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# BREEDING FOR LOW-INPUT CULTIVARS OF VEGETABLE CROPS

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## ABSTRACT

Research at the Institute of Plant Breeding has shown that it is possible to reduce the cash and labor requirements for growing various kinds of vegetables by modifying the following plant traits: 1) plant habit, 2) earliness, 3) ability to fix atmospheric nitrogen and 4) resistances to pests. In *Phaseolus vulgaris* L. (Baguio beans), savings of as much as ₱8,000 per hectare in production cost is possible with the use of bush types instead of current cultivars which are viny. In *Dolichos lablab* (batao) and *Cucurbita moschata* (calabasa) growing period can be reduced by more than 50% by using new early genotypes instead of current cultivars which are invariably late maturing. In *Vigna unguiculata* ssp. *sesquapedale's* (sitao) and batao, ability to fix atmospheric nitrogen can be increased by as much as 300%, thus reducing the need for fertilizers. In a number of vegetable species, resistances to major pests can reduce the need for chemical pest control in may cases, and make it possible to grow vegetables where these have not been successfully grown before in some cases. During the last five years, development of commercial type of cultivars with the above superior traits, has been the focus of varietal improvement work.

## Introduction

In recent months, national concern has been expressed about the value of modern seed. While the principal target is the International Rice Research Institute (IRRI), which is accused of manipulating genes to suit the interests of its donors; namely, the developed countries and multinational companies which produce and sell agricultural chemicals and fertilizers; the whole plant breeding community has been placed in a focus which it never enjoyed (or suffered) before. It can not be denied that the plant breeder is responsible for modern seed.

The concern, simply put, is this: modern seed requires so much input to grow, that in spite of its high yield, farmers and consumers become more impoverished and hungry.

Today, it is IRRI; tomorrow it could be the Institute of Plant Breeding (IPB) the national agency for storing and manipulating plant genes, which will be placed in the limelight of public concern. While there are some similarities: both Institutes are in the eastern side of UP at Los Baños, separated only by a railroad track; plant breeders in both institutes were schooled in the same Western fashion (Gregor Mendel and Luther Burbank) in the same schools (Cornell University, Iowa State University, etc.): there are more differences. To name one: The budget of IRRI, mandated to work on only one crop (rice) is approximately 85 times that of IPB which is mandated to work on all agricultural crops except rice.

The objective of this paper is to show some aspects of what Filipino plant breeders are doing to bring food to the dining table of more Filipinos. As a vegetable breeder by profession, I will have to draw inspiration and information from experience in breeding vegetable crops.

*The cost of producing vegetables*

The popular belief is that cost of production needs to be reduced to make food available to more people. This is only partly true, because food availability is a function of many other factors including cost of marketing (which in vegetables can be more than the cost of production), purchasing power and preferences.

Modern seed is capable of positively influencing all these factors, including those that are not directly related to production.

However, reliable economic and social data which can illustrate the impact of plant breeding are not available, hence it is necessary to rely mostly on production cost information to illustrate the possible impact of modern seed in quantitative terms.

Table 1 shows the proportionate cost of different production inputs in four common crops. The dominant input varies from one crop to another, with a distinct bias towards chemicals. In potato, seed is the dominant cost because it is grown from bulky tubers (2.5 tons required to plant one hectare). In cabbage, 59.1% of the cost is accounted for by chemicals, mostly to control diamond back

Table 1. Production cost of selected vegetable crops[a]

| Crop | Assumed Yield (t/ha) | Cost of Production P/kg[b] | Production Inputs (% of total cost) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Seed | Ferti-lizer | Chemicals | Miscella-neous | Labor |
| Potato (Baguio) | 20 | 2.75 | 29.6 | 21.4 | 24.0 | 3.6 | 21.4 |
| Cabbage (Los Baños) | 30 | 1.00 | 2.1 | 9.3 | 59.1 | 6.8 | 22.7 |
| Squash | 25 | 0.32 | 4.5 | 18.9 | 39.6 | – | 36.5 |
| Ampalaya (Los Baños) | 20 | 1.62 | 8.6 | 6.9 | 22.8 | 46.5 | 13.8 |

[a]Estimates based on published and unpublished data, as well as personal experiences in growing these crops.

