

**THE DEVELOPMENT OF VEGETABLE PRODUCTION TECHNOLOGY
FOR SMALL FARM FAMILIES**

by

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(ABSTRACT)

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Vegetable research was conducted to support the diversification and development of small farms in East Central Virginia. Experiments at 12 sites were successfully conducted over a 2 year period to establish superior production practices for the area's 2 major commercial vegetable crops, cherry tomato and bell pepper.

For cherry tomato production, black plastic and straw mulches significantly increased total yield. Black plastic mulch also significantly increased early yield, but neither of the mulches were cost-effective. String-weave staking generally did not affect yield or net economic returns, and it reduced yield on sandy soils during droughty conditions. Irrigation had a positive, but non-significant impact on yield when tested during a growing season with normal amounts of rainfall. Nitrogen applications of 84 kg/ha were most cost-effective, with higher rates found beneficial for irrigated plantings on lighter soils. Plant populations of 13,450 plants/ha produced similar yield and net economic returns as populations of 17,930 plants/ha. *Castlette* and *Small Fry* were superior cultivars.

For bell pepper production, steady but non-significant increases in yield and net economic returns were detected as nitrogen rates rose from 79 to 158 to 236 kg/ha.

Black plastic mulch significantly increased yield and net economic returns, mostly due to moisture conservation benefits. A single-row pattern with an in-row spacing of 41 cm was the most cost-effective planting scheme. *Gator Belle*, *Keystone Resistant Giant #3*, and *Giant Ace* were superior cultivars.

On-farm testing improved researchers' understanding of farm family needs, accelerated the adoption of new technology, and identified deficiencies of technology which were masked at the field station. Field station research was valuable for screening risky treatments, but yields at the station were uncharacteristically high. Extension staff were valuable in the designing of research, but they selected a disproportionate amount of college-educated, medium- and large-scale farm operators as participants for on-farm testing. Paraprofessionals, female personnel, and social scientists were beneficial in strengthening linkages between project personnel and farm families. Marketing was a major obstacle.

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SECTION I.

CONCEPTUAL FRAMEWORK

1. INTRODUCTION: THE VISION OF JEFFERSON

Cultivators of the earth are the most valuable citizens. They are the most vigorous, the most independent, the most virtuous, and they are tied to their country, and wedded to its liberty and interests, by the most lasting bonds The small land holder is the most precious part of a state.

Thomas Jefferson (7)

Thomas Jefferson, author of the Declaration of Independence and founder of the University of Virginia, firmly believed that the earth was the inheritance of all humanity, not just a select few. His agrarian philosophy professed that farming was a virtuous occupation, one in which farm families and the earth worked together in harmony, and one in which prosperity would be provided to the masses. Jefferson called for the lands of America to be widely and equitably distributed among its people. Such a distribution, the Virginia statesman contended, would lead to an egalitarian society without poverty, and also contribute to the spiritual and moral strength of the nation's people (4).

As the economy of the United States has grown, however, Jefferson's vision for rural America has not materialized. Economic forces in America have led to the concentration of production resources and wealth within the farm sector. Numerous Government policies have also favored large-scale farming (6, 12), and agricultural research has emphasized production efficiency over the welfare of farm families and rural communities (14). Furthermore, the development of capital-intensive farming systems has resulted in the migration of millions of families from their farms, and has often brought hardships on the nation's small farm families, "the most precious part of a state" in Jefferson's own words.

Thomas Jefferson knew from his travels in Europe that whenever land was controlled by the few, then poverty would result among many. Nevertheless, economic forces in the U.S. have led to the concentration of agricultural resources among a few large farm operators, and have contributed to significant levels of poverty for many of its farm families. In 1986, 20.3% of farm residents lived below the poverty line, compared to that of 13.8% of non-farm residents (11). Moreover, many rural areas today suffer from depressed economies, high rates of substandard housing and illiteracy, and inadequately-funded educational and medical facilities (3, 10, 13).

Being a renown agriculturalist himself, Thomas Jefferson professed that the close and natural ties between farm families and the earth made farming an honorable profession. However, through the emphasis on short-term economic efficiency in production, many farmers today use practices which may be destructive to the environment. The results of these practices are being borne out today: 1) one-third of the nation's topsoil base has been lost, with soil erosion continuing at excessive rates (9); 2) more non-renewable energy resources are used in farming than in any

other business (13); and 3) large-scale irrigation is tapping surface and groundwater sources at non-sustainable rates throughout the nation, in some cases leading to the destruction of aquifers and the salinization of soils (1, 9).

As one who cherished his family farm at Monticello, Thomas Jefferson understood that farming was an occupation that provided for vigorous health and clean living. Today, however, the widespread use of agricultural chemicals has made farming a hazardous occupation, with increased risks of developing cancerous tumors (2, 15), and 45,000 incidences of pesticide poisoning reported annually (5). Furthermore, the health of the American consumer is also threatened by these farming practices, as pesticide residues are now found on half of the nation's food (1). Almost 200 years ago, Thomas Jefferson successfully used scientific knowledge and his personal influence to introduce the tomato to an American public who feared that the vegetable was poisonous. Ironically, due to pesticide-prolific production methods, the American consumer is at greater risk in developing cancerous tumors from consuming the tomato than from any other food (8).

These and other deficiencies of large-scale farming systems have recently led the U.S. Government and land-grant institutions to begin making substantive efforts in serving the needs of small farm families. A greater understanding of these families' farming systems and the subsequent development of appropriate technology are both critical steps in these efforts.

Farming Systems Research & Extension (FSR/E) is an approach to rural development that is directed toward the development of technologies for small farm families. Developed overseas in less developed countries, efforts are now being made in the U.S. to assess the value of FSR/E in domestic rural development programs.

This dissertation shall begin by briefly describing the economic forces in U.S. agriculture. Discussions will focus on the effect that capital-intensive technology has on the welfare of farm families, farm workers, rural communities, and consumers. These discussions are then followed by a description of the resources, motivations, and constraints of America's small farm families. Among the constraints discussed is the inadequate amount of support provided to small farm families by the land-grant system.

The second section of the dissertation uses a case study format to discuss the development of vegetable production technology for small farm families. A FSR/E project recently conducted in East Central Virginia is used as the case study. In this study, the target area of the project is described, followed by a detailed description of the project's vegetable research. Proposals for future vegetable research are also presented.

The third section of the dissertation shall argue for fundamental changes in the orientation of rural development policy. First, the policy implications of the case study are addressed. This is followed by a discussion on the impact that farm structure has on the goals of the nation's agricultural and food policies.

The focus of the dissertation then shifts to the research needs of small farm families and rural communities. The role of the land-grant system in rural development is addressed, followed by a discussion on the value of FSR/E in future development programs. This is followed by a description of the research needs of small farm families. With respect to horticultural research, this dissertation discusses its current orientation, and then proposes a sampling of research topics which will serve to benefit rural society.

This dissertation supports the development of a farm sector which is predominated by traditional (small- and medium-scale) family farms. Small farms have been focused on in this dissertation, but this by no means diminishes the importance of medium-scale family farms to the development of strong rural communities. However, the development of vegetable production technology for each farm class cannot be adequately addressed in the scope of a single dissertation. Thus, small farms are herein discussed, and the needs of medium-scale farms remain to be addressed. In addition, as this dissertation is submitted to fulfill a requirement for the Doctor of Philosophy in Horticulture, discussions will focus on issues related to the production of horticultural crops, whenever appropriate.

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2. ECONOMIC FORCES IN U.S. AGRICULTURE

2.1. Capitalism

Capitalism is an economic system characterized by private ownership, private marketing, and free trade. People in a capitalistic society privately own land, labor, and capital, and they exchange these private resources in the free market to purchase desired goods (52). The population's desire to maximize profits, accumulate capital, and reinvest capital for additional wealth promotes the development of these economies.

Capitalism is an integral component in the traditional approach to economic development in the Western world (52). This approach was originated by Adam Smith in his essay, *The Wealth of Nations* (36), and has subsequently been refined by Ricardo (33), Ranis and Fei (32), and Keynes (17), among others.

In this approach, the industrial and agricultural sectors of the economy develop simultaneously. However, in the earliest stages of development, the agricultural sector initiates economic growth by providing:

1. surplus food to feed the workers in the industrial sector;
2. surplus labor and capital to supply labor to the industrial sector;
3. a surplus of exportable agricultural commodities to provide for foreign exchange; and
4. a market for the consumption of domestic industrial products (52).

The agricultural sector emphasizes productivity and efficiency in order to accomplish these four objectives. Advances in productivity and efficiency are attained by increasing the output of each worker through the use of additional capital in production. The development of capital-intensive technology, the education of agricultural workers, and a greater utilization of natural resources all contribute to this end (52).

2.2. The Establishment of Capitalism in U.S. Agriculture

The development of American agriculture has occurred within this framework of capitalism. During its colonial settlement, the United States enjoyed specific advantages over the European nations: access to plentiful natural resources, superior quality of raw materials, an abundance of land, and inexpensive energy. With labor being the limiting resource, the settlers began developing labor-saving, capital-intensive technology (22).

Major advances in the development of such technology included the development of the automatic grain reaper, the steel moldboard plow, and the cotton gin. Throughout the 1700's and early 1800's, these and many other labor-saving technologies increased agricultural productivity and encouraged farm families to increase their scales of operation. These technologies also encouraged a shift in the emphasis in farming from self-sufficiency to that of commercial production.

