Economics of Crop Diversification: An Analysis of Land Allocation Towards Different Crops

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Abstracts

Agricultural development in West Bengal during the post-Green Revolution period is associated with diverse changes in cropping pattern. Cropping pattern in terms of acreage allocation has changed largely in favour of boro rice, potato and mustard. The changes in cropping pattern may be due to various reasons. This present paper tries to analyse the basic reason behind the relatively rapid growth of those crops.

Key wards:

Crop diversification, crop cycle, cropping pattern shift, combination shift

JEL classification No.: Q1, Q10, Q15

Economics of Crop Diversification – An Analysis of Land Allocation towards Different Crops [1]

Basic Argument:

Changes in cropping pattern or crop diversification in terms of acreage allocation among different crops are the integral part of agricultural development of any region. The diversification in any particular geographical area is based on the changing social, economic, technological, geographical[2] and institutional structure of that region. Specificity of requirement of different factors in case of different crops and their availability on time as well as the system of agriculture (subsistence i.e., for self-consumption or commercial i.e., for making money) are the key factors in determining acreage allocation.

The diversification of crop in terms of variation in acreage allocation, among the crops has taken place remarkably, in West Bengal during the post-Green Revolution period. The changes have taken place largely in favour of boro rice, potato, oilseed as a whole (especially mustard) (De UK, 1999). Though in the early years of post-Green Revolution period, area allocation had moved in favour of wheat, it later turned gradually from wheat to other rabi-crops (say), potato and mustard. This can be attributed to the importance, attached to food crops' production in order to tackle the scarcity of food supply in the country (and state as well) in the immediate post-Green Revolution period[3]. But after having obtained self-sufficiency in foodgrains production, agriculture became increasingly commercialised.

Objective of the Study:

The present paper tries to explain the basic reasons behind the increasing allocation of land towards Boro-rice, Potato and Mustard in West Bengal during the post-Green Revolution period.[4]

Critical analysis of some earlier studies:

Major underlying factors which are conceived to be of great importance in determining the allocation of land resources among competing crops[5] are prices and yields of different crops, level of

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[1] The paper is drawn on the basis of chapter-8 of author's Ph.D. thesis submitted at the University of Burdwan in January 2000. The author is indebted to his Ph.D. supervisor, Dr. S. K. Datta of Burdwan University, for his constructive suggestions. He is also grateful to UGC for providing financial assistance through minor research project.

[2] Geographical structure includes the location of the place, elevation and slopes of agricultural land and other agro-climatic conditions.

[3] At that time India had to import much food to meet her domestic consumption need. A large part of food imports during the fifties came in the form of United States PL480 aid, with generous repayment conditions. For reference: (i) Government of India (1959), Report of the Foodgrains Enquiry Committee, (ii) Nilkantha Rath and V. S. Patvardhan, Impact of Assistance Under PL480 on Indian Economy, Gokhale Institute of Politics and Economics, Poona, 1967.

[4] Here the period 1970-71 to 1994-95 is considered for the purpose of study, mainly because Green Revolution though started in mid-sixties in the country, in West Bengal it stated in the early part of seventies and data concerned to the study were not available beyond 1994-95.

[5] Competing crops are defined as crops among which area shifts can occur. In other words those are the potential rivals who compete for any plot in a particular place. Different places may face different crops to compete for attracting land areas.

irrigation, availability and variation of other agricultural inputs (pattern of agricultural implements, varieties of seeds, synthetic fertiliser etc.) and geographical characteristics of the respective region.

On the one hand, high relative price and productivity of any crop at the existing state of technology, given other conditions of agricultural production (in other words, high relative profitability) may create an affinity of the farmers towards that crop and vice-versa. On the other hand, the other factors like rainfall, irrigation, improvement and availability of technology (Narayanamoorthy, 1997) etc. at relatively cheaper cost which generate conditions congenial for the farmers to produce some crops which, without the aforesaid facilities could hardly be feasible[6]. Thus, a change in these factors may be associated with a change in the cropping pattern. Specific crop has specific time and quantum of requirement of these factors, due to the particular biological nature of the production process of different crops. Adequately and timely appearance of these factors in different seasons push forward the farmers to allocate land or expand production of crops specifically, sensitive to those specific factors.

Here actually, the distinction between these two types of encouraging factors is made only to mark the nature of influence that, they exert on the farmers' cropping decision. It is of course true that, profitability influenced through changes in productivity or yield is partly dependent upon the supporting force of these input factors. Conversely, attractive price and profitability of some crops relative to that of the others may encourage the modification and innovation of technical implements needed to remove the conditions hostile to the production of those crops. For example, increase in relative profitability of potato has led to expansion of potato cultivation on the land (which would otherwise have been used for producing other relatively lower value crops[7], or remain fallow during that season) where it was not possible earlier, with the help of manual labour[8]. This shift of area from other crops to potato or extension of potato cultivation on new land has become practicable after the modification and innovation of technology (application of increasing number of tractors, power tiller etc.) and growth of suitable, highly resistant seeds.

In the short run, changing price may not bring about a significant change in acreage under crops. This is due to the particular biological nature of agricultural production. If price changes in the post cultivation or harvest period of any crop, it would not have any impact on its acreage during the same season/year. However, it may have effect in the next year (next crop rotation) when the particular season will recur. Sometimes, due to substitutability in consumption a change in price of some crop may influence the area under other crop/crops that follows the former in the same crop rotation. For example, an increase in price of aman rice/mustard may cause shift in area under boro rice/til, since aman and boro rice are

[6] Production will not be the same, if these factors do not support favourably, even though the farmers opt for cultivating any crop (being tempted by high price or yield observed in the same or any other region) that requires essential services of these factors.

[7] Any crop can not always remain relatively more or less profitable than the others can can. It depends on the dynamic character of not only prices, but also of yields and cost of production which would change over time consequent to a changes in variation in techniques of production and vagaries of nature.

[8] In earlier days most of the farmers could not cultivate potato on a large scale (or mainly on commercial basis) because it would require huge manual labour and cattle to plough. So it was not possible to complete the cultivation of many plots within the desired time period.

substitutable in consumption, as are mustard and til. But the preparation time and other facilities like, irrigation may limit the possibility of expansion. Moreover, if both boro rice and til were to expand simultaneously (as they are cultivated during the same season) a tussle between them would begin. It is also true that the impact of rising price in this case is not so prompt as that of decrease in price. This is because the cultivator can easily reduce area under any crop if he desires, than when he wants to expand. However, the market forces (price and profitability) have the ultimate bearing on the changing *cropping pattern* in a region endowed with full flow of productive resources and a well-established market structure[9]. High relative price and so profitability[10] of any crop has the motive force that evokes the farmers to come forward to generate means for the growth of that crop.