[b]Exclude cost of land, water and money, which are not normally reflected in production cost estimates.

moth, an insect pest. In squash, chemical protection is required against powdery and downy mildew diseases and insect vectors of virus diseases. In ampalaya, 46.5% of the cost of production is spent on trellising materials.

A more revealing aspect of costs is seen in Table 2, which shows that 59-73% of the cost (if ampalaya (a) is excluded) is used to pay for imports which includes seed, equipment, fuel, chemicals and fertilizers. The only siginificant local component is labor (which is also imported by some Filipino farms in the form of foreign consultants). Thus it may be said at the present time, that local vegetable production is feeding the Japanese, Americans and Arabs first; and the Filipinos only incidentally. Certainly the cost of subsidy by the Filipinos of developed countries would increase if marketing and storage are taken into account, since these two steps require energy and machines which are imported. Up to the final step, when vegetables rot in the markets and need to be dumped, Filipinos still subsidize developed countries by paying for the trucks and fuel.

*Contribution of plant breeding to the problem of costs and import dependency*

Unknown to or unappreciated by many, modern seed can significantly contribute to the solution of the above problems. Potatoes do not have to be grown from tubers if the appropriate botanical seed is developed. Resistance to pests, when incorporated to cabbage and squash cultivars, can reduce the need for pesticides. The cost of trellising ampalaya per kilo of fruit can be reduced if yield potentials are increased by appropriate breeding work. In snap beans, it is possible to eliminate trellising entirely by using bushy cultivars. The cost of marketing can be reduced dramatically if potatoes and similar crops traditionally grown only in the highlands of Benguet, can be grown closer to the population centers. Losses after harvest can be reduced if cultivars of tomatoes are developed that do not rot easily. Purchasing power of local consumers can be indirectly increased, if the retail price is eventually lowered through reduced production and marketing costs. Preferences can be altered if more attractive and better quality vegetable products are made available to consumers by using the right seed.

Table 2. Foreign and local components of production inputs in growing vegetables[a]

| *Crop* | *Production inputs (% of total cost)* | |
|---|---|---|
| | *Foreign* | *Local* |
| Potato (Baguio)60 | 60 | 40 |
| Cabbage (Los Baños) | 73 | 37 |
| Squash | 59 | 41 |
| Ampalaya (Los Baños) | | |
| a) abaca for trellis | 36 | 64 |
| b) synthetic material for trellis | 69 | 31 |

[a]Fertilizer and chemicals were generally considered as foreign inputs.

*Solving the problem of crop adaptation*

The Philippines is a land of complex preferences. While it is blessed with a climate that is favorable for the production of many kinds of vegetables, the commercially important species are limited to a few, mostly temperate type crops, that can only be grown in a limited geographical area and/or limited time. These include potatoes, cabbages, snap beans, onions and watermelon.

We have long concluded that it is much easier to change the genetic constitution of the plant to suit the needs of consumers than to change their addiction to anything foreign or sounds like one. Thus the challenge that the plant breeders have taken up for many years now, has been to develop seed of Baguio type vegetables that can be grown in places like Los Baños. This phase of plant evaluation and cultivar improvement work is actually a major improvement over that of situation immediately after World War II, at which time most of our onions and potatoes were imported from as far as the United States of America. We have finally succeeded to grow these in sufficient quantities to meet local needs in the country, but as Table 2 shows in the case of potato, 60% of production cost is still paid in dollars.