In 1862, three acts of legislation were passed which were to have significant impact on U.S. agriculture. The first piece of legislation established the United States Department of Agriculture (USDA), marking the increased role that the Federal Government was to have on the future development of the agricultural sector. The second act of legislation, the Morrill Act, led to the development of the land-grant universities. These publicly-funded institutions were created to provide higher education to the masses of society, 60% of whom worked on farms (39). The third act of legislation was the Homestead Act. This act promoted the settlement of the Western United States by providing 63 hectares (ha) of land to each of the families who would farm in the region.

Industrialists supported the passage of this legislation, as they recognized that agricultural productivity would increase if farm families were provided with higher education and fertile land resources. The expected increases in agricultural production would be conducive to industrial growth, as a bountiful supply of food in the urban areas would lead to low food prices. This, in turn, would allow the industrialists to keep the wages of their employees low, and thereby assist in the accumulation of capital for reinvestment.

Besides supporting this legislation, many industrialists began to establish profitable businesses associated with agriculture. Industrial factories were constructed to manufacture farm machinery, produce chemical fertilizers, and develop improved cultivars for agricultural production. The industrial sector also became increasingly involved in the storage, processing, and transportation of farm commodities.

This interaction between the industrial and agricultural sectors of the economy contributed to the economic growth of the nation, but it also reduced the economic independence of farm families. For it was during this period of transition that farm families had become increasingly dependent on industrial inputs in their farming practices. In addition, the inability of farm families to effectively organize prevented them from establishing any control over commodity prices. Indeed, the farm families in the late 1800's found themselves in the most subordinate and the least profitable segment of the agricultural sector. A North Carolina farm journal in 1887 described the frustrations of farm families in the evolving U.S. economy as follows:

There is something radically wrong in our industrial system. There is a screw loose. The wheels have dropped out of balance. The railroads have never been so prosperous, and yet agriculture languishes. The banks have never done a better or more profitable business, and yet agriculture languishes. Manufacturing enterprises never made more money or were in a more flourishing condition, and yet agriculture languishes. Towns and cities flourish and "boom," and yet agriculture languishes. Salaries and fees were never so temptingly high and desirable, and yet agriculture languishes (31, p. 54).

Conditions in the Northern U.S. were no better. A Minnesota editor questioned:

How long, even with these cheap and wonderfully productive lands, can ... any agricultural community pay such enormous tribute to corporate organization in times like these, without final exhaustion? (29, p. 60).

Similar questions have been asked by farm families for over a century. The responses of farm families have historically, more often than not, depended on their level of capital resources. Among those few farm families with sufficient capital, many have decided to compensate for the low profit margins by maximizing their production efficiency. These families have purchased capital-intensive production inputs from the industrial sector, and have generally increased their scales of operation to maximize efficiency. These activities continue to this day.

However, for the much larger group of farm families without sufficient capital, other choices have been made. One choice has been to find off-farm employment, and the majority of farm families today are dependent on off-farm income to keep their farms solvent (45). Another choice has been to accept a lower standard of living. In 1986, 20.3% of the farm population lived below the poverty line (43). A final decision has been to migrate to urban areas. Since 1930, approximately 40 million people made this decision, making this the single largest migration of humanity in modern times (26). These choices remain today for well over one million farm families.

2.3. The Impact of Capitalism on Rural America

Capitalism in U.S. agriculture has largely fulfilled the four objectives listed in Section 2.1. Using these objectives as a format, it may be said that capitalism in American agriculture has:

1. Provided surplus food to the industrial sector. The industrial workforce today has an abundant supply of food, and they spend a decreasing proportion of their income for it (18).

2. Provided surplus labor to the industrial sector. The development of labor-saving technology has released millions of agricultural laborers to the industrial sector. Today, only 2.2% of the nation's people live and work on farms (43).
3. Provided foreign exchange to the economy. The exportation of farm products today provides approximately 20% of the U.S.' foreign exchange (13).
4. Provided the industrial sector with a demand for industrial goods. More agricultural production inputs today come from the industrial sector (e.g., commercial fertilizers, pesticides, and farm machinery) than from the farms themselves (e.g., labor and land)(46).

These accomplishments, however, have come at a cost, particularly in social terms. Three global shortcomings of capitalism: unemployment, inequity in the distribution of income, and poverty (52), are herein discussed within the context of U.S. agriculture. Another shortcoming applicable to U.S. agriculture, the promotion of non-sustainable farming systems, shall also be discussed. All four shortcomings continue to occur in the rural U.S. today.

Unemployment

The development of capital-intensive technology in the U.S. has often led to the substitution of machinery for human labor. This has subsequently led to the displacement of labor, often without providing warning nor financial compensation to the affected workers.

The development of this technology has also reduced employment opportunities in farming communities, thereby fueling a great outmigration of farm families to urban

areas. Most of the people in this rural to urban migration have been, and continue to be "the better-educated, most adaptable portion of the rural population" (21, p. 23). Many of these migrants, however, have neither the education nor the training to subsist in the urban economy. These families have difficulties in adjusting to urban life. They may possess little or no savings, no urban job skills, and may be forced to live in overcrowded and substandard housing. During the peak migration period of the 1950's and 1960's, the President's National Advisory Commission on Rural Poverty reported that the net result of this migration for many families was nothing more than an exchange for life in a rural slum for that in a ghetto (30). In fact, the majority of farm operators who migrated to the urban areas from 1960-1965 experienced net losses in income (54).

To this day, many of the displaced migrants become involved in criminal and riotous activities; still others become chemically dependent on alcohol and drugs (2, 9, 16). The urban cities themselves suffer significant financial burdens as they are obligated to provide welfare payments and job training to these migrants, as well as to increase policing efforts (26, 54).

Rural towns have been particularly affected by the introduction of labor-displacing technology. The outmigration of farm families has left many rural towns without a sufficient clientele to maintain viable business establishments. Indeed, a South Dakota survey reported that one small business establishment closes down for every six farms that are forced out of operation (4). A recent Iowa State University study reported that the outmigration of residents from small rural towns in Iowa has contributed to these towns losing 35% of their retail sales from 1976 to 1986. "These sales losses translate into losses of businesses," stated the author of this study (38,

p. 16A). Furthermore, these losses of businesses create even more unemployment in rural areas, and furthermore, jeopardizes the solvency of those farms which rely on off-farm income. Unfortunately, rural towns have been inadequately equipped to provide the social services and job-training programs which are necessary to alleviate their unemployment (3).

Inequitable Distribution of Income

The equitability in the distribution of agricultural income among the farm classes of America is decreasing, thereby contributing to the development of a polarized farm economy.

Small farms (those farms with annual sales of less than \$40,000) represent the low end of the income scale. These farms in 1986 accounted for 72.9% of the nation's farms, but only 15.0% of the nation's farm sales (Figure 2.1). In fact, the average small farm in 1986 netted only \$139 in farming activities, and remained solvent only through off-farm employment (47). Those small farm families without off-farm skills have often been forced to leave farming altogether, or to live in poverty. As for the future of small farms, the U.S. Office of Technology Assessment (USOTA) projects that there will be a marked reduction in their numbers (approximately 30-40%) from 1982-2000 (49).

At the other end of the income scale are the *large farms* (those farms with annual sales of \$250,000 or more). In contrast to the expected decline in small farm

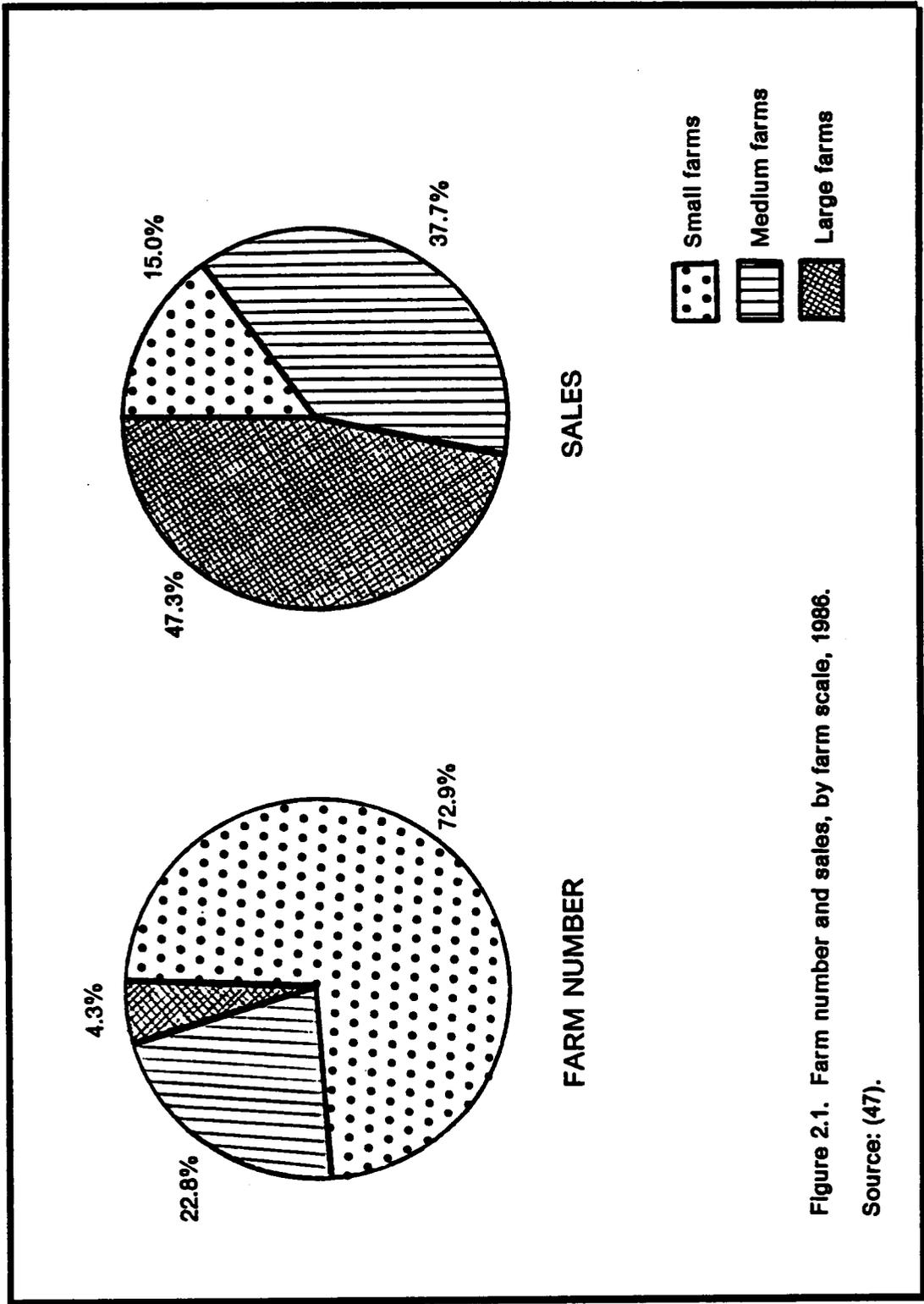


Figure 2.1. Farm number and sales, by farm scale, 1986.
Source: (47).

