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The Associations Between Growers' Inventions for Vegetable Production

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***Abstract* – This study aims at grouping the growers own inventions of vegetable production into categories, domains, types, classes, reasons and products (crops), to examine the association between inventions. All vegetable growers were males. The study is conducted in two rural areas of Khartoum North (Bahri) and Omdurman localities, Khartoum State, Sudan. Field data were collected from a sample of 120 growers selected from 6 villages of the above mentioned rural areas. The selection sampling method was systematic area sampling techniques as an alternative to random sampling. This multi-stage method is followed to pick a unit of sample at a fixed regular interval, after a random start of the first sample member in each section.**

The vegetable growers in Khartoum State managed to develop technologies, techniques and practices for increasing benefits, solve a production problem or to meet a need and opportunity unaided by officials entrusted with this task (research and extension agents).To some extent they were successful. The analysis of vegetable growers' inventions was non-statistical, depending on configuration and tree pattern methods. The results are presented by tree patterns, tables and figures which show the exact nature, common and shared characteristics of the inventions. New inventions appeared to be associated with problem-solving to increase income as the benefit; modified inventions are associated with problem-solving to save-costs.

***Keywords* – Association, Benefit, Classification, Configuration, Domains, Hierarchy, Growers, Increase Income, Inventions, Meet Opportunity, Modified, New, Practice, Reason, Saving Cost, Technology, Techniques, Tree Patterns, Types.**

I. INTRODUCTION

This study examines possible associations among and between the Growers' Inventions (GIs). "Invention is seen as the conversion of knowledge to technology", [1]. The classification is based not only on statements of the invention but on the precise identification of new i.e. actual invention, "*every new thing must grow directly out of other things which have gone before*" [2]. The inventions in this paper have been divided into two major types, new and modified, "*a basic inventions and improving inventions*" [2].

The aim is to look for common and shared characteristics of the inventions. Such association establishes more precisely the nature of what was being invented. "*are inventions mainly knowledge-induced or demand-induced?*" [3].

II. METHOD OF ANALYSIS

Field data was collected from vegetable growers in North and South rural areas, Khartoum State. Four and two villages respectively were selected purposively. The basis of selection was that these were the main vegetable production areas in which typical research units (growers) operate.

The sampling method was systematic area sampling as an alternative to random sampling, [4]; [5] [6]. This multi-stage method was followed to pick a unit of sample at a fixed regular interval, after a random start of the first sample member in each section. This procedure was followed to select 20 respondents from each village making a total of 120 respondents. Area sampling is hence basically a multi-stage sampling. "Systematic sample: Sampled units are dispersed across the entire geographic spread of the population K=N/n is the step size", [7].

Field data were collected through interview schedules, questionnaires, observation and audio-cassette recording of in-depth interviews and group discussions.

The analysis started manually during the field survey. The data was coded after collection, to classify the answers into categories to bring out the essential patterns. The analysis was non-statistical multiple correlation, using a configuration and tree pattern analysis.

These intended to establish the associations (if any) which exist between the characteristics of the 56 different GIs. These were sub-divided into six levels progressively. The numbers that fall into each level are displayed, (see Figure 1). Associations were sought between and within the GIs in terms of categories, types, classes, domains and products. Figures 1 to 10 show the results of the analysis used.

The researcher classified the vegetable growers' 56 inventions into 6 categories, Peil states that: "*It is useful to consider the phenomenon being studied as the dependent variable and other factors associated with change in this as in some sense independent; it is the relationships which are important, not what the variables are called*" [8]. Technologies (T), Techniques (Q), Practices (P), and combinations of (T+Q), (P+Q) and (T+Q+P) based on the construction of taxonomy (classifications and categories). Configuration placed inventions in the first level of the taxonomy (Technologies), Techniques, Practices and the combination of the three),"*the hardware consist of objects, such as tools, equipment, and genetic material. The software consists of methods and skills*" [9]. The tree pattern placed the inventions according to their type, reason for invention, benefits achieved, cultural components and the product (crop) concerned. The hierarchy used for these terms were categories, types, classes, domains, reasons and products. Technology is clear. Skills will be called techniques. 'Method' will be called practices.

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The introduced modification may be the use of something existing in a different way, and may range from a small to a major modification. It may also be the transformation of the original item into a different invention with different uses and purposes, while new invention means that something new has been created. Invention implies the creation and generation of new ideas and knowledge….".*When these processes lead to an object, practice or method which is effectively useful and which is made available to potential users, it may be considered to be an innovation*" [10]. "*There is incontrovertible evidence that, drawing upon their own resources, African farmers have always been and continue to be great agricultural innovators and experimenters*" [11].

The distinctions of the inventions can be demonstrated by considering the example of the specific inventions: An improved weeding hand tool is a technology. Planting coriander on the boundaries of the plots as insects repellent is a technique. Delaying the harvest of carrots for up to three months is a practice. Application of ash to retain soil moisture and absorb excess urea is a combined technology and technique. Controlling irrigation of a crop for 7-10 days before flowering to prevent the flowers from falling is a combined practice and technique. Cutting and planting the lower half of the onion to produce six times the amount of spring onions compared to planting the whole onion is a combined technology, technique and practice, "*The search was for outcomes that were better, practically oriented, effective and successful, the action was based on explanation and prediction*",[12].