1. The case of cabbage

The first major breakthrough in the effort to bring highland vegetables to the low elevations was achieved in cabbage with the introduction of heat tolerant hybrid seed ($F_1$KK) and $F_1$KY) from Japan in the 1960's. Since then, several new heat tolerant hybrids have been developed which are superior to the first commercial hybrids (Table 3). Today heat tolerant cabbages can be grown anywhere in the Philippines anytime of the year; thus cabbage prices are stabilized at levels that are at least 50% of Baguio-grown cabbages. Savings were achieved in production and marketing costs. However, with the spread of cabbage cultivation, a new insect problem (diamond back moth) has emerged, which now costs ₱0.59 to control for every ₱1.00 spent on cabbage production.

Table 3. Performance of new cabbage hybrids in relation to standard cultivars (March-June, 1985, Lipa City)[a]

| *Entry* | *Ave. Head Wt. (kg)* | *Compactness*[b] | *Maturity (days)* | *% Heading* |
|---|---|---|---|---|
| GSV82-113E | 1.29 | 4.6 | 58 | 85 |
| GSV82-125A | 1.21 | 3.2 | 66 | 72 |
| YR Summer 50 | 1.02 | 3.2 | 59 | 95 |
| $F_1$KK (ck) | 0.95 | 3.0 | 58 | 80 |
| Marion Market (ck) | 0.44 | 3.5 | 64 | 63 |

[a]Data from East-West Seed Co., Lipa City.
[b]Rating scale: 5 = compact, 1= loose

2. The case of potato

Potato is a more complex crop. Traditionally, it has been grown almost exclusively in the highlands at tremendous costs (₱2.75 per kilo), 29.6% of which is spent on seed tubers. If the same method of planting is used for the low elevations, the share of seed tuber cost will certainly increase with the distance of the new site from the highlands, where good quality seed is and will be exclusively produced. Thus in the near term, it is unlikely that production in the low elevations will spread, even if the problem of genetic adaptation is solved among the clonal cultivars.

The solution which is most likely to succeed is to grow potatoes from botanical seed, which will eliminate the logistical and economic problems associated with the use of tuber seed. We expect that the cost of seed can be reduced to lower than 5% of the total production cost; but more than this, seed can be made more readily available to more farmers.

Our most recent data on the possible use of botanical seed for the low elevation is shown in Table 4. Yields from TSV were 1/10 of the best clone in the trial and 1/4 of the check cultivar. Tubers from TSV were also generally small. New hybrid combinations are being made to improve on yield and bulking ability under low elevation conditions. It is ironic that we are getting closer to a commercially acceptable TSV in the highlands, where it is less needed (Table 4a). The data show that our best TSV (IPB OP-2) is now within 2/3 of the yield of Conchita clone. It has exceeded Conchita in percent marketable yield and tuber size.

*Solving the problem of material inputs.*

1. Trellising

In many vegetable crops, including ampalaya, sitao, snap beans, batao and

Table 4. Performance of potential true-seed variety (TSV) of white potato in comparison with advanced clones (Dec. 1984-Feb. 1985, UPLB)[a]

| Entry | Estimated Yield (t/ha) | % Marketable Tuber | Tuber Size (g) |
|---|---|---|---|
| 1. TSV | | | |
| IPB Hybrid 1 | 5.4 | 64.6 | 28 |
| IPB OP 1 | 5.1 | 50.4 | 19 |
| 2. Clones | | | |
| 8302-D12-5 | 54.2 | – | 54 |
| 8302-D185-7 | 41.2 | – | 53 |
| Cosima (ck) | 20.5 | – | 55 |

[a]Data from Fernandez, E. C., G. S. Rodulfo, E. C. Altoveros and E. T. Rasco, Jr. 1985. Breeding potato for the lowland tropics. Paper presented during the Lowland Potato Research and Development Workshop, April 19-20, 1985, DMMSU, Bacnotan, La Union.