numbers, the number of large farms is projected to increase by 40% within the same time period. The monies going to large farm families and corporations are dramatically increasing. By the year 2000, the top 1% of farms in the nation will earn approximately 50% of all farm sales. In stark contrast, the bottom 50% of farms will earn approximately 2% of all farm sales (49).

Rural Poverty

The development of large-scale, industrialized farming systems tends to increase the incidence of poverty and reduce the quality of life in rural areas (1, 7, 14, 15, 19, 20, 35, 37, 44).

In 1986, 20.3% of the farm population lived below the poverty line, compared to that of 13.8% of the non-farm population (Table 2.1). The rate of poverty within the farm population dramatically rose 5.6% during 1979-1986, which was nearly four times the rate of increase for the non-farm population (40, 43). The inability of farm families to compete against capital-intensive farming systems, the depressed rural economies, and the lack of employment opportunities in rural areas have all contributed to this financial distress. Minorities living on farms have particularly suffered: 40.6% of the minority farm population, and more specifically, 48.0% of the black farm population lived in poverty in 1984 (41).

Besides suffering from a higher incidence of poverty, rural areas also suffer from greater magnitudes of poverty. The average poor farm family in 1979 had an income level which was \$3760 below the poverty line, whereas the average poor urban family

Table 2.1. Income and poverty levels of the farm and non-farm population.

Characteristic	Farm	Non-farm
Median family income, 1986 (\$)	21,853	27,881
Poverty rate, 1986 (% persons)	20.3	13.8
Rise in poverty rate, 1979-1986 (%)	5.6	1.5
Among impoverished families, 1979:		
Mean income deficit (\$)	3,760	3,590
Receive public financial assistance (%)	5.9	33.4

Sources: (40, 43).

earned a level of income \$3590 below the poverty line. But despite the higher incidence and magnitude of poverty that exists among farm residents, the farm poor have been among the least likely of citizens to receive public assistance. Indeed, only 5.9% of the poor farm population received public assistance income in 1979, compared to that of 33.4% of the non-farm poor (40).

Likewise, many rural communities have been impoverished. The health, education, and public welfare services of rural areas all receive less per capita financial support than those of urban areas (46). These deficiencies in community development have together contributed to the higher incidences of maternal and infant mortality, illiteracy, and substandard housing in rural areas (7).

Finally, despite the abundance of food produced by the agricultural systems of the U.S., there is an increasing prevalence of hunger and malnutrition throughout the population (27). Approximately 20 million Americans regularly go hungry for at least some period of each month, and 500,000 American children suffer from malnutrition (including severe growth- and mentally-disabling malnutrition). Although most of this malnutrition occurs among the urban population, rural families may also become susceptible to malnutrition due to the high incidence and magnitude of rural poverty, geographic isolation, and the lack of social and educational services in rural areas. Furthermore, rural areas have a disproportionately high amount of impoverished elderly citizens, a population group particularly susceptible to malnutrition.

Non-Sustainability

The utilization of large-scale, capital-intensive technology has led to the development of farming systems which are both non-sustainable and environmentally degrading.

Fossil fuels are widely used today to power farm vehicles and machinery, manufacture fertilizers and pesticides, dry and store crops, and transport farm produce. The increasing dependence on these non-renewable energy resources causes farming to use more petroleum than any other business in the nation (46).

From a global perspective, the dependence of U.S. agriculture on the use of petroleum has caused the nation to utilize a disproportionately high amount of the planet's non-renewable energy resources. Americans use five to six times more energy per capita than the world average, and its farming systems are among the world's least efficient (3).

An analysis of the farm sector's utilization of fossil fuels indicates that more energy goes into the production of the nation's commercial fertilizers than goes into the nation's plowing, planting, cultivating, and harvesting operations combined (12). The utilization of commercial fertilizers in the U.S. has increased by 440% since 1960 (47).

As in the case of fossil fuel consumption, the emphasis on short-term economic efficiency in U.S. agriculture has led the nation to be dependent on the natural resources of other countries. In fact, the importation of commercial fertilizers has risen by over 70% since the early 1970's, to the point that approximately 40% of the fertilizers used by American farmers are imported (42).

This increased dependence on imported fertilizers is particularly evident for those nutrients which are in the greatest demand for agricultural production: nitrogen, phosphorous and potassium. In the past, the U.S. had been an exporter of nitrogen and potassium fertilizers, and was the world's largest producer of phosphate rock. Today, however, the U.S. must import nitrogen to keep up with its consumption. In addition, it is projected that by the year 2000 the U.S. will have exhausted its phosphate resources and will be forced to import 90% of its potash (12). Alternative and renewable sources of fertilizer (particularly legumes) have been used for centuries, but the need to maximize short-term economic gains in today's farm economy has detracted from their use.

In addition to enhancing soil fertility, legumes and other green manures could also play a valuable role in protecting soils from erosion. The terracing of slopes and the planting of windbreaks are additional soil conservation strategies, but again, short-term economic pressures and the utilization of large-scale machinery constrain their use (34).

L.R. Brown, former administrator of the International Agricultural Development Service in the USDA, places the importance of soil conservation in perspective when he states that:

Croplands are the foundation not only of agriculture but of civilization itself. Thus, the loss of soil is in some ways the most serious of the threats civilization faces there are no widely usable substitutes for soil in food production. Civilization can survive the exhaustion of oil reserves, but not the continual wholesale loss of topsoil (8, p. 13).

Agronomists agree that land with deep topsoil may lose as much as 2.8 MT/ha of soil per year without adversely affecting soil productivity. Likewise, land with thin layers

of topsoil may lose 1.1-1.7 MT/ha of soil per year. Currently, however, 34% of the nation's cropland have erosion rates which exceed 2.8 MT/ha/yr (11). The conditions in Virginia are alarming: the average erosion rate on the state's cropland is 3.7 MT/ha, and for over one-third of its cropland the average erosion rate is 4.5 MT/ha/yr. Moreover, nearly 400,000 ha of Virginia's pastureland have severe erosion problems, and half of these lands are eroding at an average rate of 4.5 MT/ha/yr (51).

The only resource which compares with soil in its value is that of water. The nation's farming systems presently consume 83% of the fresh water that is withdrawn, and it is projected that the use of water in agriculture will increase 17% by the year 2000 (50). Today's farming systems, in fact, are becoming so water intensive that the rates of ground water removal exceed those of replenishment in most areas of the nation (28). The U.S. Water Resources Council reported that, based on the existing levels of use, almost every region west of the Mississippi River will have insufficient water for agricultural production by the year 2000 (50).

In addition to these concerns over the quantitative loss of soil and water resources, the quality of these resources has also become increasingly threatened through the widespread use of chemical pesticides and commercial fertilizers in agriculture. From 1960-1986, farm expenditures on pesticides increased 1493% (47).

Such dependence on the use of agricultural chemicals in food production threatens the health of American consumers, especially since the National Research Council reports that 64% of agricultural pesticides have inadequate toxicity data (24). In livestock production, the USOTA has identified 140 pesticides and drugs that remain in meat after slaughtering operations. Among these 140 chemicals, 42 are known or suspected carcinogens, 20 may cause birth defects, and 6 have caused genetic

damage to laboratory animals (48). In crop production, 47 pesticides registered for use in the U.S. are known to be carcinogenic (23). Many of these pesticides are commonly used in production. In fact, 9 out of 10 fungicide, 6 out of 10 herbicide, and 3 out of 10 insecticide applications in U.S. agriculture are of chemicals which are classified by Congress as being either carcinogenic or potentially carcinogenic (25). The magnitude of this threat to the health of American consumers is enormous, as half of all foods marketed in the U.S. have detectable levels of pesticides (3).

The health of American farm families is also threatened. In reference to short-term dangers, approximately 45,000 Americans are poisoned each year by exposure to pesticides (12). In reference to long-term effects, a survey of licensed pesticide applicators in Florida has shown that the incidence of lung cancer significantly increases as time of employment increases (5). Furthermore, national and statewide reports have shown that farmers have higher incidences of leukemia, prostate, and stomach cancers than the general population (6, 10). Wiklund and Holm report that the increased utilization of pesticides may have contributed to Swedish agricultural workers having a significantly higher incidence of cancer in recent years. Prostate, primary liver, and genital organ cancer rates were particularly high in this study (53).