The inventions have already been placed in six categories technologies, practices, techniques, combined technology plus techniques, practices plus techniques and combination of the three. None of the inventions were fit in the category of combined technology plus practice. "*Some cases, where the farmers' own practices have been examined, have shown their values as a source of knowledge and innovation*" [13].

III. Associations of Categories with Domains

Figure 1 shows the associations of categories with domains. The focus on successful crop growth is evident from the number of inventions concerned with irrigation, fertilization, plant protection, planting and weeding. The early (seed) stage and the later (harvest) stage are relatively ignored. The dominance of fertilizer, plant protection, planting and irrigation inventions is in order to cut the cost of expensive imported inputs. With regard to weeding, inventions were aimed at reducing the number of weedings, which are the most numerous and expensive operations in vegetable production. The reason for the high number of GIs involved in planting was to obtain extraordinary high prices at times of high demand and to supply for these products, and/or to avoid the most harmful period of the parasitic weed Orobanche. The dominance of inventions in practices is also obvious. Together, they demonstrated well the very practical and applied nature of grower inventions.

IV. Associations of Categories with Types and Products

The six categories of invention are shown in relation types (new or modified) and products (crops) in Figure (2).

Perhaps surprisingly the new inventions outnumber the modifications. This suggests that production systems simply developed by refinement to past systems, but often new elements that do not previously attract the interest of inventor—growers. The focus on practices and practices with related techniques is again evident.

Inventions of practices contributed to a large number of different crops. This was because they were intercropping inventions and so involved a number of vegetable crops grown on the same piece of land at the same time.

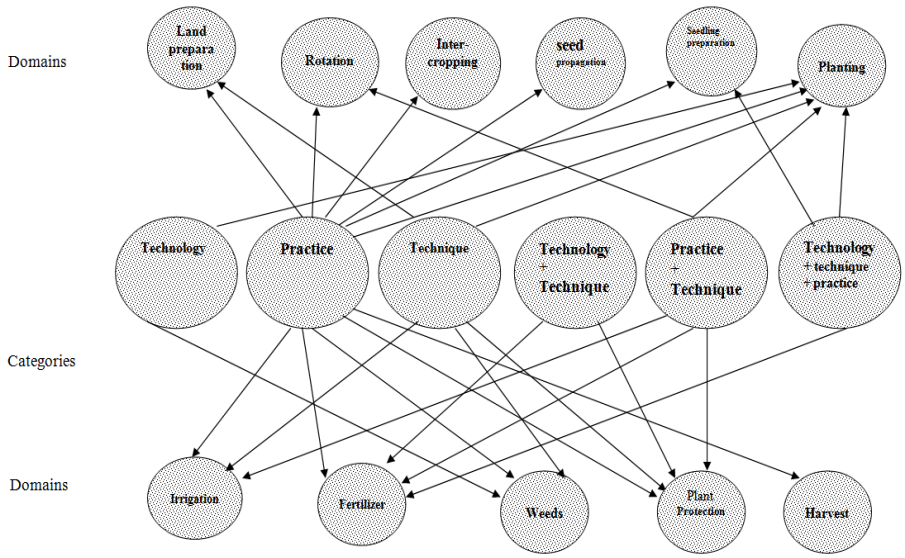

Fig. 1. Categories of inventions associated with domains

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V. Associations of Categories with Classes of Invention

The six categories of invention are examined here in relation to the benefits that resulted from these inventions, and the reasons given by the growers for their invention. The latter two constitute the classes of invention in this study.

The categories of inventions can be seen to give quite a wide spread of benefits. The main outcome of the invention was to directly increase income: the related managerial skill to reduce costs was much less important, though it is also distributed among a large number of categories Figure (3).

Similarly, the relationship of the invention with a direct solution to a problem is more pronounced than with the managerial skill to take a market opportunity (Figure 3).

Overall, the impression is given of a reactive rather than proactive approach to invention by these growers. It may also be that this is the character of their management of which, invention may then be seen as a component.

VI. Association of Categories with Classes, Types, Domains and Products

The analysis so far has given a general picture of how the categories are associated with types, classes, domains and products. This section discusses the associations of each of the six categories individually with the other five characteristics of the inventions, and within these.

(a) Associations of invented technologies

There were only 3 invented technologies. Of these, 2 were modifications and one was new. The two modified invented technologies were for the purpose of problem-solving associated with cost-saving, and the new one was to solve a problem and increase-income (Figure 4). These are important to the growers in managing the use of hand tools. In this regard, the efficient use of labor is important, as is the efficiency of the hand tool.