Table 4a. Comparison of potential true seed varieties (TSV) with clonal varieties of white potato (Dec. 1984 to March 1985, La Trinidad)[a]

| *Entry* | *Estimated Marketable Yield (t/ha)* | *% Marketable Yield* | *Tuber Size (g)* |
|---|---|---|---|
| *TSV* | | | |
| IPB OP-2 | 15.6 | 82.6 | 40 |
| IPB OP-3 | 12.9 | 75.9 | 42 |
| IPB OP-4 | 12.6 | 74.0 | 45 |
| IPB OP-5 | 12.5 | 76.2 | 36 |
| Desiree (ck) | 0.0 | 0.0 | – |
| *Clones* | | | |
| Barolina | 27.2 | 80.6 | 81.1 |
| Conchita (ck) | 22.0 | 72.4 | 33.5 |

[a]From Altoveros, E. C. and E. T. Rasco; Jr. 1983. UPLB Potato Breeding Program: Highlights of 1984-85 Results in Highland Trials. Paper presented in the Highlands Potato Research and Development Workshop, NPRCRTC, MSAC, La Trinidad; Benguet, April 16-18, 1985.

patani; the cost of trellising or staking can account for a huge proportion of production cost. In ampalaya, it is 46.5%; in snap beans, it is 33.3%. While in sitao, batao and patani, bush cultivars are already in use over the last 20 years; in snap beans, bush cultivars have been introduced only recently. These new cultivars can be grown in Los Baños and Baguio with equal ease during the dry season. A comparison of yields and cost of production of a traditional high elevation cultivar of pole snap beans, Alno and several bush type cultivars, recently introduced, is shown in Table 5. Unlike in bush sitao, whose yields are comparable to pole sitao, bush snap beans tend to have a lower yield compared to the pole type. In the data presented, however, it may be noted that bush snap beans were produced in Los Baños near the market center, thus it is expected that the cost to the consumer will be lower.

2. Fertilizer

Leguminous vegetable species have the capacity to produce nitrogen. There are considerable differences within species, which can be exploited in breeding for low-fertilizer requiring cultivars. Table 6 shows variety differences in ability to produce nitrogen in pole sitao and batao. Attempts to incorporate high nitrogen fixing ability to commercially accepted cultivars by hybridization are in progress.

3. Chemicals

Chemical pesticides account for as much as 59.1% of the total cost of production in the case of cabbage. Genetic resistance to various pests is a continuing

Table 5. Comparison of yield and cost of production of pole and bush snap beans

| *Entry* | *Yield (t/ha)* | *Estimated Production Cost*[a] | |
|---|---|---|---|
| | | *(P/ha)* | *(P/kg)* |
| Pole (high elevation)[a] | | | |
| Alno | 23.8 (small farms) | 21,625 | 0.91 |
| | 4.5 (big farms) | – | |
| Bush (low elevation)[b] | | | |
| Bush Blue Lake 47 | 9.3 | 10,975 | 1.18 |
| Resisto | 8.8 | | |
| Peak | 8.4 | | |

[a]From Bumonya, E. B. 1978. Costs and returns analysis of Baguio bean production in La Trinidad, Benguet. BSA Thesis, MSAC.
[b]From Maghirang, R. G., P. C. Sanchez and R. L. Villareal. 1984. Development of crop varieties for rice-based cropping systems. Annual Report. 1984-85. UPLB.
[c]Estimate by R. G. Maghirang.

Table 6. Total and specific nitrogenase activity in pole sitao and batao[a]

| *Entry* | *Total Activity* $\mu m\ C_2H_4$/plant/hr. | *Specific Activity* $\mu m\ C_2H_4$/gm nodule/hr. |
|---|---|---|
| *Pole Sitao* | | |
| Maagap | 31.2 | 108.0 |
| Sandigan | 14.0 | 36.7 |
| $UPLPS_2$ | 20.7 | 55.8 |
| $UPLPS_3$ | 16.5 | 42.2 |
| $UPLP_4$ | 25.9 | 58.3 |
| $UPPS_1$ | 18.5 | 38.6 |
| *Batao* | | |
| PI 284801 | 51.0 | 96.3 |
| PI 388000 | 2.9 | 18.6 |
| PI 388002 | 2.1 | 23.5 |
| PI 392369 (field type) | 7.2 | 423.1 |

[a]Data were obtained with support coming from N-fixation project of IPB.

concern of vegetable breeders, precisely to reduce dependence on pesticides.