Existence of alternative opportunities however, creates a conflict of allocation of land resources to alternative crops when there is limited availability of land. In the traditionally backward society, the farmers, specifically small and marginal farmers usually allot a major part of their land holding for the production of means for their self-use. With the development of marketing system or growing commercialisation, farmers increasingly switch over to some specific crops[11]. Production in this system is maintained mainly for earning profit. In this system of capitalist farming it is possible to collect the means of requirement from the market in exchange of money that had earlier been obtained in exchange of goods produced by the individual farmers.

Explanations of responsiveness of area under different crops are not adequate. Most of the earlier studies designed to analyse the impact of different factors on the acreage growth under different crops, have recognised all types of factors, noted above. But many of them have put emphasis either on market forces or input adequacy factors in isolation. Relative prices are much recognised attracting force that plays a crucial role in the determination of acreage of different crops of any region. Studies available in this line are prominently due to J. D. Black (1924), B. B. Smith (1925), L. H. Bean (1929), J. M. Cassels (1933) and R. M. Walsh (1944), Nerlove (1958), Narain (1965), Vyas (1996) etc.

Many of them, to analyse, the supply response to price have used acreage as an approximation of planned output. But that may not be a good procedure. As both acreage and yield determine output, it can be approximated by acreage only if yield is expected to be constant. But it cannot be a reasonable assumption because in the long run, technological change is very likely to cause an improvement in yield[12]. So expected yield should have also been taken into account, which was later considered by Nerlove. Moreover, prospective yield has some kind of motivating force, which would in the long run affect the

[9] Even if full scale multiple cropping is not possible and cropping is done only once in a year, the inter-crop acreage shift is possible.

[10] The implicit assumption here is that, though yield of different crops may change, the relative yield is most likely to remain unchanged.

[11] The set of specific crops is determined by the profit motive and thus would change as profitability of crops expected by the farmer change.

[12] Each year, some plots are usually abandoned in the midway of the season due to flood or drought. Sometimes it becomes very costly to tide over all, those adverse situations and thus the cultivators may revise their target production of crops. Vagaries of nature may also be considered by them to form expectations regarding future yields, which is very difficult to include in a model.

acreage planning of farmers. Long run shifts in acreage from one crop to another, for whatever reason, change the relative importance of different crops. As prices of crops, which compete for area, may play a relevant role in this inter-crop acreage shift, prices of competing crops could always be explicitly introduced in the explanation of acreage diversification.

In his pathbreaking analysis, Nerlove has explained the price responsiveness of farmers in terms of a *partial stock adjustment model* (a dynamic model), which later has been used by many agricultural economists in their explanation of *cropping pattern* change. In his analysis he has distinguished between the actual and expected normal price[13]. Expected normal price was found to be more important factor in determining long run equilibrium acreage in contrast with the actual price level. Prices in his econometric approach were assumed to be independent data and farmers were the price takers and they adjust acreage distribution in response to the variation of prices and their expectations regarding future values. The farmers however, can not adjust area allocation immediately. There is always a time lag between the price variation and the consequent adjustment measures taken by the farmers on their cropping decision. The extent of time lag for adjustment depends on the nature of the commodity and the *adjustment bottlenecks* (specificity of input bottlenecks) which again depends on the time needed to make up the lack in the input requirements. Thus he had introduced an *adjustment factor* in the same way as the *coefficient of expectation* introduced in his model.

Dharm Narain (1965) in his pioneering work has observed that the shifts in *cropping pattern* are traceable to changes in the relative prices of crops, expansion of irrigation and changes in technology, all of which alter the relative profitability of crops in ways which affect different regions differently[14]. In his explanation of impact of price movements on areas under crops, he made a distinction between the *production for self-consumption* and *production for market*. Production for self-consumption in his system means the production of foodgrains and production of commercial crops indicates the production of non-food crops. He also made the hypothesis that proportion of area under commercial crops increases with the size of the land holding. This statement finds support from the argument that the small farmers allocate major portion of their holdings for the production of food crops to meet their own (family) consumption need while the large farmers could afford a large portion of their area for non-food crops. So a large farmer can be assumed to be more commercial minded than a smaller one because he has a larger surplus to sell.[15] In his study rainfall, broadly weather, is found to have a leading role in determining the area to be allocated for growing foodgrains, whereas, the prices (market forces) are the leading determinants of area under commercial crops. Moreover, price relatively to weather becomes a feebler consideration when different food crops compete among themselves for area. However price acquires the prime consideration when foodgrains as a whole compete with the cash crops.

[13] Nerlove M. (1958), ibid, Chapter 2 and 3.
[14] Dharm Narain (1965), *Impact of Price Movements on Areas under Selected Crops in India: 1900-1939*, Cambridge University Press, ch.1.
[15] Raj K. N., Sen A.K. and Rao C.H.H. (ed.), (1988), ibid, Ch.1, pp.32-33.

Most of the aforesaid studies, in order to explain the price responsiveness, have often used the deflated price of crops. Different analysts have used different indices for the adjustment of price[16]. In Walsh's study, it was the index of goods and services, which the farmer buys. Rationale of using this index derives from an effort to arrive at "real" price i.e., the *purchasing power* of the nominal price the farmer gets[17]. But the basket purchased by farmer contains the goods for his direct consumption as well as the inputs or implements for the production of commodities. If the portion of direct consumption goods constitute a very negligible part of total expenditure then the argument will have some relevance. This is because the portion of his purchase that goes to inputs and implements will affect the cost of cultivation and so when the price is deflated by the aforesaid index the changing cost is scraped out of the profit function. The influence of price of commodity he produces as well as yields remains the only determining factor. On the other hand, if the consumption goods constitute a major part of the purchasing basket then an upward variation in price of those commodities will raise the cost of living and will force the farmer to exert more pressure on land to earn more. In that case also, if it is not possible to expand net or gross area under cultivation a substitution of land from lower value crops to higher value crops may take place. The adjustment of price by this index in that case results in wiping out the effect of changes in cost of living. This is most likely that, small farmers spend relatively more on goods for direct consumption whereas; the big one spends more on means for production. So the case would be different for the two types of farmers.