Horticultural farms are especially dependent on fossil fuel energies, commercial fertilizers, and agricultural chemicals in production. These farms spend 5.39 times more money on energy and petroleum products per hectare, and 3.06 times more money on commercial fertilizers per hectare than those farms specializing in the production of other crops (Table 2.2)(45).

Horticultural farms also spend 7.80 times more money on agricultural chemicals per hectare than do those farms raising other crops (45). These chemicals are used in

Table 2.2. Expenses of energy-based production inputs, expressed as dollars per hectare of harvested cropland, by farm type, 1982.

Production input	Vegetables ^a and melons (016)	Fruits and tree nuts (017)	Hort. specialties (018)	Hort. crops mean	Field crops (011,013)	Hort. crops to field crops ratio
Energy, and petroleum products	164.97	184.85	1287.46	254.55	47.20	5.39
Commercial fertilizers	185.55	130.24	206.94	156.70	51.13	3.06
Other agric. chemicals ^b	172.31	209.13	187.13	193.55	24.80	7.80

^aFarms are classified under Standard Industrial Classification units, as cited in the U.S. Census of Agriculture.

^bIncludes pesticides, fumigants, thinning sprays, and liming materials, among other chemicals.

Source: (45).

numerous cropping activities, including the reduction of weed populations, protecting fruits and vegetables from insects and diseases, thinning fruits from trees, promoting the uniform ripening of fruits, easing the abscission of fruits off plants, and facilitating the long-term storage of crops, among other activities.

This widespread utilization of fossil fuels and chemicals in horticulture significantly increases the productivity and efficiency of production operations. But these practices also have profound effects on rural unemployment, the quality of life in rural communities, the environment, and the health of farm families and farm labor. This dependence on chemicals in horticultural production also places the health of consumers in jeopardy. Indeed, of the 15 foods whose consumption are mostly likely to cause tumorous cancers, nine are horticultural crops, with tomatoes topping the list (Table 2.3)(25).

Table 2.3. The 15 foods with the greatest estimated oncogenic risk, 1987.

-
-
1. Tomato*
 2. Beef
 3. Potato
 4. Orange
 5. Lettuce
 6. Apple
 7. Peach
 8. Pork
 9. Wheat
 10. Soybean
 11. Bean
 12. Carrot
 13. Chicken
 14. Corn (bran, grain)
 15. Grape
-

*Estimates were calculated for each food by multiplying the pesticide intake for each food by the oncogenic potential of pesticides used in food production. The pesticide intake for each food was estimated by accounting for the acceptable residue levels of pesticides for each food, the level of consumption for each food, and the percentage of each food type produced with pesticides.

Source: (25).

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3. SMALL-SCALE FARMING IN AMERICA

Since the settlement of Jamestown in 1607, the American small farm has provided sustenance and a fulfilling way of life to millions of families. In an even broader perspective, the American small farm has both served as the backbone of rural communities, and has provided food and fiber for the nation's people. The following chapter describes the current status of America's small farms. It begins with a description of their characteristics, and then follows with a discussion of the constraints they face today in their development.

3.1. Characteristics of Small Farms

Financial Resources

In this dissertation, the classification of farm scale has been defined by the level of farm sales. Small farms have been defined as those farms which gross less than

\$40,000 in annual farm sales, large farms gross \$250,000 or more in farm sales, and medium-scale farms have an intermediate level of farm sales. Using this criteria, small farms represent the major class of farms in all 50 states (36), and 72.9% of farms nationwide (Figure 3.1)(39).

The average American small farm in 1986 grossed \$15,140 in farm sales, but actually netted only \$139 in farming operations (Table 3.1)(39). Many small farm operators, therefore, worked off the farm to maintain their farm's solvency. In fact, 68.5% of small farm operators reported in 1982 that they worked off the farm, and 48.1% worked off the farm for 200 or more days (36). The income that small farm operators gained from off-farm employment averaged \$22,534 in 1986, contributing to their total mean income of \$22,673. This total mean income was only 7.6% that of large farm operators, and 81.3% that of the non-farm population (30, 39).

Clearly, many small farm families today are living under severe economic distress. The USDA reports that one-third of small farm families were living in poverty in 1986 (38). Moreover, the financial status of these families in the future may be even worse, as the ongoing development of labor-displacing technology and the loss of vitality in many rural communities may reduce the off-farm employment opportunities in rural areas. Small farm families are especially dependent on these off-farm employment opportunities for their sustenance.

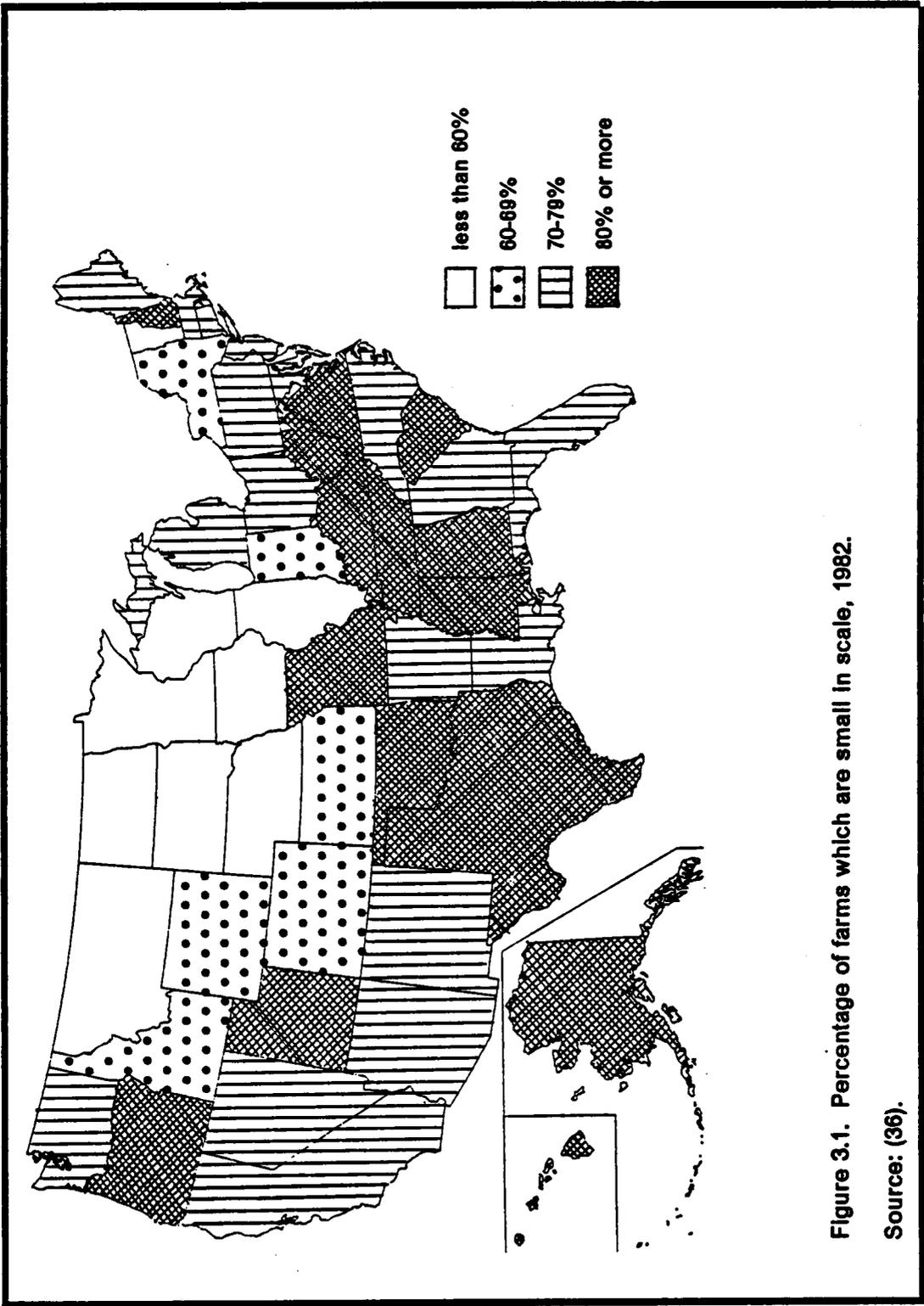


Table 3.1. Resources of farms in the United States, by farm scale.

Characteristic	Farm scale		
	Small	Medium	Large
Financial resources, 1986:			
Farm sales (\$)	15,140	122,403	804,742
Net farm income (\$)	139	18,680	280,281
Off farm income (\$)	22,534	13,427	17,509
Total income (\$)	22,673	32,107	297,790
Physical resources, 1982:			
Value of land, bldgs. (\$1000)	156	609	2,108
Farmland (ha)	72	321	981
Harvested cropland (ha)	24	140	392
Operator characteristics, 1982:			
Work off farm:			
Any days (%)	68.5	31.7	21.3
200+ days (%)	48.1	11.0	7.9
Debt to asset ratio (%)	11.6	20.6	28.6
Rent land (%)	30.7	66.8	67.9
Hire labor (%)	28.9	60.3	86.4

Sources: (36, 38).

Physical Resources

As a group, small farms in 1982 possessed 32.3% of the total value of agricultural land, buildings, and machinery resources of the United States. On average, the individual small farm had physical resources of \$156,004 in value, as compared to \$2,108,003 for large-scale farms (Table 3.1)(36).

The land resources of small farms are often limited in terms of both quantity and quality (10, 17). The average small farm in 1982 had a land base of 72 ha, with 24 ha of harvested cropland. This is in contrast to large farms, which had average land bases of 981 ha, 392 of which were in harvested crops (36). In addition, the quality of land on small farms is often marginal, limiting the type and scale of enterprises which may be implemented (10, 42).