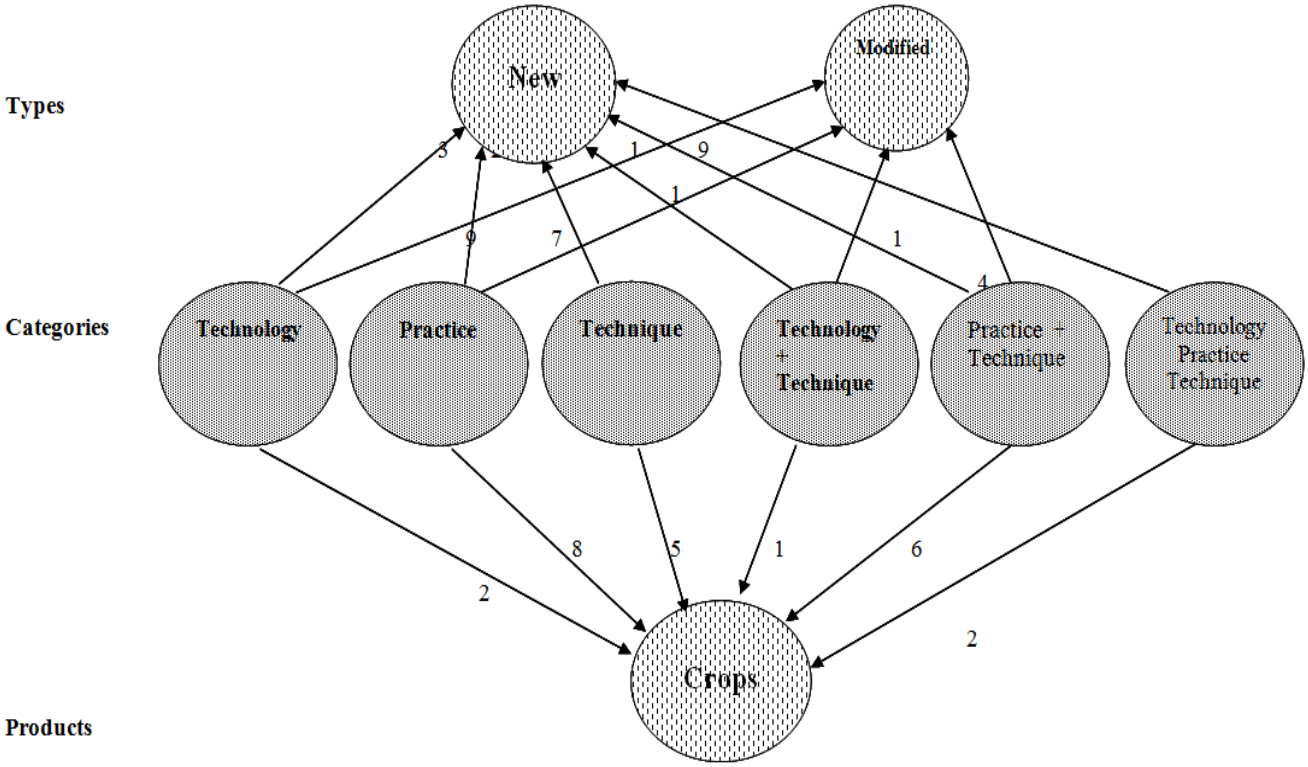

Fig. 2. Categories associated with types and products.

The emphasis was on weeding which is potentially expensive and can lead to yield losses if the crop is damaged in the process.

The inventions made use of available scrap and materials. As can be seen, they were concentrated on a few domains and products: weeding and transplanting onions. The grower who modified the onion transplanting hand tool tried first with a home two-edged strong knife. This did the job better but resulted in injuring the fingers of his left hand. At length he arrived at his invention by making use of scrap pieces of iron. One end was sharpened and on the other was fixed a heavy layer of plastic by heating. This made comfortable use possible, by the right hand.

Although small in number, these invented technologies, proved to be efficient, reliable and well-suited production problems on which they were based.

(b) Association of invented practices

There were 28 invented practices 9 of these were new and 19 were modifications. They had been produced in 11 different domains, more than any of the other categories of invention. The associations are shown in Figure (5).

The invented practices were dominated by problem solving inventions. They were also divided between new

and modified types. They concerned all the 11 domains and a large number (8 of the 14) of products. There was some concentration of invented practices on the intercropping of vegetables aimed at increasing the growers' incomes. Cost-saving was also a focus of invention. What seems to be happening is that intercropping as a continuous process, leads to a too much searching and experimenting to find the most appropriate and profitable combinations of crops. Within these attempts at improvement arises the need for new practices. Hence, these are a common category of invention.