In ampalaya, a breakthrough was achieved in 1984 when Fernandez discovered resistance to fruit fly from two small-fruited varieties (Table 7).

Table 7. Fruit Fly resistance in ampalaya[a]

| Entry | Per cent Fruit Damage | | | |
|---|---|---|---|---|
| | Field | Rating[b] | Laboratory | Rating[b] |
| 9-7-1 | 12.2 | R | 16.7 | R |
| 9-62-1 | 13.1 | R | 16.7 | R |
| Sta. Rita (ck) | 56.5 | S | 100.00 | HS |

[a]From Fernandez, E. C., E. P. Cadapan, E. T. Rasco; Jr. and E. D. Magallona 1984. Resistance of bitter gourd (*Momordica charantia* L.) to the fruit fly (*Dacus* [Strumata] *cucurbitaceae* coq.) Paper presented at the 19th SAVI Conference, PCARRD, Los Baños, Laguna, Nov. 15-16, 1984.

[b]Rating System:

| | | |
|---|---|---|
| 0-9 = HR | | 46-70 = S |
| 10-25 = R | | 71-100 = HS |
| 26-45 = MR | | |

Table 8. Comparison between $F_1$ Jade Star and Sta. Rita ampalaya cultivars at low and high input levels[a]

| Treatment | Based on 6 harvest dates | | | | |
|---|---|---|---|---|---|
| | Marketable Yield (t/ha) | | Estimated Gross Income (P x 1000) | | |
| | JS | SR | JS | SR | Difference |
| High input | | | | | |
| Full spray<br>50 cm. spacing<br>4.0 bags/ha. fertilizer | 15.3 | 6.8 | 30.6 | 13.6 | 17.0 |
| Low input | | | | | |
| No spray<br>70 cm. spacing<br>1.5 bags/ha. fertilizer | 7.3 | 1.6 | 14.6 | 3.2 | 11.4 |

[a]From Mendoza, D. S. and J. van Balen. Jade Star: a new high yielding, disease resistant $F_1$ hybrid of bitter gourd (*Momordica charantia* L.). Paper presented during the 19th Symposium of SAVI, PCARRD, Los Baños, Nov. 15-16, 1984.

On the same crop, Mendoza and van Balen reported the development of a new hybrid cultivar, Jade Star, which performed better compared to the commercial cultivar Sta. Rita at low (no spray, low fertilizer) and high (full spray, high fertilizer) input levels (Table 8). The advantage was attributed partly to a higher level of resistance to foliage disease in the new hybrid. The source of resistance of the hybrid is an inbred line extracted from a downy mildew resistant population developed by IPB.

In garden pea, several accessions with potential as commercial cultivar were found to have resistances to the major disease and insect problems (Table 9). Two of these (Sugar Snap and 05005) are being multiplied for introduction to farmers, while the others were used in crosses with Chinese Dark Green, the local cultivar.

*Solving the problem of land space and time*

Part of the cost of production, which is often glossed over in analysis of production cost, is the cost of using land. Under an intensive cropping system, time of planting and harvest are critical in determining the total output of the farm. Early maturing cultivars provide more flexibility in crop sequencing and allow the use of the same piece of land for more crops over a period of time. Earliness also minimizes the exposure time to adverse conditions and reduces production cost. On the other hand, highly productive, compact plants allow closer spacing and higher yields per unit area.

Extremely early and compact accessions have been identified recently in upo and batao (Table 10 and 11). In all cases, the early types were compact, hence can be planted with close spacing.