A lack of appropriate farm machinery for small farms has contributed to the overmechanization of many of these farms. Overmechanization is most common for small farms with traditional farm enterprises (small grain and livestock production), and leads to production inefficiencies (5, 8). This absence of appropriate small farm technology is largely attributable to the lack of attention placed on the needs of small farms by both agribusiness and the land-grant universities (9).

Human Resources

Small farms are often limited in both the quantity and quality of their human resources. With respect to quantity, the dependence of small farm operators on

off-farm employment generally takes an appreciable amount of time away from their farming activities. With respect to quality, small farm operators on average have lower managerial abilities, less formal education, a higher incidence of physical disability, and are slightly older than large farm operators (10, 12, 17, 25, 42). These human limitations constrain many small farm operators in both their farming activities and in obtaining off-farm employment.

Motivations of Operators

Two common motivations of small farm operators are the desires to: 1) minimize living expenses while living in a rural environment; and 2) to maintain farm solvency (42). With these motivations in mind, many small farm operators are not likely to take significant risks in their farming operations. This aversion of small farm operators to risk is reflected in their low debt to asset ratios, their hesitancy to rent land, and their reluctance to hire labor (Table 3.1). It should also be noted, however, that some small farm operators are willing to take risks in their farming operations. But these ambitions often go unfulfilled, as the operators are limited in their resources and have less access to credit. In addition, the lack of appropriate technology for small farms impedes the development of these farming operations.

Among other objectives, particularly for older farm operators, is the desire to integrate their farming operations into their retirement plans and/or to transfer the ownership of their farming operations to their offspring (42). Lastly, a common objective for those farm operators with substantial off-farm earnings is to use their farm as a source of recreation and/or as a tax shelter.

3.2. Constraints to the Development of Small Farms

There are numerous constraints which impede the development of small farms. Government policies, marketing limitations, and racial discrimination have been among the major constraints, and they are discussed in this chapter. Inadequate support from the land-grant system has also been a major constraint; this subject is addressed in Chapter 4.

Government Policies

The United States Government has historically designed its agricultural programs to promote the development of family farms. In the Food and Agriculture Act of 1977, the U.S. Congress reaffirmed its commitment to the family farm when it legislated:

... the maintenance of the family farm system of agriculture is essential to the social well-being of the Nation and the competitive production of adequate supplies of food and fiber. Congress further believes that any further expansion of nonfamily owned large-scale corporate farming enterprises will be detrimental to the national welfare (32, p. 918).

In their support of family farms, the Federal Government has provided financial credit, fair commodity prices, and other needed assistance for over 50 years. All farms have been eligible to participate in these programs, however, it has primarily been the interests of large farms which have been served (1, 6, 11, 14, 22, 23, 34). As evidence, in 1986 only 17.9% of federal farm program payments went to small farms, with participating households receiving an average payment of \$1315. In contrast, the

relatively few large farm operators received 23.7% of these funds, and average payments of \$29,329 (Figure 3.2)(39).

The Task Force on Southern Rural Development summed up the directives of the Federal Government's rural policies as follows:

The United States government's rural policy since World War II has been virtually synonymous with policy favorable to commercial agriculture (and) has largely ignored the needs and problems of small farmers, farm workers, and especially non-agricultural workers and their families in rural non-farm communities. Moreover, it has resulted in loss of jobs through displacement from farming and has done little to help those displaced adjust to employment situations in urban areas (26, p. 72).

The following section discusses the impact of the U.S. Government's commodity price support programs, taxation policies, and lending programs on small farm families:

Commodity Price Support Programs. These Government programs increase and stabilize the incomes of farm families by guaranteeing them fair prices for their crops. Payments in the form of nonrecourse loans are provided to participating growers on the basis of program eligible acreage and yields per unit area. At the time of their enactment in 1933, nearly all of the nation's farm families benefited from these programs since farms were uniformly small in scale and generated chronically low incomes. As large-scale farming systems began to develop, however, the payment structure of these Government programs began to disproportionately favor the larger-scaled farms (11, 13, 18, 22, 23).

There is strong evidence that this bias against small farms continues today, both through direct and indirect means. Through direct means, small farms receive a

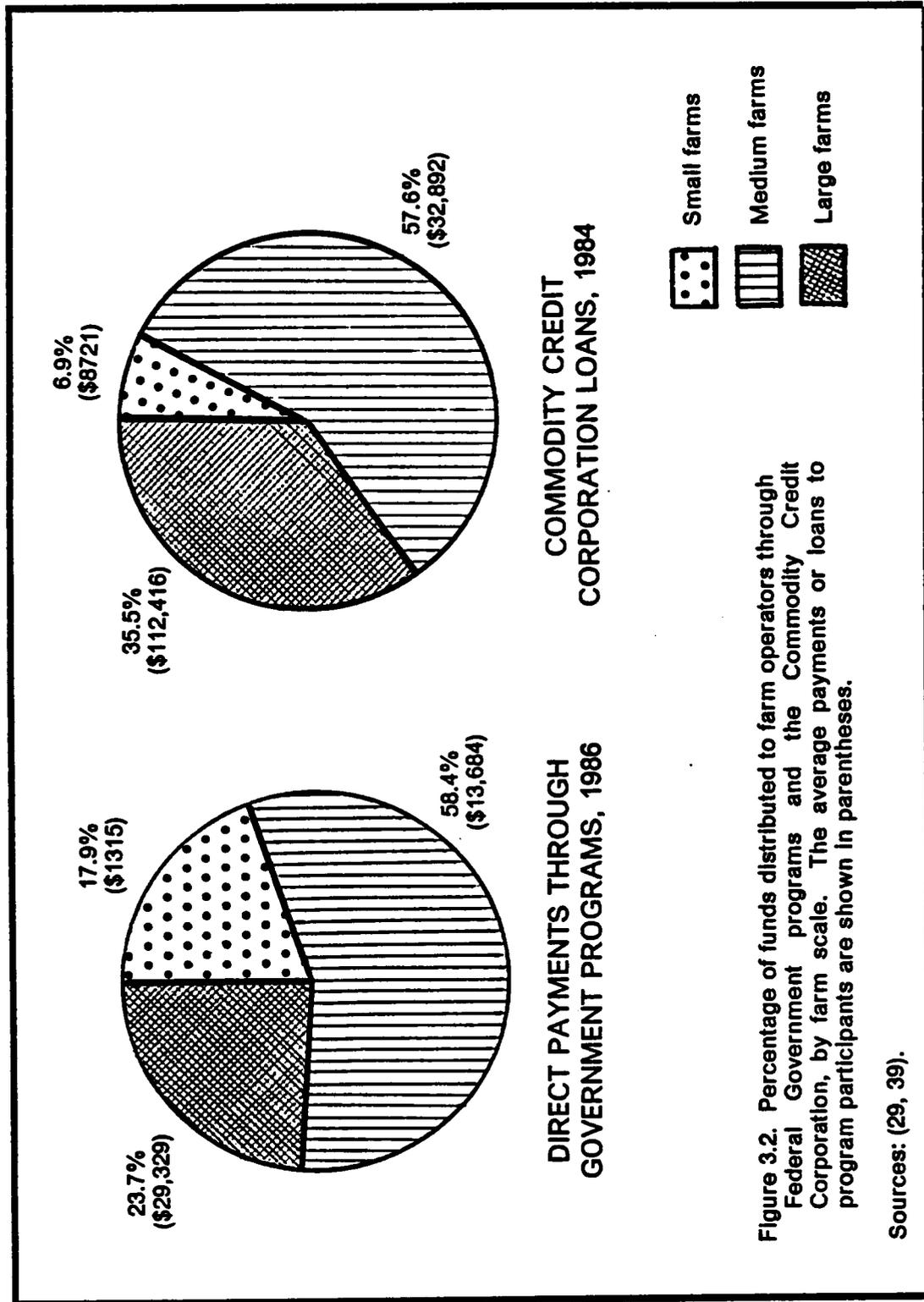


Figure 3.2. Percentage of funds distributed to farm operators through Federal Government programs and the Commodity Credit Corporation, by farm scale. The average payments or loans to program participants are shown in parentheses.

Sources: (29, 39).

disproportionately low amount of commodity price support funds. In 1984, only 6.9% of these funds went to small farm operators, with the average loan being \$8721 (Figure 3.2). In contrast, the relatively few large farm operators received a total of 35.5% of the program's funds, and average loans of \$112,416 (29).

Through indirect means, commodity price support programs favor large-scale farms by stabilizing farm prices and reducing risks. This increases the value of farmland, and thus, those farms with the largest tracts of land (generally large farms) benefit most. These inflated land prices also encourage greater concentration in farming by making it more difficult for landless farm workers and potential farm families from purchasing land. Furthermore, by reducing risks in production, these programs also encourage the adoption of expensive, yet efficient technologies. Again, this favors large-scale farms (14, 19).

Taxation Policies. The Federal Government provides investment tax credits and accelerated depreciation allowances to those farm operators who purchase farm machinery. These policies favor large farm operators, as these people have a greater availability of financial resources to make such purchases (4, 20, 34, 40). In addition, the Federal Government imposes payroll taxes upon farm operators for their hired labor costs (4). These taxation policies taken together, *i.e.*, providing tax breaks for the purchasing of machinery while imposing payroll taxes upon hired labor costs, contributes to the substitution of capital for labor in agriculture.

The beneficiaries of these taxation policies are the capital-rich, large farms. Former Secretary of Agriculture Robert Berglund reports that such policies were not intended to favor the large farms. He admits, however, that "those individuals or firms with

considerable wealth or in high income tax brackets have the greatest incentive or financial ability to utilize tax rules to their benefit" (34, p. 91).