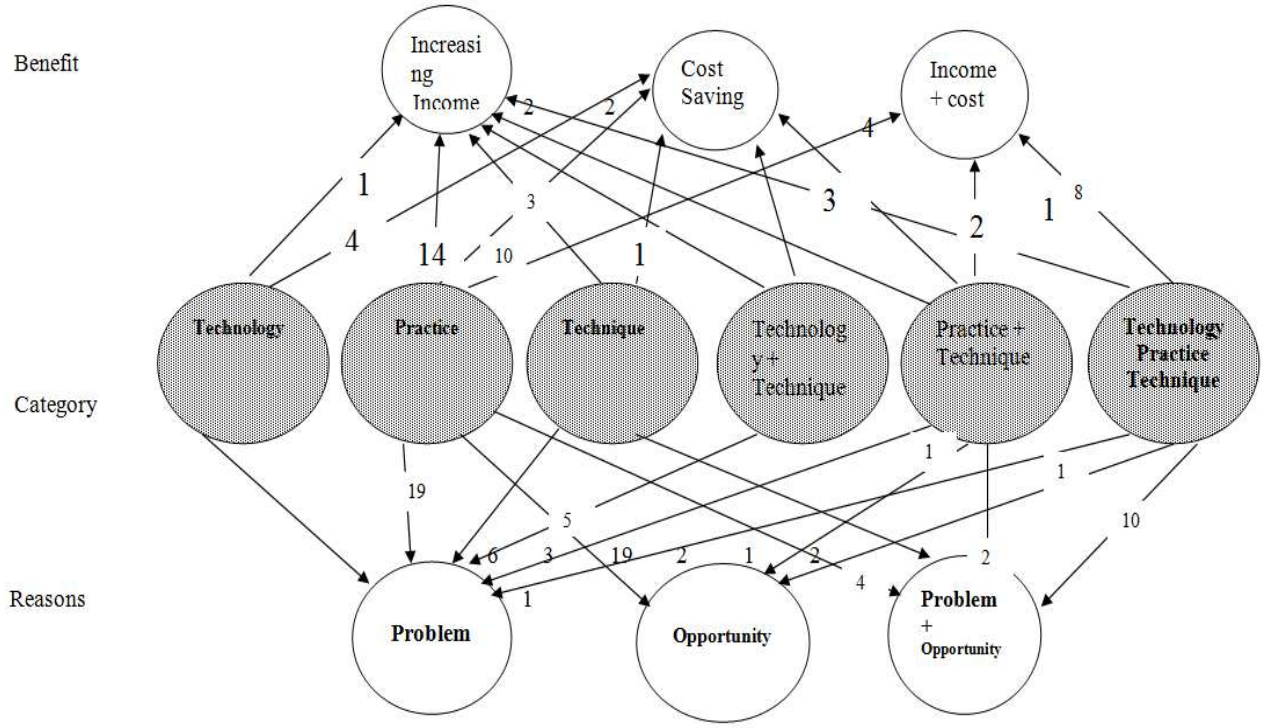

Fig. 3. Categories associated with benefits and reasons for invention benefit

(c) Associations of invented techniques

The technique category had only 7 inventions. This is relatively few compared with the practice and combined practice plus technique categories. It did, however, contain a relatively wide range of inventions: these covered 5 different concerning 5 different crops. All the 7 technique inventions were new.

Only 2 of the 6 problem-solving inventions were in the income-increasing class, and 4 were cost-saving. One invention combined both problem-solving plus opportunity-meeting (Figure 6). This spread of a small number of GIs among the classes of inventions but focused on a relatively high number of domains and crops reflects the specificity of the growers' techniques. These are related to strongly targeted needs. Because the invented techniques are essentially skills, these results are probably to be expected in the skill-base horticultural industry.

They also reflect the growers' ability to invent across a wide range of their experience and understanding of vegetable production.

(d) Associations of invented technologies plus techniques

This combined category contained the least number of inventions. There were only 2, involving two domains but one crop only, namely the egg plant. This crop is very important in the study area, and in this study of invention: it account for the second highest number of inventions after tomatoes.

One invention, which was new, solved a problem and increased the income. The other was a modified invention, and solved a problem and saved costs (Figure 7). These follow a trend which is emerging in the results so far.

(e) Associations of invented practices plus techniques

The category is evidently a common form of invention: it contained a total of 13 GIs.

The new inventions were more than double those in the modified type. The 9 new inventions contained 6 which were problem-solving associated with income-increasing class of invention. Three modified inventions were problem-solving associated with cost- saving (Figure 8). The trend which has already been noted becomes apparent again here. The new inventions are associated with problem-solving and increased-income, and the modified inventions are associated with problem-solving that saved-costs. Because problem-solving is common to the two types of inventions, the essential association to be noted so far is that new inventions are to increase incomes and modified inventions are to reduce costs.

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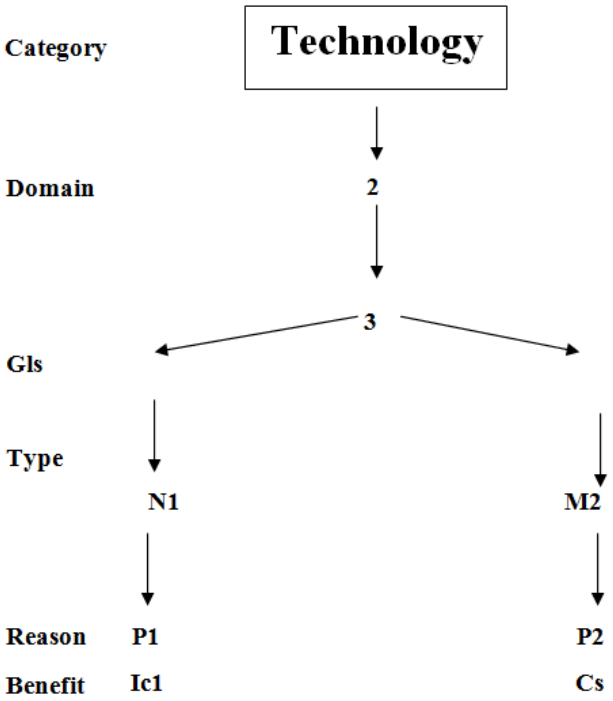

Fig. 4. Technology associated with domains, type and classes

Key:
N= New, M = Modified, P = Problem solving
Ic = Income increasing, Cs = Cost saving

(f) Associations of invented technology plus practice plus technique

There were only 3 inventions in this category. All' of the 3 were of the new type Figure (9).