Another argument which may be advanced against it is that, any rational farmer in a modern agricultural system always tries to maximise his net agricultural income from his limited holding, whatever be the expenditure on the goods he buys. If the cultivator is purely commercial, it is the changing relationship between the prices or in principle the comparative profits of different crops that are likely to provide the stimulus to change in area under individual crops. Where relative profitability is involved, any correction for changes in costs, which is uniformly applied to different crops, is meaningless. Since the cost components of different crops are different and so the incidence of variations in constellation of factor prices on various crops will be different. Thus, price of each competing crop should have a distinct adjustment factor, which is very difficult to calculate. Moreover, if the farmer compares relative price of competing crops in explaining the relative area allocation, then deflation of each price by a common denominator does not matter much.

Some of the former analysts have used the general index of wholesale prices to deflate the price, who seeks to remove the effects of forces which, influence prices in general, so that 'corrected' price may reveal changes specific to the particular item under study. The use of this general index of agricultural prices rests on the belief that a general decline in the prices obtainable for the several crops the farmer grows, or can grow, would not by itself induce him to contract his total sown area. A fall in his earning

[16] Price is deflated to isolate the real change in price of crop whose acreage variation is to be analysed and to eliminate the variation in other economic factors. This is done to arrive at the conclusion regarding the effect of real change in price of crops under discussion on its acreage assuming other things as constant.
[17] Raj K. N., Sen A.K. and Rao C.H.H. (ed.), (1988), op. cit. P.12; Walsh R. M., ibid.

notwithstanding, he will endeavour to make the most of his resources by concentrating on crops, which are relatively more profitable.

In the context of per unit prices one may consider cost per unit of output, instead of cost per unit of area. But the former varies with every variation in yield and these variations cannot be assumed to be too small. In the present analysis this will be considered by taking into account the proceeds per hectare (price times yield per hectare). This variable i.e., relative proceed is a pertinent indicator of relative profitability where relative changes in cost is not significant between crops. Then it can also be found out whether the farmer responds more to proceeds in preference to price.

The deflation of price by general index of agricultural prices also suffers from some kind of drawbacks. It is true that (as is appeared in Raj et al.) the prices, relevant to the farmer's sowing decisions are the prices of a crop relative to that of crops, which compete for area with it. All the agricultural crops cannot be directly competitive for area with any particular crop. Only the crops that can be grown during the same season (say mustard, wheat, rabi-pulses etc.) will be competitive to any crop (say potato). So in case of deflating the price, one needs to consider the prices of those competitive crops. In practice, however, a difficulty arises from the fact that competing crops cannot always be placed into well-demarcated groups and these groups do not form rigid categories. In this case Dharm Narain has prescribed for using the general index of agricultural prices. The above argument is also not perfectly true, because the seasons of some crops grown successively are overlapping. So, due to the overlapping harvesting and sowing season, cultivation of any crop can affect the cost-benefit of its successor. In that way they can be partially competitive. This question will be considered in the latter part of this study.

The choice of the above index also involves another kind of problem. Since price of the crop, which is to be rectified, is also involved in the general index of agricultural prices, a part of its own variation will be out of consideration. The crop, which has greater weightage in the index, will suffer relatively, more than the others. Therefore, it is better to use explicitly the price of competing crops[18].

Another basic argument, which may be placed against Dharm Narain's division of food crop and commercial crop, is that no such accurate demarcation is possible. In a well-developed system of agriculture accompanied by a good market structure, crops may be grown on a commercial basis. Market can play an important role in the determination of acreage of competing crops. There may be a simultaneous relationship between acreage and price. Any crop, even food crop, can turn into commercial crop if it is produced mainly for earning money, in spite of the fact that food crops are essential for daily consumption. This is because; the migration of foodgrains from a surplus zone to deficient zone is always

[18] Since the area under any crop at any time displays the maximum amount that it can surrender to other crops, the competitive crops having a very small area under them would be kept out of the present analysis. A crop with a small area under it cannot make a large difference to the area under crops being discussed about. So relative areas under crops could be used as the basis for weighing prices of crops under discussion. But the area under a crop though sets limit on the maximum area that it can lose; it sets no limit how little it may surrender. There is no compulsion for a crop occupying a large area under it, to lose in a big way. Besides, although a crop cannot lose more than it has the area under the crop does not set a limit to its capacity to snatch area from other crops.

possible through the market. In a well-developed system, any crop can be obtained in exchange of others where, money plays an important role of medium of exchange.

Vyas (1996) has argued that the significant changes in cropping pattern in India could be explained in terms of a change in relative prices. R Chand (1996) Narayanamoorthy (1997), Singhal and Gauraha (1997), Singh, Rai and Karwasra (1997), and Bhalla and Singh (1997) also explained the differential role of all the noted factors in the acreage expansion of different crops in various regions.

Price responsiveness is however one aspect of the impact of the market forces on the cropping pattern change. Equally important are the market infrastructure and the institutional arrangements. If the transport and communication system is weak and there exists problem of imperfect information, cropping pattern is bound to differ from what it ought be, since the precision of the expectation formed regarding future is contingent upon the appropriateness of the actual information available. The delivery system of inputs and credit are also other important factors in determining cropping pattern decisions of the farmers.

Econometric Analysis of Acreage Growth of Boro rice, Potato and Mustard

Regression method:

Impact of major factors like, irrigation, rainfall, chemical fertiliser, yield and price etc. on the acreage change of the aforesaid crops will be first explained in terms of multiplicative regression analysis. The three crops boro rice, potato and mustard have been considered only because of the burgeoning growth of these crops relatively to the others in the cropping scenario of West Bengal throughout the entire period except a few sudden disorders. Before going into the details of modus operandi some important points (related to our discussion) should be noted.

(i) Any crop may gain in area due to substitution in one place and may lose area to other crops in another place simultaneously. The possibility of this kind of change is more likely when one considers a large area like, West Bengal. In this case it is better to pursue the analysis for a smaller area, like a district. But the possibility of occurrence of the aforesaid problem cannot be completely ruled out.