In contrast to these benefits bestowed upon the wealthy, those people most directly harmed by these pro-mechanization policies are hired farm workers who may lose their jobs. Small farm operators are also disserved by these policies, since these people lose both their competitiveness in the farm sector, as well as opportunities for supplementary employment on nearby farms.

In summarizing the net effect of these policies, Secretary Berglund reports:

Research results to date are consistent on one point: the direction of change caused by tax policies has been toward increased concentration of farm production and wealth and perhaps, more capital intensive technology (34, p. 91).

Lending Policies. All scales of farms may benefit from the use of credit. The purchasing of inputs, farm refinancing, and making capital improvements on farms often requires outside funding. Small farm families, however, generally have less equity and fewer financial resources, making them less desirable to private lending institutions. The Farmers Home Administration (FmHA) was specifically established by the U.S. Government to provide loans to these and other disadvantaged families who could not obtain credit elsewhere. This agency, however, has been criticized for not fulfilling its mandate, as it has been deficient in providing low-interest loans to limited-resource farm families, including those operated by racial minorities (3, 11, 18, 23).

This deficiency has been especially evident in the South, where limited-resource farms are most predominant. In fact, the FmHA in only one of 15 Southern states

during 1983-1984 provided 20% of its loans to limited-resource farms at the reduced rate of interest allowed for under law. The FmHA in Virginia was most deficient, providing only 1.2% of its loans to limited-resource farms at the reduced rate of interest. Aware of these shortcomings, the U.S. Congress has since established lending guidelines for the decentralized agency (18).

Other concerns of credit for small farm families are that the FmHA is particularly slow in the processing of loan applications, and that small farms are not made aware of credit lending programs by public service agencies (3, 12, 15, 23). These concerns are largely explained by the shortage of personnel in the FmHA, as loan officers have difficulty in processing loans expediently, and are also reluctant to increase their workloads by publicizing their loan programs (23).

Marketing

The present day marketing system is characterized by: 1) a high degree of concentration among the producers and purchasers of farm products (21); 2) the preference of purchasers for standardized products delivered in an orderly manner; 3) the preference of purchasers to buy their agricultural goods from as few producers as possible; and 4) a significant amount of packaging and processing done before the farm product reaches the consumer. All these marketing characteristics are reported to favor large-scale farming operations (27).

These marketing trends have, in turn, provided small farms with both fewer marketing options and less bargaining power. The principal strategy used by small farms to

remedy the former is through direct marketing. Pick-your-own markets, roadside stands, farmers' markets, farmhouse specialty shops, as well as direct sales to public institutions, local groceries, and restaurants are all examples of direct marketing options (24). Drawbacks to direct marketing are the time and labor involved, the relatively low volume of sales (27), and difficulties in obtaining production credit (42).

The principal strategy used by small farms to increase their bargaining power is through the development of cooperatives (11, 27, 42). The potential advantages of participating in cooperatives are: 1) a reduction in unit production and marketing costs; 2) a greater volume and dependability in the timing and delivery of farm products; 3) the ability to explore new markets; and 4) the ability to hire management personnel with specialized knowledge in marketing (27).

Despite their potential, most small farm cooperatives have experienced serious problems. The independence and skepticism of some small farm families have often limited the activities of these cooperatives. Many small farm cooperatives also suffer from a lack of capital due to the members' reluctance to invest in the cooperative, and the reluctance of banks (including the publicly-supported Bank of Cooperatives) to provide initial funding. Small farm cooperatives have also been weakened by unqualified management (27). Moreover, small farm cooperatives have at times been treated with hostility from the established farmers, particularly in Southern states where many small farm families are black (16).

Racial Discrimination Against Black Farm Families

Black-operated farms continue to rapidly disappear throughout the rural United States. From 1920-1982, the number of black-operated farms declined by 97%. And, while the decline of white-operated farms temporarily tapered off from 1978-1982 at a rate of 0.6%, the number of black-operated farms continued to fall by 11.0% (36). It is commonly believed that if present trends continue, there will be few remaining black-operated farms by the year 2000 (2, 3, 18). Among the farms operated by black farm families today, a disproportionately high percentage of them (over 90%) are small in scale (36).

Black farm families are generally much poorer than white farm families. Median family income for black farm families in 1979 was \$9233, only 56% of the median family income for white farm families (\$16,456). Moreover, 48.0% of black farm families in 1984 lived in poverty, compared to 19.8% of white farm families (28).

Among the numerous obstacles to their development, black farm operators have historically been discriminated against in the purchasing of land. Black families were often required to have the approval of their white-dominated communities before they were allowed to purchase a tract of land, and were often forced to settle on lands which were either infertile or purposely distant from highways, railroads, white-segregated schools or churches. In addition, black families often had to have large sums of cash on hand to purchase land (3).

The difficulty that blacks had and still have in purchasing land is in part attributable to the actions of the FmHA. Due to the low income and equity of many black families, it would appear that this lending agency would be well-suited to serve this clientele.

Black farm operators in 1982, however, received only 1.4% of the agency's loans for the purchasing, improvement, and refinancing of farms. Similarly, black farm operators received only 4.5% of the loans provided to support the management of farms, and 2.3% of loans for soil and water conservation projects. The opportunity of black families to receive low-interest, limited-resource farm loans is nearly non-existent in some states, including Virginia (only one black applicant received such a loan in 1982)(3).

After reviewing numerous complaints of racial discrimination directed toward the FmHA, the USDA determined that there has been:

... discrepancies in the real estate appraisal of farmland owned by blacks; inordinate waiting periods between applications and loan approval by blacks; absence of deferred loan payment schedules for blacks; requirements that some blacks agree to involuntary liquidation of their property (should they default on their loans) as a condition of their loans; and disparities in the number and amount of economic emergency loans made to blacks (3, p. 48).

Besides lending policies, an additional constraint to the development of black-operated farms is the lack of support they receive from the land-grant institutions of the South, where 94% of the black farm families reside (36). From a historical standpoint, after the Southern black population received their freedom from slavery through the Emancipation Proclamation, they nevertheless did not have access to the services of the land-grant schools. Indeed, it wasn't until 1890 that black farm families were provided with their own "separate but equal" land-grant institutions.

Commonly referred to as the "1890 colleges," these institutions have historically focused their efforts on serving the needs of small farm families. In fact, much if not

most of the nation's small farm research is conducted by these Southern institutions (7, 40, 41). However, as evidenced by the distribution of research funds, these "separate but equal" 1890 institutions have never been commensurate with their 1862 counterparts. Indeed, even with recent increases in research funding, the 1890 institutions have received less than 10% of the Southern states' *total funds* for land-grant research during the post-Civil Rights Era (9, 33, 35, 37).

This inequitable distribution of funds, as well as the slow compliance of the Cooperative Extension Service to Civil Rights legislation (9, 31), have greatly impeded the development of black-operated farms. In an even broader context, the lack of funding provided to these small farm-oriented institutions is but one of many facets of the general lack of land-grant support provided to small farms nationwide. Additional facets are addressed in the following chapter.

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4. LAND-GRANT SUPPORT OF SMALL FARMS

The land-grant universities have been instrumental in increasing the productivity of U.S. agriculture. At the time of their inception in 1862, the previously established American universities were patterned after the European models of higher education. Such colleges were private and elitist, and limited their studies to medicine, law, theology, and the classics. The land-grant schools, in contrast, were envisioned to be anti-elitist, bringing the democratic values of America to higher education. The land-grant schools were to be "the colleges of the people," and were constructed to provide higher education to the masses through what evolved as a tripartite mission: teaching, research, and extension (24).

In teaching, the land-grant schools broadened the scope of classroom instruction to include all areas of human interest: agriculture, the mechanical arts, the social sciences, business, and the fine arts, among many other disciplines. In research, their programs generated knowledge on the problems facing American society, and then sought to apply this knowledge in a practical manner. The extension mission,

that of disseminating knowledge to the public-at-large, made the land-grant system profoundly democratic (24, 39).

Liberty Hyde Bailey, the first President of the American Society for Horticultural Science (ASHS), described the role of the land-grant system in the dynamic agricultural sector of the U.S. as follows:

We are now in the midst of a process of the survival of the fit. Two opposite movements are very apparent in the agriculture of the time: certain farmers are increasing in prosperity, and certain other farmers are decreasing in prosperity. The former class is gradually occupying the land and extending its power and influence

.... this is the very time when agricultural colleges and experiment stations and governmental departments have been expanding knowledge and extending their influence. The fact is, that all these agencies relieve first the good farmers. They aid first those who reach out for new knowledge and for better things. The man who is strongly disadvantaged by natural location or other circumstances, is the last to avail himself of all these privileges

The failure of a great many farmers may be less a fault of their own than a disadvantage of the conditions in which they find themselves. It is fairly incumbent on the state organization to provide effective means of increasing the satisfaction and profit of farming in the less-fortunate areas as well as in the favorable ones (1, p. 14, 15).

Bailey's words are as fitting today as they were in 1911, but his call to effectively serve disadvantaged farm families has largely gone unheeded. The large and prosperous farms remain the principal beneficiaries of the land-grant system, whereas small farms find themselves more and more at a competitive disadvantage (2, 9, 13, 22, 31, 32, 42, 47, 50, 52, 53, 54, 57, 58, 59). This chapter shall discuss the impact of the land-grant system on the structure of U.S. agriculture. A

complementary approach to rural development, Farming Systems Research & Extension, will be introduced as a methodology which may be useful in serving small farms.