The inventions covered 3 domains which were linked production, off-season production and dry young maize ploughed into the soil as green fertilizer. There was no common benefit or reason for the invention. Only one was specifically concerned with solving a problem. One was in the smaller class of an invention to take advantage of a market opportunity and income increasing. Hence this analysis does conform to the trend which has been noted so far. These inventions of course, are limited in number and concerned with quite specific issues in vegetable production.

VII. Inventions as Single or Grouped Categories, Associated with Types, Classes and Domains

The inventions can be organized into three groups based on the principal three categories which have so far been treated separately. Hence the technologies and their combinations with practice and technique are treated as one group. Similarly, this is the case with practice and technique (Figure 10). When this is done, the number of grouped practices (44) appears to be less dominant when compared with the grouped techniques (25) than is, in fact, the case. This grouping places the thirteen combinations of practice plus technique in both categories. The analysis into new and modified types of inventions is also considered.

VIII. Associations of Practice-based Inventions as a Combination, with Types, Classes and Products

The inventions which have been classified as practices singly or in combination, constitute the largest group of inventions. They total 44 (78.6 %) of the GIs. The group also contains 23 (88.5 %) of the modified inventions. Because of the dominance of inventions of practices in this study, they are considered now in greater detail. It seems that, by using their experience and ingenuity, the growers can improvise and find new methods of husbandry and ways to produce vegetables, and that these are the features of their ability to improve their production systems based on their own efforts.

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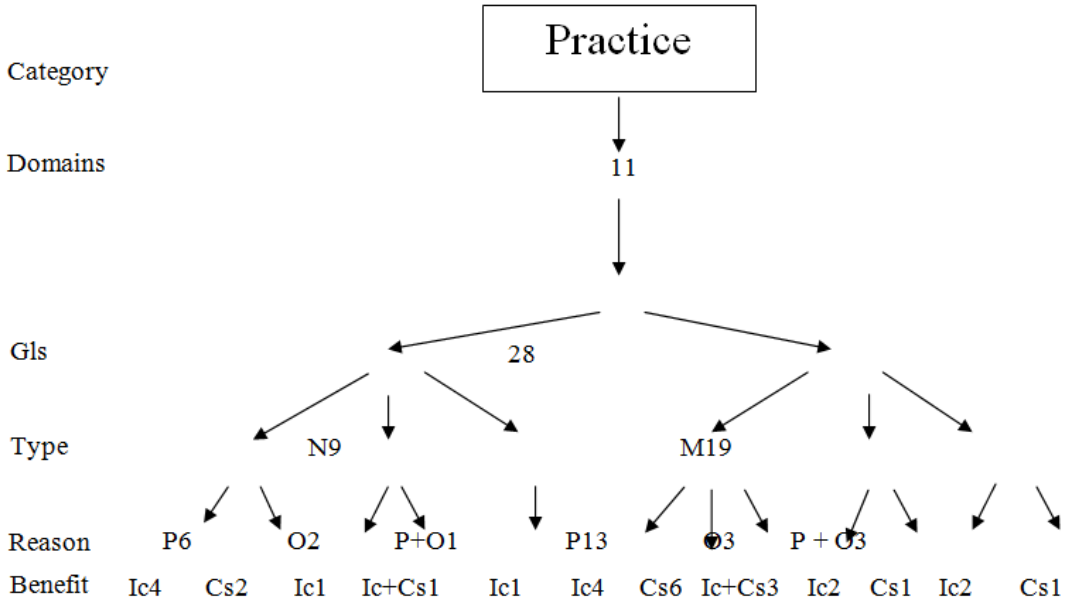

Fig. 5. Practices associated with domains, Type and classes

Key:

N= New, M = Modified, P = Problem solving
O = Opportunity, P+O = Problem + Opportunity
Ic = Income increasing, Cs = cost Saving, Ic + Cs = Income and cost

The analysis of these inventions is shown in (Figure 10), the 44 practice-based inventions consist of 21 inventions. This is 70 % of all the new GIs. Within these, there is the already noted trend for inventions that solve a problem to be associated with those increase income nearly half this association.

The modified inventions also conform to the trend to be problem-solving and cost saving, though this is less evident (39.1% of the total modified based practices).

All (100 %) of the inventions to take advantage of a market opportunity are practice based. Finally, and perhaps most interestingly, the practice-based inventions concerned every domain and every crop. Every act of what the growers did, at a practical level, gave evidence of their inventive ability.