(ii) Yields of crops especially, the expected yields have an important role where crops compete among themselves for a particular plot. But due to agro-climatic reason, absolute and relative yields of crops differ across the region and the same land behaves differently for different crops. Moreover, inter-crop competition for area changes across the region as well as from year to year. So it is very difficult to have a particular set of crops, which are competitive to some other crop or set of crops in all circumstances. In a large area number of crops compete for area with a crop is very large and thus it is very difficult to manage all of them. Number of competitive crops will be limited and manageable, if the analysis covers a small region. The minimum area for which comprehensive data on major variables are available is a district. So the regression analysis is performed for the district of Burdwan, which is reckoned with as a good agricultural district called the granary of West Bengal.

For the purpose of analysis, three stochastic forms of equations are considered. These are,

1. $\text{Ln } A_{it} = a_0 + a_1 \text{LnR}_t + a_2 \text{LnI}_t + a_3 \text{LnC}_t + a_4 \text{LnY}_{it} + a_5 \text{LnP}_{i-1} + a_6 \text{LnY}_{jt} + a_7 \text{Ln } P_{j-1} + a_8 D_t + U_{1t}$

2. $\text{Ln } A_{it} = a_0 + a_1 \text{LnR}_t + a_2 \text{LnI}_t + a_3 \text{LnC}_t + a_4 \text{LnT}_{it} + a_5 \text{LnT}_{jt} + a_6 D_t + U_{2t}$

3. $\text{Ln } A_{it} = a_0 + a_1 \text{LnR}_t + a_2 \text{LnI}_t + a_3 \text{LnC}_t + a_4 \text{Ln } (P_{i-1} Y_{it} / P_{j-1} Y_{jt}) + a_6 D_t + U_{3t}$

Here, A_{it} represents acreage of i^{th} crop in t^{th} year, R is the level of rainfall measured in millimetre, I is the area under irrigation (only government canal is considered), C represents consumption of chemical fertiliser, y, the yield of the particular crop. D is the dummy variable, where, D takes value 0 in a pre-land reform year and 1 in the post-land reform years started with 1979[19]. Here the inception of land reform year is supposed to coincide with the time when collection and distribution of vested land to the landless people started in West Bengal[20]. a_js are the elasticities of acreage growth with respect to j^{th} explanatory variable and U_is are the conventional random disturbance term. Here P_{i-1} and P_{j-1} represent respectively price of i^{th} crop and j^{th} crop lagged one year. Suffix j is used to denote the crop or crops that can be grown during the same season on the same field on which i^{th} crop is cultivated. U*i*s are the random disturbance terms. a_6 and a_7 in equation-1 are the cross yield and price elasticities of area under i^{th} crop with respect to yield and price of j^{th} crop. Similarly $T_i = (P_{i-1}.Y_i)$ and $T_j = (P_{j-1}.Y_j)$ are the proceeds per hectare of i^{th} and j^{th} crop evaluated at the previous year's prices. a_4 and a_5 in equation-2 represent direct and cross elasticities of area under i^{th} crop with respect to proceeds per hectare of i^{th} and j^{th} crop respectively. Equation-3 where proceeds in ratio form; are included, is considered on the presumption that, farmers would still continue to produce i^{th} crop if relative revenue is increased, irrespective of the direction of price movement. This is done to know whether the cultivators are much concerned with the relative revenue of crop, whatever is the cost. It is however true that; variation in yield is associated with a change in cost per unit of area. The implicit assumption is that the cost of production per unit of area either has not changed or even if it has happened, had affected all the crops in a similar fashion or the farmers had taken it at a discount.

Major competitor of boro rice in Burdwan is til. But the data on price and yield of til are not available for a major part of the period. Though price could be substituted by the price of its substitutes in use (consumption) say, mustard, the method can hardly be applied for yield. Hence it is kept out of consideration. On the other hand potato, mustard and wheat are the principal competitors during rabi season in the district. So price and yield of all of them are taken into consideration in the regression analysis for area under any one of them.

Here prices of crops and that of competitors of the preceding year are included. In addition to that yield of substitute crops should be included along with the yield of the crop under consideration as they also have an impact on the allocative decision of the farmer. However, there is usually observed considerable lag between the changes in prices of crops and acreage allocation. The price, which motivates production decision, should neither be the price at the beginning of the production process (just prior to the sowing time) nor should it be the price at the end. The former does not determine profits as it generally undergoes changes during the process. Even if the price variation that has occurred just before the sowing

[19] The equations represent a modified Cobb-Douglas form of equation.
[20] There is the likelihood of the presence of a time lag after which the effect (it has) would be realised.

time, the decision of the farmer is assumed to remain unaltered. He can hardly take it into account, as there may not be available sufficient time for the preparation of land, which can be reallocated to suitable remunerative combinations. Price at the end of the period is unborn when production is initiated. Nerlove has used a series of past prices with weights declining over time in his lag adjustment model from which the acreage variation is estimated. In practice however the immediate previous results are believed usually to play a predominant role in determining expectations and farmers even in advanced countries have found to respond to actual prices. Thus the use of these latter "although not strictly in accord with the theoretical definition of supply price, ought in fact to yield results that are nonetheless significant" (Cassel, 1933). Nerlove's method though more scientific and consistent, can not be applied here primarily since the channels through which price information is disseminated are not so well developed in the countryside of a developing economy like West Bengal as in advanced countries[21]. Moreover, Nerlove has explained acreage variation with an emphasis on the substitution between competing crops, which is more appropriate in a situation of pure commercial structure. In the present case area under any crop has been changing significantly due to substitution as well as expansion of total area under cultivation and there are several sorts of changes (cost of production, market structure, government policies), which ought to be taken into account for the adjustment of prices. However, it is very difficult to take care of all of them as they are subject to continuous change. In addition to that, farmers in most of the regions are mostly influenced by the pioneering role of a few innovators, who take the risk of introducing a new technology in the production of crops. Sometimes a few farmers are forced to withdraw their decisions of cultivating some crops because of non-matching decisions by their neighbours, which would otherwise create several problems (problem of harvest, transportation and marketing etc.). Changes in prices also depends on the other uncertain features, like government policies on export, import, support prices all of which may change during the gestation period and hence it is very difficult to form expectation in advance.