Table 9. Reaction to diseases under natural infection of garden pea accessions (1983-1984 dry season, La Trinidad)[a]

| *Accession* | *Resistance ratings*[b] | | | |
|---|---|---|---|---|
| | *Aschochyta blight* | *Powdery Mildew* | *Fusarium wilt* | *Leaf miner* |
| Set 1 | | | | |
| Sugar Snap | 3.0 | 3.0 | 4.0 | 3.5 |
| 05005 | 3.0 | 2.5 | 4.5 | 3.5 |
| Chinese Dark Green (ck) | 1.0 | 1.0 | 1.0 | 1.0 |
| Set 2 | | | | |
| 236493 | 3.5 | 3.5 | 4.0 | 2.0 |
| 244110 | 3.5 | 3.5 | 4.0 | 1.5 |
| J1461 | 4.5 | 3.5 | 5.0 | 2.1 |
| Chinese Dark Green (ck) | 1.0 | 1.0 | 1.0 | 1.0 |

[a]Data from Annual Report. 1984. Institute of Plant Breeding.

[b]Scale: 5 = highly resitant; 1 = highly susceptible

Table 10. Earliness in upo[a]

| *Accession* | *Days to Flowering* | *Days to first harvest* |
|---|---|---|
| Tambuli | 46 | 52 |
| Acc 3 | 63 | 73 |
| Acc 5 | 60 | 78 |
| Acc 6 | 62 | 69 |

[a]Data from Annual Report 1982. Institute of Plant Breeding.

Table 11. Earliness in batao[a]

| *Entry* | *Days of Flowering* |
|---|---|
| 345607 | 38.5 |
| 388007 | 46.0 |
| 388019 | 36.0 |
| 393501 | 43.0 |
| Acc 54 | 44.0 |
| Hiyas (ck) | 100.5 |
| Luningning (ck) | 111.0 |

[a]From Maghirang, R. G. 1985. MS Thesis, UPLB. Graduate School.

*Solving the problem of post-harvest losses*

Among agricultural food crops, vegetables have the highest rate of wastage after harvest. This is estimated to be 42-50% on the average[1]. What this means is that cost-reduction to consumers can not be complete, if postharvest control of losses is not considered.

In the past, this aspect of variety development has been glossed over if not completely ignored. There are indications, however, that postharvest performance can be a critical factor in variety usage. In tomatoes, it is known that VC11-1 a heat tolerant, bacterial wilt resistant cultivar, is often rejected by farmers in favor of Improved Pope which is inferior in both respects, but has superior post-harvest character. In cabbages, one of the reasons why $F_1$KK does not command as high a price as Marion Market is that $F_1$ KK's keeping quality is very short.

Plant breeders are now aware of the need to control postharvest losses by genetic means. In tomatoes, several test hybrids have shown excellent keeping qualities (Table 12). A similar type of evaluation is now being done with other crops.

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[1]Personal communication from Ms. Emma Labios, PHTRC, UPLB.

Table 12. Evaluation of fruits of potential $F_1$ hybrid tomato after 10 days storage under ambient conditions (Feb. 1985, Lipa City)[a]

| *Entry* | *RATING*[b] | | |
|---|---|---|---|
| | *Shrivelling* | *Rotting* | *Color* |
| Hybrids | | | |
| 31098 | 4.5 | 4.0 | 5.0 |
| 31103 | 4.5 | 4.5 | 3.5 |
| 31105 | 5.0 | 4.0 | 5.0 |
| OP checks | | | |
| VC II-1 | 2.0 | 1.0 | 1.0 |
| Improved Pope | 3.5 | 3.5 | 3.5 |

[a]Data from East-West Co., Lipa City

[2]Rating scale: 5 = superior: 1 = inferior

*The challenge ahead*

Good vegetable seed is either in the pipeline or already out of it, ready for use by farmers. Filipino plant breeders are doing their job even with meager resources, but as Swaminathan[1] said, "research is only one member of a good symphony orchestra, the parts of which should work harmoniously to improve food production".