IX. Associations of Technology-based Inventions as a Combination with Types, Classes and Products

The grouping of 8 inventions concerned with technologies consists of 5 new and 3 modified inventions. Of the new ones 3 were in the problem-solving class of invention, (Table 1).

Table (1) Inventions of single or grouped technologies associated with types and classes of invention domains and products

Type	New				Modified				Total
Classes	Problem-solving	Opportunity -meeting (0)	P+0	Total	Problem-solving	Opportunity -meeting (0)	P+0	Total	
Income-increasing	2	1	1	4	-	-	-	-	4
Income-saving	-	-	-	-	3	-	-	3	3
Income +cost	1	-	-	1	-	-	-	-	1
Total	3	1	1	5	3	-	-	3	8

The new inventions are mainly concerned with problem-solving are divided between income-increasing and combined income- increasing plus cost-saving. The 3 modified types of technology inventions were all problem-solving and cost-saving classes of inventions. The numbers are again small but there is overall consistency with the trend established for these inventions.

When the new and modified types of invented technologies are considered together, the cost-saving class accounts for 3 (37.5%) of the total 8 inventions, and the increasing—income class also accounts for 4 (50 %). These classes of invention dominate the technology inventions; only two (25 %) were opportunity—meeting (Table 2). The problem-solving class accounted for 6 (75

%) of the total technology based inventions, indicating again how well the growers were capable of solving different kinds of production problems.

In summary, the most common characteristics of the technology— based inventions are that the new were limited to income- increase, and the modified with cost-saving invention.

X. Associations of Technique – Based Inventions as a Combination, with Types, Classes and Products

Inventions involving techniques were 25. Of these, 20 were new inventions. These are mainly based on two classes. 14 (70 %) were problem-solving and 13 (65 %) income-increasing inventions (Table 3). This, again, conforms to the trend for new inventions to be aimed at increased incomes.

The 5 modified invented techniques were all problem-solving, of which 4 were cost-saving.

Overall, this analysis of the GIs singly and in various grouping shows that practices accounted for the highest number of inventions. Perhaps the growers find these easier to develop. Perhaps this is where the needs are greatest. Practices are probably quicker in securing relatively higher returns than invented technologies, and are more comprehensive techniques. Although they are limited in number, interestingly all of the opportunity-meeting inventions are practices. It seems that opportunities are more difficult to exploit than is problem-solving as a stimulus for invention. This could be a reason why market opportunity class contained the least number of inventions.

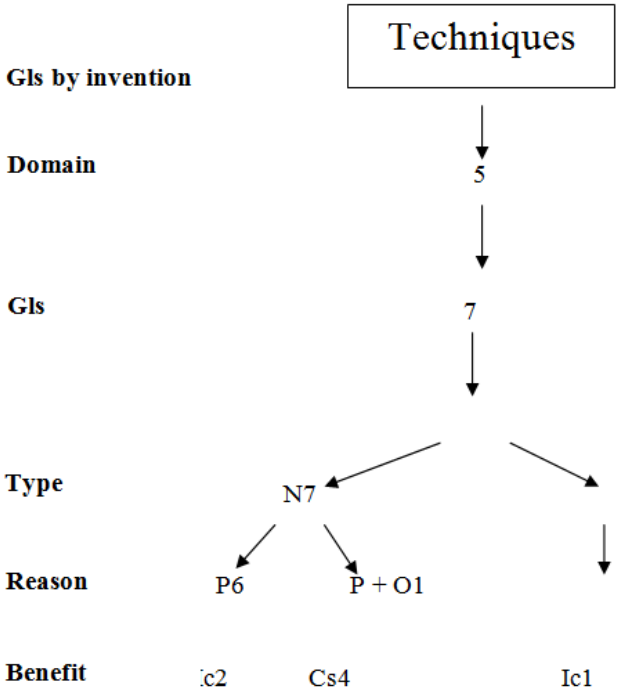

Fig. 6. Techniques associated with domains, types and classes

Key:
N= New , P = Problem solving
P+ O = Problem + Opportunity , Ic = Income increasing, Cs = Cost saving

Table (2) Inventions of single or grouped techniques, associated with types and classes of invention, domains and products

type	New				Modified				Total
Classes	Problem-solving	Opportunity -meeting (0)	P+0	Total	Problem-solving	Opportunity -meeting (0)	P+0	Total	
Income-increasing	9	2	2	13	1	-	-	1	14
Income-saving	4	-	-	4	4	-	-	4	8
Income +cost	1	-	2	3	-	-	-	-	3
Total	14	2	4	20	5	-	-	5	25

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Within the invented techniques, new inventions were more numerous than the modified type. This suggests that existing techniques are generally specific for the existing cultural practices, but that when new methods of production are developed, effort has to be exerted to arrive at completely new techniques to deal with issues with which little is currently available to he1p.

XI. Domains Associated with Categories, Types and C1asses of Inventions

Attention now turns to the associations between the eleven domains to which the inventions applied, and the classification of inventions used in this study.