The regression is performed on the data collected for the district of Burdwan from various issues of *Statistical Abstracts* and *Economic Review* of West Bengal. The estimated equations are:[22]

Regression results: For boro rice:

At first regressing on all the explanatory variables we get,

1. $\text{Ln } A_b = -24.44 + .156 \text{ LnR} + 3.53 \text{ LnI}^* + .714 \text{ LnY}_b + .68 \text{ LnP}_{b-1}^* - .17 \text{ LnC} + .067 \text{ D}$

   (.27) (.99) (.674) (.26) (.274) (.403) , $R^2 = .856$

Excluding dummy variable,

2. $\text{Ln } A_b = -23.57 + .186 \text{ LnR} + 3.39 \text{ LnI}^* + .625 \text{ LnY}_b^{**} + .693 \text{ LnP}_{b-1}^* - .138 \text{ LnC}$

   (.1945) (.562) (.397) (0.24) (.185) , $R^2 = .856$

Taking $P_{b-1}.Y_b = T_b$ (expected proceed per hectare, evaluated at the previous year's price) we received,

[21] Raj, Sen and Rao (Ed), op. cit., p.11.

3. Ln A_b = -23.99 + .174 LnR + 3.41 LnI* + 6.74 LnT_b* - .123 LnC , R^2 = .856

(.172) (.542) (.194) (.15)

In case of potato: Considering all explanatory variables

4. Ln A_p = -6.093 - 0.114 LnR +.208 LnI + .427 LnC* + .003 LnP_{p-1} + .355 LnY_p***

(.094) (.355) (.129) (.097) (.213)

-.019 LnP_{m-1} + .205 LnY_m - .006 LnP_{w-1} - .0123 LnY_w - .244 D_t

(.109) (0.11) (.117) (.157) (.137) , R^2 =.94

Excluding dummy and rainfall

5. Ln A_p = -6.89 +.54 LnI*** +.303 LnC* +.0073 LnP_{p-1} + .4187 LnY_p**-.015 LnP_{m-1}

(1.65) (.1356) (.108) (.2427) (.1237)

+ .0688 LnY_m - .0294 LnP_{w-1} - .069 LnY_w

(.1028) (.1328) (.166) , R^2 = .919

6. Ln A_p = -1.813 -.121 LnR +.087 LnI + .493 LnC* +.0284 LnT_p + .081 LnT_m -.02LnT_w -.159 D_t

(.097) (.378) (.130) (.0916) (.1038) (.084) (.1447) , R^2=.916

7. Ln A_p = -1.58 +.105 LnT_p +.24 LnT_m* + .0266 LnT_w

(.1306) (.072) (.111) R^2 = .808

8. Ln A_p = -2.216 -.157 LnR +.338 LnI + .446 LnC* -.026 Ln (T_p/T_m) + .013 Ln (T_p/T_w)

(.0888) (.294) (.0625) (.069) (.074) , R^2 = .909

In case of mustard, considering all explanatory variables

9. Ln A_m = 3.174 -.295 LnR -2.72 LnI +.809 LnC + .668 LnP_{p-1} - .689 LnY_p

(.77) (2.9) (1.054) (.796) (1.74)

-.251 Ln P_{m-I} +.936 LnYm*- .263 LnP_{w-1} + 1.128 LnYw +.752 D_t

(.892) (.896) (.956) (1.128) (1.12) , R^2 = .748

10. Ln A_m = 4.98 +.178 LnR -2.1 LnI +.118 LnC + .397 LnT_p + .422 LnT_m -.361 LnT_w +.91 D_t

(.697) (2.712) (.93) (.744) (.657) (.601) (1.037) , R^2 =.71

11. Ln A_m = -7.92 +0.22 LnT_p + 1.014 LnT_m* -0.414 LnT_w

(.318) (.376) (.587) , R^2 = .621

12. Ln A_m = 9.93 +.435 LnR -3.59 LnI** +.94 LnC* + .08 Ln (T_m/T_p) + .595 Ln (T_m/T_w)

(.685) (2.10) (.448) (.655) (.53) , R^2 =.669

13. Ln A_m = 3.345 +.196 Ln (T_m/T_p) + 1.119 Ln (T_m/T_w)*

(.696) (.49) , R^2 =0.55

From the above estimates it has been observed that, irrigation and chemical fertiliser have substantial positive impact on the acreage growth of boro rice. Chemical fertiliser and yield growth has led to acceleration in acreage of potato and mustard. In case of boro rice, yield and dummy variable (that represents the influence of land reform measures) coefficients are also found to be positive and significant

[22] Here figures in the parentheses represent standard error of the corresponding coefficient. *, ** and *** represent respectively that the coefficient is significant at 5%, 10% and 20% level of significance by two tailed test.

but not to the extent as that of irrigation and chemical fertiliser[23]. Irrigation is the leading determinant (input) in case of boro rice because it is grown in summer time and regular water supply is essential for rice cultivation. Formerly, tanks and canals were the principal sources of irrigation and the capacity was at a very low level. The system was primarily maintained to ensure water during aman season when much of the capacity was used as supplementary irrigation, insuring against breaks in the monsoon. The growth of irrigation infrastructure here is associated with a shift in the composition of dry season crops, particularly with a rising share of area under boro rice.

But the effect of irrigation is not seen to be much stronger in case of potato, and even negative in case of mustard. The actual situation is however not like so. The reason is that, potato and mustard are winter crops and during winter one cannot depend on rainfall. Thus irrigation is essential. What happened actually is that, here area under canal irrigation (provided by government canals) has been considered from which still now, hardly a few places in West Bengal get irrigation during winter. The major part of areas in winter and summer have been covered by minor irrigation dominated by shallow tube-well, deep tube-well, submersible pumps, tanks etc. owned mainly by private people along with a few under government ownership. With the expansion of sphere of these sources cultivation of potato, mustard has increased. But continuous data on these sources are not available and so they are not included in the list of explanatory variables of present discussion.

Though coefficient of dummy variable is found to be significant in no case. The low value and dubious fluctuation of coefficient would raise question about the efficiency of land reform measures in mobilising lands from other uses to these crops[24]. There is much doubt about the contribution of the beneficiaries to the process of undergoing diversification. Most of the evaluation studies are conducted on the basis of the performances of the beneficiaries of the programmes. The diversification is actually associated with the spread of new technology and adoption of new technology by the beneficiaries is mainly dependent upon their financial strength[25]. But the government support measures are not adequate (Raychaudhuri and Sen, 1996) and the channels through which the government helps are distributed are not so reliable. However, the beneficiaries may have benefited in different ways from substantial changes that have occurred in different fields of technology (especially irrigation) and inputs' market, which push them forward to cultivate those crops. But, just by looking at the performances of the beneficiaries one

[23] Yield of boro rice has not increased significantly over the period under discussion. In Burdwan the exponential rate of growth of yield of boro rice during the 1970-71 to 1993-94 period was only .102 per cent per annum. In the first half the trend rate growth was negative due to uncertain irrigation and during the second half the rate was significantly positive.