4.1. Land-Grant Research

The needs of small farms have been inadequately addressed by land-grant research. Although small farms account for the vast majority of U.S. farms, a 1978 inventory of land-grant research by Kansas State University found only 67 research projects out of 20,725 which were specifically oriented toward their needs. The objectives of these special projects were the development of appropriate production technology, the evaluation of resources and enterprises on small farms, and increasing marketing efficiency. In this inventory, 22 additional projects were identified which had at least some component of their research directly applicable to small farms or had potential implications for small farms. These combined research efforts accounted for only 0.43% of research projects, 0.55% of researchers' time, and 0.41% of research funds spent by the land-grant system (58).

An examination by the Experiment Station Committee on Organization and Policy (ESCOP) in 1981 also indicated a lack of research directed toward the development of small farms. After reviewing a 10% random sample of Current Research Information System (CRIS) reports, this committee reported that approximately 50% of land-grant research was scale-neutral. Of the remaining research, however, a disproportionately low amount was directed toward small farm families (10). Indeed,

only 7.3% of production research and 3.5% of processing and marketing research was directed at this major farm class (10).

After an evaluation of land-grant research in the early 1970's, the United States General Accounting Office (USGAO) reported that the "USDA and the land grant colleges have not made a concerted effort to solve problems impeding the economic improvement of small farm operators" (52). After a follow-up study in 1980, the USGAO again concluded that most agricultural research was ill-suited to the needs of small farms (54).

While land-grant researchers have not been remedying the problems of small farms, they have been placing a significant amount of effort on increasing the economic efficiency of production. Inventories of land-grant research indicate that the 1862 institutions spend approximately 60% of their research funds in efficiency research (31), and more specifically, approximately 40% of their research funds toward achieving USDA Goal III: "Produce an adequate supply of farm and forest products at decreasing real production costs" (Table 4.1)(51). In achieving this goal, research efforts have traditionally concentrated on increasing biological efficiency and the level of mechanization in production.

These, and other land-grant research efforts have generally required farm families to possess large amounts of capital and to increase their dependence on non-farm inputs in production (53). Clearly, as evidenced by the increasing scales of farming operations, the polarization of farm classes, and the historic migration of limited-resource farm families to urban areas, land-grant research has been both structurally and socially biased toward large-scale, capital-rich farms (31).

Table 4.1. Percent distribution of land-grant research funds directed toward achieving the nine USDA goals, by institution, 1982.

USDA Goal	Institution	
	1862	1890
I. Insure a stable and productive agriculture for the future through management of natural resources.	10.8 %	5.1 %
II. Protect forests, crops and livestock from diseases and other hazards.	21.1	7.9
III. Produce an adequate supply of farm and forest products at decreasing real production costs.	41.4	32.8
IV. Expand the demand for farm and forest products by developing new and improved products and processes and enhancing product quality.	7.9	7.3
V. Improve efficiency in the marketing system.	2.4	0.9
VI. Expand export markets and assist developing nations.	0.3	0.0
VII. Protect consumer health and improve the nutrition and well-being of American people.	5.1	15.4
VIII. Assist rural Americans to improve their level of living.	2.2	18.1
IX. Promote community improvement, including development of beauty, recreation, environment, economic opportunity, and public service.	8.8	12.5
	<u>100.0</u>	<u>100.0</u>

Source: (51).

Mechanization research has particularly been biased toward serving the needs of large farms. Within the scope of this research, technologies developed for the mechanical harvesting of crops, including horticultural crops, have led to the displacement of millions of American farm families from their lands (13, 31, 47).

The Mechanical Harvesting of Horticultural Crops

Among horticultural crops, the development of the mechanical harvester for the processing tomato is a well-documented example of how publicly-funded research has displaced farm families and promoted a concentrated, large-scale production industry. Within six years of its introduction, this harvester eliminated more than 32,000 jobs in California, providing neither consideration nor compensation to the displaced workers. Likewise, within 10 years, the number of farms producing processing tomatoes in the state declined precipitously, from 4000 to 597. Also, the average size of the tomato plots increased from 13 to 143 ha, as this technology was suitable only for farms with large tracts of land and the financial resources required to purchase the machinery (which today costs more than \$150,000). The impact of this technology was also felt outside of California, as other areas of major production (Ohio, Indiana and Maryland) lost their competitiveness in the market (43, 47).

Those people most hurt by this and other mechanization research have clearly been small farm families and hired farm workers. As described in Chapter 2, literally millions of these people were placed in poverty through the development of capital-intensive technology. James Hightower, currently the Commissioner of

Agriculture in Texas, described the insensitivity of this mechanical harvesting research toward displaced farm workers:

Farm workers have not been compensated for jobs lost to mechanization research. They were not consulted when that research was designed, and their needs were not a part of the research package that resulted. They simply were left to fend on their own - no retraining, no effort to find new jobs for them, no research to help them adjust to the changes that came out of the land grant colleges. Corporate agribusiness received a machine with the taxpayer's help; farm workers were put out of a job with the taxpayer's help, and those workers are not even entitled to unemployment compensation (13, p. 34).

The socio-economic impacts of mechanical harvesting research on small farm families, farm workers, and rural communities are rarely addressed in the professional journals of agriculture. This includes the two scholarly journals of horticulture in the U.S., *The Journal of the American Society for Horticultural Science* and *HortScience*. For horticultural crops, the development of mechanical harvesting technology is reported to have "revolutionized" the production of numerous fruit crops (26), and is cited as "probably the single-most dramatic development in vegetable production [in this century]" (56). Scientific progress in the development of these revolutionary machines, however, has been slow, as fruits and vegetables are generally quite sensitive to bruising, generally ripen over an extended period of time, and are grown on small tracts of land.

These drawbacks in the mechanical harvesting of horticultural crops, however, have afforded scientists the opportunity to learn from experiences in the mechanical harvesting of agronomic crops. As described in Chapter 2, the development of mechanical harvesters for agronomic crops has displaced millions of farm families from their lands, created unemployment for millions of farm workers, contributed to

the single largest migration of Americans in modern times, depressed many rural economies, and contributed to poverty in both rural and urban areas. Such socio-economic effects could hardly be more profound, but as evidenced through the writings in the scholarly journals of horticultural science, the scientific community has chosen not to address them.

A review by the author of 114 mechanical harvesting articles published in the two journals from 1969-1987 shows that 95% of the articles have a strict agro-biological focus. In these articles, scientists report on the developments of agricultural chemicals, cultural practices, and cultivars which facilitate mechanical harvesting. Although the developments of this technology certainly have profound effects on small farm families and hired farm workers, references to labor are not even mentioned in over 80% of these articles. If labor is ever mentioned, the scientists almost invariably attempt to justify their research by stating that labor is too scarce, unreliable, or too costly. Hightower responds to these statements as follows:

It is outrageous that those who have been brutalized so badly by mechanization have been used as the excuse for mechanization. Again and again there are references in land grant research materials to the scarcity, unreliability and cost of farm labor as the factor requiring mechanization. In fact, mechanization has been the force that has eliminated farm jobs

The turn to machinery has a snowball effect. As one crop is mechanized, there is less work in the area; as two or three crops are mechanized, there is not enough work in the area to make a living, so the farm worker hits the road. Then there is a 'scarcity of labor,' so other crops are mechanized. In the 1960's there arose a farm worker union and serious efforts to legislate an end to the most blatant farm worker exploitation. This assertion of farm worker dignity was met with a rush to mechanize as completely as possible (13, p. 32, 33).

Apart from these journals' overwhelming emphasis on the agro-biological considerations in mechanical harvesting, the economic impacts of this technology are discussed in depth in only 5% of the published articles. These particular articles describe the potential savings that growers receive in mechanizing their harvesting operations, and/or report the status of mechanized harvesting in the horticultural industry.

The social impacts of this technology on small farm families, farm workers, and rural society have not been adequately addressed. The displacement of labor, certainly a direct impact of this technology, has been discussed in only two articles to date, one with an economic focus (18), and one with a sociological focus (11). Both these articles discussed the potential impact of harvest mechanization in the production of iceberg lettuce. At the time of their publication and continuing to this day, manual labor has been both abundant and efficient in the harvesting of this crop. Nevertheless, the USDA and the University of California independently developed and constructed mechanical harvesters. In their pro-mechanization article, Johnson and Zahara (18) report that the mechanization of lettuce would provide "small but significant cost savings to the industry," and additional jobs for mechanics. The displacement of labor was considered as a justifiable expense in the short-term since the *production firms* would gain more through production savings than the *displaced laborers* would lose through costs in unemployment and job transition.

In the only article published in these two journals on the social consequences of mechanical harvesting, Friedland *et al.* (11) dispute Johnson and Zahara's estimates of labor displacement and provide the only in depth description of the impact that mechanized technology has on farm workers and farm families. Friedland *et al.*

report that a 50% adoption rate of this technology could lead to a displacement of 87% of the labor force (even a 50% adoption rate is conservative as most vegetables in which mechanical harvesters have been developed have a near 100% adoption rate [19]). Moreover, this article is the single writing in the journals which explicitly states the obvious consequence that small farm families may be forced out of operation through the implementation of mechanical harvesting technology (11). Still yet to be addressed in these journals are the broader implications of this technology to society, including the impacts of the technology on the welfare of farm families, rural communities, and American consumers.

In addition, the small farm nature of horticultural production is not being accounted for in much of this mechanization research. Fifty-two percent of horticultural farms gross less than \$10,000 in total farm sales, and 74% gross less than \$40,000 (48). When one considers the great cost of this mechanization technology, it may be concluded that the land-grant institutions are primarily serving the needs of agribusiness and large farms in this research effort. In fact, farm machinery companies will not generally develop these machines without land-grant support, due to the low demand for such machinery and the difficulties in patenting (18, 19).