The domains in which the largest number (9) of inventions had been made were the fertilization, plant protection and planting domains, (Table 3).

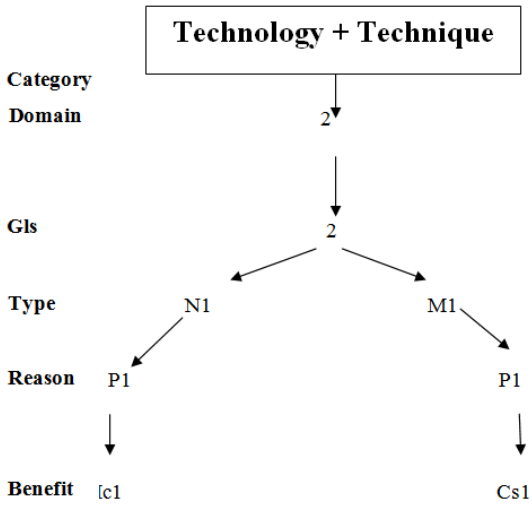

Fig. 7. Technology + Technique associated with domains, type and classes

Key:

N= New, M = Modified, P = Problem solving

Ic = Income increasing, Cs = Cost saving

Table (3) Domains associated with categories, types, and classes

domain	Numbe r of GIs	Number of categories contained in each domain	type		class					
					benefit			Reasons		
			new	modifi ed	income	Cost saving	both	Probl em	Oppor tunity	both
Fertilization	9	4	2	7	3	3	3	3	1	5
p. protection	9	5	7	2	3	6	-	9	-	-
Planting	9	5	6	3	5	3	1	7	2	-
Irrigation	7	4	6	1	5	2	-	7	-	-
Weeding	6	3	3	3	2	3	1	4	1	1
Rotation	5	2	1	4	4	1	-	3	1	1
s. preparation	3	2	1	2	1	1	1	2	-	1
Intercropping	3	1	2	1	3	-	-	2	1	-
L. preparation	2	2	1	1	1	-	-	2	-	-
s. propagation	2	1	-	2	1	1	1	2	-	-
Harvesting	1	1	1	-	1	-	-	-	1	-

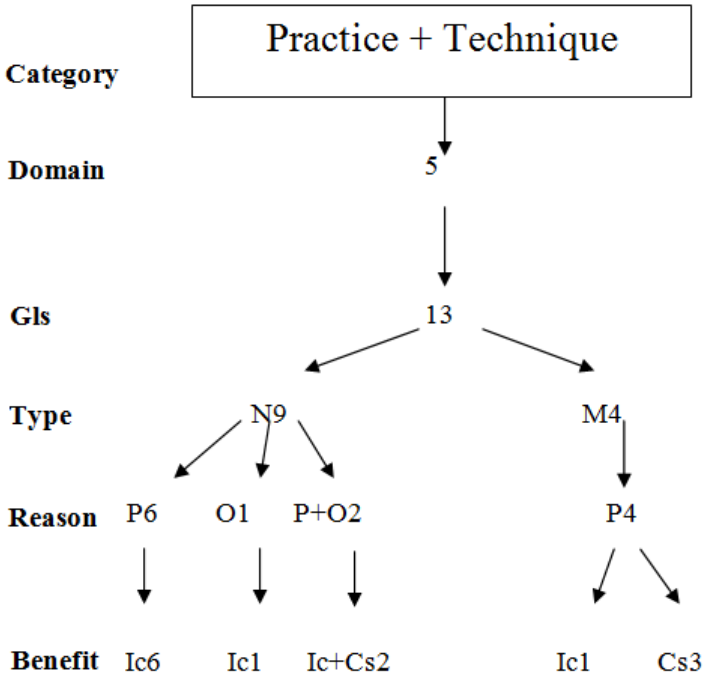

Fig. 8. P+ Q associated with domains, type and classes

Key:

N= New, M = Modified, P = Problem solving
O = Opportunity, P+O = Problem + Opportunity

The domains are related to the categories of invention in Table (4).

It is evident that there is a variation in the categories of inventions associated with domains. For example, the practice category inventions dominated the fertilization and plant protection domains. The inventions which dominated the planting and irrigation domains were practices and combined practices plus techniques. Rotation domain inventions were also entirely practices and practices plus techniques. Intercropping domain inventions were all practices.

Table (4) Domains and invention categories

Domain	Invention						Total GIS
	Technology (T)	Practice (P)	Technique (Q)	(T+Q)	(P+Q)	(T+P+Q)	
fertilization	-	4	-	1	3	1	9
p. protection	-	4	2	1	2	-	9
Planting	1	3	2	-	2	1	9
Irrigation	-	1	1	-	5	-	7
Weeds and Weeding	2	3	1	-	-	-	6
Rotation	-	4	-	-	1	-	5
S. preparation	-	2	-	-	-	1	3
Intercropping	-	3	-	-	-	-	3
s. propagation	-	2	-	-	-	-	2
L. preparation	-	1	1	-	-	-	2
Harvesting	-	1	-	-	-	-	1
Total	3	28	7	2	13	3	56

The different associations between categories and domains presumably reflect the growers' perceived priorities and the choices open to them. What they invent depends to a large extent on the growers' individual capabilities to formulate new ideas, and their knowledge, skills and production resources. They also reflect the actual problems which confront them. Hence the inventions are not developed equally throughout any of the classifications used in the analysis presented in this study.