[24] The question has been raised in several studies regarding the developmental impact of rigorous land reform measures (mainly collection and distribution of vested land and operation barga) undertaken by the Government of West Bengal. Some former evaluators have argued that in the self-evaluation made by the Government, results have been manipulated in order to inflate the success of the programs [Mallick R (1992), p.740, "Agrarian Reform in West Bengal, The End of an Illusion", *World Development*, Vol. 20, No.5, pp. 735-50]. Harriss (1993), Lieten (1990), C.H. Hanumantha Rao (1992) and Vaidyanathan (1988) have acknowledged the turnaround of agricultural performance in West Bengal was due to significant growth of irrigation, especially, ground-water irrigation.

[25] Cultivation of potato, boro rice are much costly affairs and so only distribution of small plots to the landless people does not ensure the cultivation of crops on commercial basis unless they are provided with financial and technical supports.

cannot single out the impact of land reforms because the improvement in this respect may be due to the advancement of other things. A comparison may be made between the cropping pattern change on the farms under beneficiaries and of the same category (small and marginal) non-beneficiaries to ascertain the efficiency of land reform measures.

In no case rainfall shows significant effect on the variation of acreage. This may be due to the fact that the data used here relates to rainfall of the whole year, which is not evenly distributed over throughout the year. For the sowing of any crop quantity of rainfall in the pre-sowing period is most effective.

It is evident from the above estimated equations that the farmers are highly influenced by last year's price of the crop which is to be chosen for cultivation. The total proceeds per hectare $\{T_i = (P_{i-1}.Y_i)\}$ of any crop has a direct impact on the acreage of the crop even if any one of price and yield effect is not much significant. Upward movement of expected gross remuneration per hectare (evaluated at previous year's price) through a rise in price has also imparted its force on the farmers to opt for that crop. It is realised that irrigation and chemical fertiliser are the leading inputs for potato and simultaneously the yield and price, both are found to have an attractive influence on the farmers' choice. However the cross (indirect) effects of price and yield are found to result in ambiguity when different equations with alternative sets of explanatory variables are compared. Though impact of changes in price and yield of wheat on area under potato is negative, the effect of variation in those of mustard on potato is completely opposite (though not significant) which seems to be inconsistent with the rational economic behaviour. If an increase in price and yield of mustard brings an expansion of area under it, with area kept the same; acreage of potato cannot increase[26]. The relative proceeds (per hectare relative yield in value terms) also exhibit the same type of result.

An explanation may be putforward in respect of the above argument and results those are seemingly contradictory. In the early years of development much of land used to remain uncropped during winter and summer seasons and thus was open to the cultivators. With the expansion of capacity of irrigation it became easier to bring those plots under cultivation during rabi season and also in summer time. Initially, during seventies, when changes came, wheat observed an impressive growth relative to the others. This was due to the government's special programme on food production, high yielding varieties of wheat came and entered the erstwhile rice regime of West Bengal. Gradually the food crisis in the region was over and agriculture of West Bengal faced a commercial movement. Cultivation of potato and mustard became increasingly profitable with rising prices and yields due to the arrival of high yielding seeds, development of irrigation and of technical implements. There started a shift of land from other (relatively less profitable) crop like wheat, rabi-pulses to potato and mustard. Simultaneously, most of the new plots brought under the umbrella of assured irrigation responded accordingly. Farmers in each place faced the task of allocating their increased area under cultivation between potato and mustard meticulously, on the

[26] Here it is presumed that during rabi season, there is a maximum manageable area supprted by irrigation at any time on which any kind of rabi crop can be grown (though different rabi crops require different quantity of irrigation). So in any year with unchanged irrigation, if cultivation of any crop is to expand, area under any other must have to contract.

basis of increasing profitability of one with respect to other and their managerial ability, which has however been increased with the development of technology. Moreover, cultivation of potato is relatively more costly and risky[27] than mustard though it is found to be more profitable in an even condition. Thus, increased land has been devoted for the cultivation of both in such a way as to balance between management and profit and also to disperse the risk. At individual farm level however, a substitution may take place if land is too scarce and there is a slack in the input constraints and managing capability.

From the above analysis it is possible to throw some light on the impact of individual factors, on the acreage growth of crops under study. But it is not possible to draw any particular conclusion regarding the effect of price, yield or proceeds per hectare of competitive crops on absolute acreage from the multivariate regression analysis when they are included in regression equation explicitly. It is thus very difficult to build up any irrefutable hypothesis regarding the cross effects from those equations. Moreover, in the above cases cost of production of a crop was not taken into account which when changes and not supported by revenue in spite of a rising price and yield may cause for an end of the production of any crop. So for the removal of ambiguity in the above behavioural analysis it requires a more subtle and rigorous explanation.

An Alternative Approach:

One explanation can be drawn from the accepted pattern of relationship among different crops that can be grown on a particular piece of land in a crop year (one complete crop cycle). The relationship among the crops in production is exposed through the overlapping sowing and harvesting seasons, which is manifested in the yield and output of crops.

Each and every crop has an ideal time of sowing and harvesting, which a rational farmer always tries to maintain under usual conditions. In a multiple cropping system some bottlenecks arise due to the overlapping timing of harvesting of a crop and that of sowing of its subsequent crop/crops, where crops within a cycle are cultivated in succession. The cycle repeats itself year after year and the combination of crops grown may change over the years depending upon the nature of effect that the cultivation of one crop has on its successors. Harvesting of any crop must be completed within a certain time to leave adequate time for the preparation of land to cultivate the next crop. The preparation time has been reduced to a great extent with the help of tractors, power tillers etc. and the completion of harvesting is also now possible in a much shorter time by mechanical devices. In addition to that crops with short period maturity and high yielding varieties are increasingly grown. Still there is a relationship because in many cases, ideal/natural timing of sowing and maturity has not changed significantly until a new variety emerges[28]. By ideal time of sowing we mean the duration of timing within which, the crop should be cultivated to get the best possible result with the usual application of other inputs; otherwise the yield will be affected or cost will be affected adversely. If any crop is cultivated at its usual time and inputs are used in an optimum proportion,

[27] This is because, potato is more perishable than mustard and good storage facility is essential for its preservation if not sold immediately after the harvest. Thus the market of potato is relatively more unstable than mustard.

