro-Economic Network (IRAEN)", Draft mimeo., April, 1974.

[7] Kanwar, J.S., M.N.Das, M.C.Sardana and S.R.Bapat, "Are Fertilizer Applications to Jowar, Maize and Bajra Economical?", *Fertilizer News*, 18(7) : 19-28, 1973.

[8] Kanwar, J.S., "Twenty Five Years of Research in Soil, Fertilizer and Water Management in India", *Indian Farming*, August 1972.

[9] Krishnamurthy, Ch., S.L.Chowdhury and E.D.Spratt, "New Horizons for Dry Farming in the Rainfed Tropics - Results of the All India Coordinated Research Project on Dryland Agriculture", paper presented at the FAO/UNDP Expert Consultation Meetings on the Use of Improved Technology for Food Production in Rainfed Areas of Tropical Asia, Hyderabad, India, November 24-30, 1974.

[10] Krishnaswamy, M.S. and K.V.Patel, "Managing an Action Programme for Dryland Agriculture", Monograph No.48, Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad.

[11] Mahindra Singh, B.A.Krantz and G.B.Baird, "Agronomic Production Techniques in Sorghum", in N.G.P.Rao and L.R.House (ed.) *Sorghum in Seventies*, Oxford and Ibh Publishing Co., New Delhi, 1972, pp.302-333.

[12] Murthy, B.R., "Response of Hybrids of Sorghum (Jowar) and Pennisetum (Bajra) to Nitrogen", *Journal of the Post-Graduate School*, Indian Agricultural Research Institute, 5(1) : 147-157, June, 1967.

[13] Programme Evaluation Organization, Planning Commission, *Evaluation Study of the High Yielding Varieties Programme*, Report for the kharif 1967, Government of India, August, 1968.

[14] _____, *Evaluation Study of the High Yielding Varieties Programme*, Report for the Rabi 1968-69, Government of India, November, 1969.

[15] Raheja, S.K., *et al.*, "Crop Response to Potassic Fertilizer Under Different Agro-Climatic and Soil Conditions", *Fertiliser News*, 15(2) : 15-33, February, 1970.

[16] Rao, V.K.R.V., *New Challenges Before Indian Agriculture*, Dr. Panse Memorial Lecture, Institute of Agricultural Research Statistics, New Delhi, 26th April, 1974 (mimeo.).

[17] Saxena, P.N. and A.S.Sirohi, "Response of Mexican Dwarf and Indian Tall Varieties of Wheat to Nitrogen Application", *Journal of the Post-Graduate School*, Indian Agricultural Research Institute, 5(1) 123-148, June, 1967.

[18] Shah, V.H., "An Analysis of Response of Hybrid Maize to Nitrogen", *Journal of the Post-Graduate School*, Indian Agricultural Research Institute, 5(1) : 158-168, June, 1967.

[19] Swaminathan, M.S., *Our Agricultural Future*, Sardar Patel Memorial Lectures, India International Centre, New Delhi, October 30-31 and November 1, 1973.

[20] Venkataram, J.V. and R.Ramanna, "Economic Aspects of High Yielding Crops - Hybrid Jowar", *Indian Journal of Agricultural Economics*, 23(4) : 132-138, October-December, 1968.

JGR:KVS:NSR
May 30, '75

APPENDIX

Prices Used in the Analyses (1974)

Price of Nitrogen			Rs.4.355 per Kg.
Price of Produce:			Rs./Q.
White Jowar		...	115.00
Bajra		...	104.00
Maize		...	120.00
Dwarf Rice		...	95.00
Local Rice		...	105.00
Wheat		...	130.00
Price of Seeds:			Rs./Kg.
Wheat -	HYV	...	3.75
	Local	...	2.30
Paddy -	HYV	...	2.20
	Local	...	1.00
Jowar -	Hybrid	...	12.00
	Local	...	2.00
Bajra -	Hybrid	...	9.00
	Local	...	2.00
Maize -	Hybrid	...	4.00
	Local	...	3.00
Seed Rates:			Kg./ha
Wheat -	Local	...	90
	HYV	...	100
Paddy -	Local	...	22
	HYV	...	50
Jowar -	Local / HYV	...	10
Bajra -	Local / HYV	...	
Maize -	Local / HYV	...	15

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