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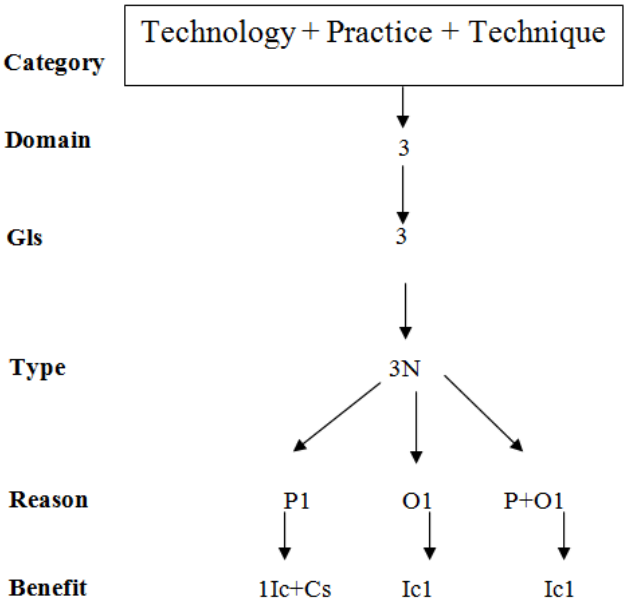

Fig. 9. Technology + Practice + Technique associated with domains, Type and classes

Key:

N= New, P = Problem solving, O = Opportunity, P+O = Problem + Opportunity
Ic = Income Increasing, Ic +Cs = Income+ Cost Saving.

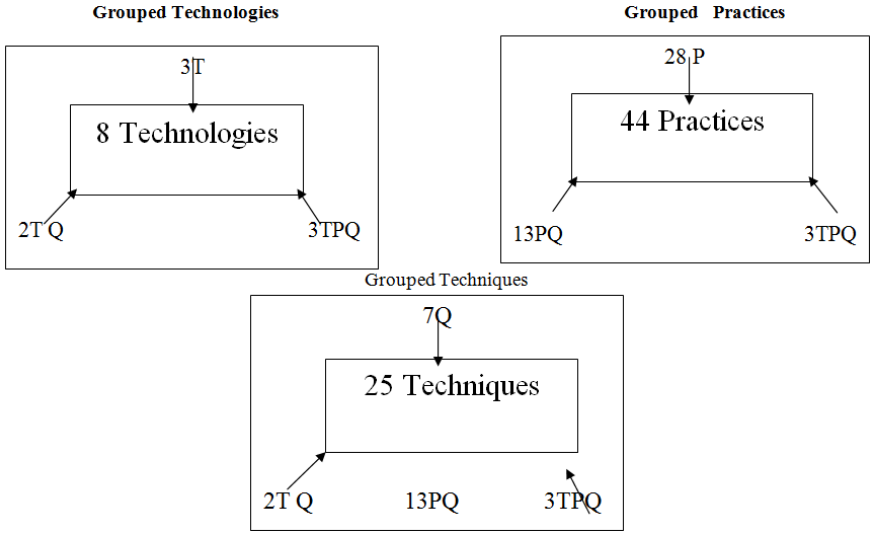

Fig. 10. Grouped Categories of Gls

Numerical Values = Number of inventions in each category.
Inside the rectangle: the total grouped Gls. T = Technology, P= Practice, Q= Technique.

XI. Association of the Inventions with the Products (CROP)

The inventions reported by the growers' concerned 14 crops. Practice inventions were concerned with all of them. The transferability of invented practices and techniques among so many of the crops grown presumably made these inventions particularly useful to the growers. Whether this acted as an incentive for invention, or was simply a welcome outcome was not explored in this study.

Results

The growers emerge as the main actors in the process of technology development in the area under study. One interesting trend was for the inventions which were new to increase-income, whilst for modified inventions were to save- costs.

The inventions had increased the growers' incomes and/or reduced production cost. They had solved

production problems and rarely enabled a market opportunity.

The findings have useful implications for the formal Research and Development strategies for vegetable production.

XII. Conclusion

Three main reasons were given by the inventors for developing their own inventions. These were problem solving, or meet an opportunity, or both. There were also three benefits that were said to have resulted from their own inventions, namely income-increasing, cost-saving or both.

There was much concentration on problem solving, and on increasing incomes. There was an interesting trend for new inventions to be mainly for higher income, and modified inventions to save costs.

Opportunity-meeting inventions were relatively few in number and, understandable strongly associated with the income-increasing class of inventions.

The highest number of inventions were those that in the practice and technique categories. Overall, among the 56 different inventions reported in this study, it was those new inventions, associated with problem-solving, that increased-income and could be used with a large number of different crops that were the commonest. Hence, it is the new practices and techniques which can improve production technically and financially that are the focus of the growers' inventions.

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