[28] Sometimes a little early maturity may however be observed for certain crops due to disproportionate application of inputs but not, without affecting yield rates.

then it will be matured at an ideal time (if no natural disturbances occur) and give optimum gross and net profit. The natural harvesting time of any crop may coincide with the natural sowing time of its immediate successors. So, if the latter is cultivated after the harvest of former on the same piece of land then performance of the latter will be delayed and productivity or profitability will be adversely affected. The same effect may be transmitted to the following crops due to the identical relationship. Sometimes premature crops are harvested to leave room for the next one. It is done if there is a possibility to compensate the loss incurred due to early or premature harvest by the next crop.

The case will not be similar where on the same plot of land cultivation of potato is preceded by aus and followed by boro rice to that one in which aus or high yielding varieties (H.Y.V.) aman, mustard or wheat and boro rice come in succession. In the two cases yield of boro rice and also cost of boro cultivation would be different. This is due to the differences in combination of crops in which it is grown. Empirically found that the cultivation of boro rice preceded by the harvest of wheat in February-March from the same plot of land is a late running performance and its productivity would be much lower even with usual application of other factors, than that if it had been sown earlier. However, if wheat is followed by jute or potato is followed by jute then the yield of jute is not affected due to this problem of matching of time. In the earlier case if the yield and profitability of wheat is not so high that it can overcompensate the expected loss of profit of boro rice due to its late sowing and harvesting, the farmers are supposed not to choose this combination. On the other hand if boro rice follows potato it also become too late and the yield of boro rice is likely to be adversely affected. Cost of potato cultivation is much higher than that of other crop but at the time of harvest it leaves (the residual) much of fertiliser used and thus virtually very little amount of chemical fertiliser is needed for the following crop like boro rice, til etc. The pesticides' cost however increases because the invasions of pests are comparatively higher in case of late running crops[29]. Still the farmers may choose this combination if the productivity and net profit of potato is so high that it can overcompensate the expected loss of profit of latter. The farmers are supposed to choose a combination in such a way (to grow on the same field in a particular year) that they can disperse the risk and maximise expected profit.

Cultivation of some crops like potato, jute etc. leads to an increase in land productivity through preserving surplus fertiliser in case of potato and raising nitrogen content of land, in case of jute. This rising land productivity is utilised in the production of next alternative crop. The imputed value of rising land productivity due to the above reasons however can not be calculated directly by an economist but the task can be left to a biochemist or soil-scientist. What an economist can do is to compare the average yield of any crop (like boro rice) of different plots within same environment (having similar land character, water resources etc.) but grown after/in combination with different crops (such as, potato or mustard or local aman etc.). However, due to differences in former crop not only benefit, but also cost of the following crop differs; which is not very difficult to calculate.

Like yield and price or revenue, cost of cultivation is also an important instrument that can explain

[29] The late running crops are usually more vulnerable to pests and different bacterias.

relative merit and demerit of different crops through an analytical framework of cost-benefit analysis, which is generally used to analyse the relative advantage and disadvantage of different enterprises. Though the farmers are more encouraged by higher gross revenue (as is evident from the earlier results) expected from each plot, cost of cultivation can also be regarded as instrumental in the determination of cropping pattern. The alternative possible combination of crops that can be cultivated on a single plot in a crop year (which may be assumed to start with the cultivation of aus or aman and ends up with the harvest of boro rice, til or jute) can in this regard be evaluated to find out the net possible earning from each alternative combination. It can be used as one more reasonable explanation than that used earlier.

Rationale of this more subtle explanation arises out of the impact that the harvesting season of one crop has on the yield of the immediate next possible alternative crop, through the distortion of natural sowing and harvesting time on a fixed plot of land. Here the explanation is made on the basis of the assumption that land is a scarce factor and each plot is under optimum useable multiple cropping system (i.e., cropping intensity is almost 300 per cent). Even if irrigation is not available throughout the whole year and thus cropping intensity is less than optimum then also a similar explanation can be made under the unchanged existing condition. When the existing condition changes the pattern changes.

The frequently observed combinations in West Bengal,[30] particularly in Burdwan are identified first. These are: (i) high yielding aus, potato and boro rice, (ii) high yielding aus, potato and jute (iii) high yielding aus, mustard and boro rice, (iv) high yielding aus, mustard and til, (v) high yielding aus, potato and til, (vi) high yielding aman, boro rice, (vii) high yielding aman, potato and boro rice, (viii) high yielding aman, mustard and til, (ix) local aman and boro rice, (x) high yielding aman, wheat and til, (xi) high yielding aman, wheat and jute, (xii) high yielding aman, potato and til, (xiii) high yielding aman, mustard and boro rice.[31]

Data on separate plot on which either of these combinations have been tried are not available from secondary sources. The farm management study conducted by the Evaluation Wing of the Directorate of Agriculture, Government of West Bengal presents data on cost, revenue and net benefit for different crops in different districts of West Bengal. The study made by the Evaluation Wing (latest, 36th volume, published in 1993-94 is available) would throw some light on the average yearly farm income emerging from different combination of crops and thus an understanding of the prospect of the crops/combinations grown in the district/state may be possible. Here a cross section study of a particular year is being adopted. Most of the combinations noticed in the present days were absent in the early part of the seventies. So it is

[30] Though the regression analysis has been done for the district of Burdwan, Cost-benefit analysis here is made on the data of West Bengal average collected from Evaluation Branch, Directorate of Agriculture, Government of West Bengal. Since data for the district of Burdwan (in their study) have not been collected for all major crops cultivated in the district.

[31] High yielding aman is the newly generated varieties of paddy that are now increasingly cultivated in place of traditional aman. The new one is generally planted in the month of July and harvested in October-November after which it is thus possible to grow mustard or potato. On the other hand the old varieties are planted normally in July-August and harvested in the month of December-January, after which cultivation of potato or mustard will become too late and the performance will not be good enough. However wheat can easily be cultivated as usual. Aman

not possible to compare the relative profit of the present dominant combinations with the relative profit of the same in the early years of seventies after deflating by index of prices. At any time, any combination can be compared with the existing competitive combinations in term of their profitability and the combinations do change over time with the development of situation. The present study explains the rationality of farmers in the state (in aggregate) for preferring one particular combination in a given situation. Cost and benefits per acre for each individual crop in West Bengal during 1993-94 and cost-benefit of different combinations are presented in table-1 and 2 respectively.