Good seed in the hands of a plant breeder is useless. It must reach the farmer. First it must be mass produced by highly qualified seed growers.

Then comes the tedious task of convincing farmers to grow them.

The problem of reducing production (and marketing) costs is certainly beyond the capability of a plant breeder to solve completely. Agricultural scientists from other disciplines must develop the appropriate package of technology. Horticulturists must continually develop production management practices that will help the seed grow: water, spacing, fertilizer, cropping patterns. Crop protection scientists must continue to explore alternatives to chemical pest control. Postharvest scientists must continue to develop practical ways of reducing losses.

The problem in the final analysis is not simply producing vegetables with the least cost; but putting vegetables to the dining tables of more Filipinos. To me, this means that it is alright to spend a little more, as long as the money is plowed back to the local economy in the form of more jobs, more local materials.

[1]Datuin, M. 1984. Is IRRI seed sabotaging our economy? UPLB Newsletter, Sept.-Oct. 1984.

## Summary

Research by Filipino plant breeders shows that it is possible to reduce the cost of production and marketing of vegetables by modifying the following traits:

1. adaptation
2. growth habit
3. N-fixing ability
4. resistance to pests
5. earliness
6. postharvest characteristics

Savings of 50% or more of the total cost is possible by using appropriate seed.

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## Ricardo M. Lantican, Discussant

Dr. E. Rasco has demonstrated how certain items of cost of production in vegetables could be reduced by simply modifying certain plant characters through breeding and be able to do away or minimize the use of trellises, expensive tubers of white potatoes for planting and chemical protection against pests.

In fact, this is what plant breeding is all about – the collective infusion of desirable morphologic and physiological characters into the plant system through genetic manipulation. The result desired is for the crop to tolerate and nurture itself better under adverse soil and climatic environments, severe infestation by pests and diseases and provide man with nutritious and wholesome products.

To further substantiate Dr. Rasco's points, let me cite to you other examples in other crops in which genetic manipulations have made some very tangible impacts to crop industry. The "downy mildew" disease of corn was once considered the main bottleneck to progressive corn farming in this country.

Thanks to the arduous efforts on the part of our plant scientists; two effective means of control were finally devised – one by chemical seed treatment, the other through genetic resistance. These developments paved the way for the entry of very high yielding $F_1$ hybrids to the Philippines. These important local discoveries saved the corn industry and farmers from annual losses of millions of pesos due to the ravages by the downy mildew disease and afforded the country the opportunity to intensify yields to unheard of levels and enhance the growth of the corn industry.

Another example is the problem that high soil acidity and element toxicity (Al and Mn) poses to crop production in this country. We have about a million hectares of farmland whose pH is below tolerable levels of 5.5. To bring some of these areas to productive use, addition of three to five tons of agricultural lime is needed. We have found in UPLB that certain cultivars of corn, mungbean and peanuts can tolerate acid soils and thus would obviate the need for expensive lime application. Use of such varieties should be a boon to countless farmers.

The job of plant breeding is to continually search for genes that ultimately will confer benefits to mankind. Such job needs painstaking effort and is akin to looking for the proverbial needle in the haystack. The high lysine genes in corn were chanced upon in an indigenous variety collected in a remote place in South America. And to make the genetic transfers into a final commercial entity, we would need all the sciences and scientific skills at our command. It is a team of work effort from among many disciplines. The emergence of the newly acquired experience in biotechnology rekindles our hope that someday we can come up with appropriate technology for our less privileged toilers of the earth.

**Ruben L. Villareal, Discussant**

I am pleased to be a discussant of the paper entitled "Breeding for Low-input Cultivars of Vegetable Crops" during the 7th Annual Scientific Meeting of the National Academy of Science and Technology.