Table-2 shows that combination (vii) yields highest gross remuneration and also net remuneration over paid-out cost[32]. Next to it combination (i) and (ii) represent second and third highest gross turnover over other combinations as well as third and second highest net remuneration over paid-out cost compared to that of others. This explains the rationale behind the increasing choice of these combinations by the farmers. During monsoon season farmers have no other alternative but to choose highest profitable among different varieties of aus and aman. High yielding aman appeared to be the most profitable among them without having any adverse effect on the sowing time of next crops. Combination of it with potato and boro rice in succession yields most over paid-out cost as well as total cost; which appears to be an important reason behind this combination increasingly chosen in preference to others. So, the cultivation of potato and boro rice has been accelerated over the years. This does not indicate that, this combination gives highest profit in all the years. In any year due to any natural disturbance or any other reason it may give lower profit than any other combination. However it has the likelihood of yielding more than any other combination during most of the years under discussion. In future any other varieties of crop/crops may be generated and thus a new crop combination may be developed that will yield higher possible profit than that of any other combination. Then the farmers will tend to switch over to that combination if other conditions necessary for the cultivation of those crops are available.

In spite of high profitability of potato, during rabi season cultivators (especially the small cultivators) do not always remain in a position to cultivate potato to the extent they desire. This is because of the highest cost per unit of land and risk involved with the cultivation of potato. Demand-supply mechanism and storage facility also matters much in this case. This would provide another reason behind the expansion of mustard (mainly with the development of irrigation facility) in spite of much lower profit than potato over paid-out cost. The profitability consideration also provides the reason why growth of cultivation of mustard during nineties decelerated irrespective of a high growth in eighties as is observed earlier. However, the results of recent past suggest that choice of crops to be grown though a matter of cost-benefit in a commercial system, it is bound to come to a limit unless further technological breakthrough occur from time to time. A further technological breakthrough would bring new cost-benefit

(HYV), potato and jute can also form another combination like aus (HYV), potato and jute; but the same is not popular because of uncertainty in the jute market.

[32] Here gross and net remuneration means total revenue in value terms and net profit per acre of land in a whole year out of different combinations.

relatives and thus a new cropping pattern may emerge accordingly.

Conclusions:

The whole study reveals that expansion of irrigation and technology in other fields is the main factors responsible for the relatively rapid expansion of cultivation of boro-rice, potato and mustard. Growth of chemical fertiliser also plays an important role in accelerating growth of those crops. However profitability of crop combinations can be grown successively on a plot in a crop-year is found to make the ultimate ground for increasingly allocating limited land holdings of the cultivators where there is no dearth of essential factors of cultivation.

Limitations:

The main limitation of the above calculation is that the data on cost of individual crops for different combinations are not collected from the field on which the combinations have been exercised. Here evaluation of each combination is made after the calculation of cost and benefit of each crop from a sample of farms that cultivate the particular crops included in any of the combinations. The cost and benefit of each crop for different combinations would be different. Those types of data were not available from the secondary sources. Though it provides an analysis of average farm condition, examination of data based on farms exercising different combinations on different plots would provide a more logical analysis of the consistency of cropping pattern choice. Collection of data for aus (local) only from four farms in a particular district (that has been done in the study) to approximate the state average is also not a rational one[33]. The best process would be to consider the data on separate combinations i.e., of individual crops in combination with several others in other season, separately from sample survey and to calculate distinct expenditure and revenue of different combinations.

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Table-1

Cost Benefit Analysis of Different Ctrops in West Bengal on an Average Farm for the year 1993-94 (per acre)

Crop	Value of Output (Rs)	Cost of Cultivation (Rs)		Net profit (Rs) over	
		Paid-out Cost	Total Cost	Paid-out Cost	Total Cost
Aus (local)	2376.08	2072.17	3766.36	303.91	-1390.28
Aus (HYV)	3430.06	1727.81	2934.12	1702.25	495.94
Aman (HYV)	4544.92	1851.22	3982.0	2693.70	562.22
Boro (HYV)	5899.83	2791.86	5054.16	3107.97	845.67
Wheat	3662.85	2472.22	4225.58	1190.63	-562.73
Jute	6541.68	2565.61	5207.13	3976.07	1334.55
Mustard	3034.86	1915.67	3223.62	1119.19	-188.76
Potato	14389.04	8821.41	14255.35	5567.63	133.69
Til	2746.59	1407.10	2575.45	1339.49	171.14

Table-2

Gross and Net Benefit per acre for Alternative Possible Combinations in a Crop-Year (1993-94)

Combination	Gross Turnover (Rs)	Net Benefit (Rs) Over	
		Paid-out Cost	Total Cost
(i) Aus (HYV), Potato, Boro	25828.48 (2)	10860.46 (3)	1392.56 (6)
(ii) Aus (HYV), Potato, Jute	24360.78 (3)	11245.95 (2)	1468.24 (4)
(iii) Aus (HYV), Mustard, Boro	14474.3 (8)	6412.02 (9)	1070.11 (9)
(iv) Aus (HYV), Mustard, Til	9211.51 (12)	4160.93 (13)	478.32 (12)
(v) Aus (HYV), Potato, Til	20565.69 (5)	8609.37 (5)	800.77 (11)
(vi) Aman (HYV), Boro	13909.21 (9)	6698.55 (8)	1608.6 (3)
(vii) Aman (HYV), Potato, Boro	28298.25 (1)	12266.18 (1)	1742.29 (1)
(viii) Aman (HYV), Mustard, Til	11681.28 (11)	5566.65 (12)	828.05 (10)
(ix) Aman (Local), Boro	12554.3 (10)	6284.28 (10)	1325.15 (7)
(x) Aman (HYV), Wheat, Til	8646.42 (13)	5638.09 (11)	454.08 (13)
(xi) Aman (HYV), Wheat, Jute	16104.36 (7)	8274.67 (6)	1617.49 (2)
(xii) Aman (HYV), Potato, Til	23035.46 (4)	10015.09 (4)	1150.5 (8)
(xiii) Aman (HYV), Mustard, Boro	16944.07 (6)	7817.74 (7)	1419.84 (5)

Note: Figures in the parentheses represent ranks.