Dr. Rasco's topic is acceptable and relevant to the current needs. However, if it were given in 1972, it could be considered counter progressive. In fact, when I introduced the concept of minimum input in sweet potato before the oil crisis, the idea was received with skepticism.

I fully agree with Dr. Rasco's conclusion that low input cultivars could be developed by modifying a number of traits such as adaptation, growth habit, N-fixing ability, resistance to diseases, earliness and post harvest characteristics. I am glad that the Institute of Plant Breeding has been doing something on these breeding objectives.

Nevertheless, let me elaborate further the case of low fertilizer requiring plants by using tomato as an example. In Dr. Rasco's paper, he used a legume plant, a N-fixing plant, as his example.

The average nutrient uptake of tomatoes per ton of fruit are:

| *Nutrient* | *Kilogram* |
|---|---|
| N | 2.90 |
| P | 0.40 |
| K | 4.00 |
| Mg | 0.45 |
| Ca | 2.35 |

These figures represent the amounts of nutrients that must be returned to the soil to replenish those removed by a ton of tomato fruits. The amounts should be higher if the stalks and the leaves of tomatoes are included. Thus, even fertile soils will be unproductive if the nutrients removed by a crop are not adequately replenished.

If the soil is deficient in NPK and the efficiency of applied fertilizers is 35% for N, 25% for P, and 40% for K, the estimated nutrient uptake requirements of tomatoes at different yield levels are as follows:

| YIELDS | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|
| Ton/ha | Kg/ha | | |
| 1 | 18 | 4 | 12 |
| 5 | 40 | 20 | 60 |
| 10 | 80 | 40 | 120 |
| 25 | 200 | 100 | 300 |
| 50 | 400 | 200 | 600 |
| 100 | 800 | 400 | 1200 |

As shown in the table, a grower should apply 200 N kg/ha, 100 $P_2O_5$ kg/ha and 300 $K_2O$ kg/ha in order to obtain the target yield of 25 tons per hectare. There is a need to apply more fertilizers as the predicted yield increases. This table also partly explains why our national average yield for tomato is only 8.5 t/ha. Our farmers hardly apply fertilizer to their tomato crops.

Several studies were conducted to demonstrate the genetic control of some nutrients (Harvey, 1939; Pope and Munger, 1953 a & b; Villareal and Lai, 1976; Whitaker 1975 and O'Sullivan *et al.*, 1974). The reports suggest interesting possibilities in the breeding of crop varieties that can give adequate yield despite excesses or deficiencies of different elements. The study of O'Sullivan *et al.*, (1974) in Wisconsin, for example, showed that variations in the efficiency of nitrogen utilization exist in *Lycopersicon esculentum.* Under severe N stress (35 mg N/plant) in nutrient solutions, efficient strains produced as much as 45% more dry weight than inefficient strains.

Some scientists at the International Rice Research Institute discovered striking differences among varieties and genetic lines of rice in terms of tolerance for low levels of phosphorous, zinc, and other elements, as well as to low pH and toxic levels of elements such as iron and aluminum (IRRI, 1971, 1972, 1973, 1974). In fact, modern rice varieties developed at IRRI have consistently performed better than traditional varieties with or without additional fertilizer.

Before I end my paper, I would like to ask the following:

1. Can plant breeders develop varieties that are more efficient in utilizing available nutritive elements? If yes, how much resources and efforts are needed?

2. Should we increase our efforts on developing varieties resistant to pest and diseases which have been popular, practical and have given us sufficient dividends?

3. Is it feasible to develop crop varieties that are resistant to adverse conditions (i.e. drought, water logging, high salinity soils, etc.)? If yes, how much efforts should we devote on this?

4. As in rice production, can we develop cultural practices that will insure efficient utilization of nutritive elements and minimize losses? Are we paying enough attention to solve this problem?

5. We have depended so much from various government agencies in producing and distributing vegetable seeds. Why don't we encourage the private sector to take over this responsibility?

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