The Lack of People-Oriented Research

The narrow and non-sociological focus of land-grant research is most clearly shown in the conspicuous lack of research which is directly focused on people, rather than on production, processing or marketing. *People-oriented research* is that term used by the USDA to describe research efforts which are directed toward the achievement

of USDA Goals VII, VIII, and IX: "Protect consumer health and improve the nutrition and well-being of American people;" "Assist rural Americans to improve their level of living;" and "Promote community improvement, including development of beauty, recreation, environment, economic opportunity, and public services." Efforts in this people-oriented research concern human nutrition, financial management for families, rural housing, alleviating rural poverty, improving the economic potential of rural people, improving income opportunities in rural communities, and improving the institutions and services in rural communities. As described in Chapter 2, the needs of rural families are substantial. But in contrast to their emphasis on reducing production costs, the 1862 land-grant universities spend approximately 16% of their funds on people-oriented research (Table 4.1). Although receiving an extremely low portion of funds, the 1890 institutions have a much stronger people-orientation to their research, with 46% of their research funds directed at these efforts (51).

Recognizing the Bias Toward Large Farms

The bias toward large farms in land-grant research remains largely unrecognized. The USOTA reported in 1986 that the land-grant universities bear a special burden of responsibility for serving the needs of small-scale and subsistence-level farm families, however, "this responsibility has not generally been realized and, therefore has not been fulfilled" (55, p. 24).

Indeed, surveys of land-grant research directors and scientists report that these people believe their research to be scale-neutral (5, 8, 10, 25). However, even the USDA admits that "technological change is almost never neutral" (50, p. 127). And,

indisputably, much of the technology developed through land-grant research favors large-scale and capital-rich farms (2, 9, 13, 22, 31, 32, 47, 50, 52, 53, 54, 55, 58, 59).

This is due to numerous reasons, including:

- Many new technologies (e.g., chemical sprays, commercial fertilizers, farm machinery, plastic row covers, and hybrid seeds) require additional production expenses. Small farms have fewer financial resources and also have less access to credit than do large farms. Small farms also have a smaller resource base, and therefore, less ability to take risks in utilizing new technology.
- Many new technologies (e.g., mechanical harvesters and irrigation systems) are more adaptable to farms with a greater quantity of land and other resources. Other technologies (e.g., high-yielding cultivars) are more responsive to a high quality, fertile growing environment. Small farms are generally lacking in both the quantity and quality of farm resources.
- Many new technologies (e.g., farm machinery and chemical sprays) require a high degree of farm management skills. Small farm operators generally have fewer management skills, less formal education, and utilize Extension less often than large farm operators (14, 15, 16, 52, 58, 59).

Even if newly-developed technologies are not inherently biased, the marked difference in their rate of adoption by the capital-rich large farms and the more risk-averse small farms creates a similar effect (55). For when a technology is first developed, "the most alert, the most innovative, the most aggressive, the socially dominant, the better managers of the large farms" are its immediate beneficiaries (31, p. 131). These early adopters utilize the new technology to lower their production costs, and thereby increase profits. Herein lies the commercial gains to efficiency research. Continuing with this scenario, yields generally increase with the use of this new technology, creating a greater supply of farm products and a corresponding decline in commodity prices. As commodity prices fall, the profit margins for later adopters of this technology become increasingly less. Finally, the last farm families

to adopt this technology are often forced to do so or cease production altogether (55). Since many new technologies call for increased levels of capital in production, these late adopters are generally those families who are limited in their capital resources. Such a scenario has occurred countless times during the last 40 years, fueling the polarization of class structure among farm families.

Reasons Behind the Bias Toward Large Farms

Funding sources and political pressures contribute to the large farm bias in land-grant research. But the reward system for researchers, and more specifically, the rewards accrued to staff for publishing in professional journals, may be most responsible (16, 39). G.E. Schuh, former Director of Agriculture and Rural Development at the World Bank, states that:

... today the criteria for promotion is publishing in scholarly journals. In turn people are self- and peer-oriented. They do not feel a responsibility to contribute to the institutional mission of solving society's problems. They do research to advance knowledge, publish for peers, and earn consultancies. Generating and applying knowledge to solve today's social and economic problems are not given sufficient priority (39, p. 8).

Schuh's comments are supported by the research of Busch and Lacy (5, 20). Through a survey of 1431 land-grant researchers, Busch and Lacy ranked the criteria that scientists use to determine their research agendas (Table 4.2). Respondents to the survey stated that, among other concerns, the probability of publishing in professional journals and the evaluation of peer researchers were of more concern to them than either the demands raised by their clientele (farm families) or input from

Table 4.2. Rank order of criteria used by agricultural scientists in the development of research agendas, 1983.

Rank	Criteria
1	Enjoy doing this kind of research
2	Importance to society (scientist's own judgement)
3	Availability of research facilities
4	Scientific curiosity
5	Potential creation of new methods, useful materials
6	Publication probability in professional journals
7	Clients needs as assessed by you
8	Likelihood of clear empirical results
9	Funding
10	Evaluation of research by scientist in your field
11	Priorities of the research organization (college or USDA)
12	Potential contribution to scientific theory
13	Demands raised by clientele
14	Credibility of investigators doing similar work
15	Currently a "hot" topic
16	Length of time required to complete the research
17	Potential marketability of the final product
18	Colleagues' approval
19	Publication probability in experiment station bulletins
20	Feedback from Extension personnel
21	Publication probability in farm and/or industry journals

Source: (5).

Extension personnel. Similar views in support of peer orientation in research were recently expressed by ASHS President and long-time Science Editor, Jules Janick. In his recent Presidential Address, Janick stated that when research agendas are formulated, publishing in professional journals should be the major criterium (17).

This drive of researchers toward peer evaluation and publication in professional journals has led many to become increasingly specialized and to concentrate their efforts at the "cutting edge" of their disciplines' knowledge. When relevant, these research efforts are certainly worthwhile, as they may lead to scientific breakthroughs that benefit society. However, the priority that has been placed on such research has led to the neglect of contemporary social needs (13, 39). This neglect is manifested in numerous ways: the lack of people-oriented research; inadequate efforts in the adaptation of existing technology to contemporary farming systems; and the disregard of socio-economic impacts of technological development (6).

In addition, this increased emphasis on cutting edge research has led to the isolation of researchers from rural communities. Consequently, the noted disregard of scientists toward input from Extension staff and farm families in the designing of research programs calls into question the basis of any research effort that addresses the needs of rural society. Indeed, the lack of relevant research emanating from college campuses has forced many Extension agents to conduct their own research. It has been reported that 56% of Extension specialists with 100% extension appointments have now taken on the additional responsibility of conducting research (23).

In concluding this discussion, it must first and foremost be noted that land-grant scientists are devoted toward serving society through their research efforts.

However, their lack of communication with traditional farm families and Extension staff may lead to the development of abstract and impractical research. Furthermore, by placing such enormous value on the published word in professional journals, much land-grant research has become so narrowly-focused that it has become insensitive to socio-economic impacts. This insensitivity may lead to research which unknowingly does more harm than good to rural communities and traditional farm families.

4.2. Land-Grant Extension

The Cooperative Extension Service is the component of the land-grant system whose role it is to assimilate information from the land-grant universities, and then disseminate the appropriate elements of this information to the public. Extension also has major responsibilities in stimulating a desire for information, to demonstrate research, and to report to the public and the government on rural development matters (37).

Limited in its own human and financial resources, Extension has historically reached out to the most receptive farm families. In the past, this information would diffuse from the receptive farm families to the broad and relatively homogeneous farm population (13, 27). But farms today have become more specialized, and information provided to one farm family may not be appropriate for another. Moreover, it has been reported that less information is now being passed along from neighbor to neighbor as farm families face the real threat of being taken over by a more efficient, neighboring farm (33).

In responding to the needs of the most receptive farm families, Extension has primarily served large-scale, commercial farms (16, 30, 33, 47). The USDA reported in 1980 that for every major program area of Extension "the largest proportion of clientele fall into the moderate or higher income and educational achievement levels ..." (49, p. 175). Indeed, numerous studies have reported that large farm operators are more likely to attend Extension-directed grower meetings and farm workshops than are small farm operators (4, 21, 27, 57, 58). With knowledge being a valuable resource, the lack of communication among Extension staff and small farm operators further hampers the development of this major farm class (30).

From the perspective of small farm operators, they are often reluctant to initiate discussions with Extension due to the irrelevance of the information provided, a lack of physical resources needed to participate in Extension programs, a lack of incentive to take risks in production, and/or a feeling of inferiority in communicating with Extension personnel and the larger farm operators to whom Extension primarily serves (38, 58, 59).

From the perspective of Extension, its staff may find it difficult to reach out to small farm operators because of the great number and the diversity of small farm operations, the limitations of Extension resources, the reluctance of small farm operators to attend Extension programs, and the poor response of small farm operators to mass media programs (34, 40, 45, 58). Even if small farm operators are receptive to Extension personnel, their general lack of formal education often makes it difficult for them to assimilate Extension's information (40).

As is the case for land-grant researchers, the reward system for Extension personnel also contributes to their bias toward large farms. The existing reward system

provides greater recognition for staff members who report outstanding results from their efforts. Dramatic results are more likely to be obtained in working with the well-educated farm families who commonly have operating capital and good management skills. In addition, local Extension units may risk losing community funding by working with limited-resource farm families when the needs of the socially-dominant and politically-active large farm families are not fulfilled (40).

With increased responsibilities and a limited resource base, Extension faces trade-offs in choosing their target audience. In maintaining its dedication to the service of large commercial farms, Extension is helping to maximize production efficiency, lower production costs, and increase total production. On the other hand, by increasing its emphasis on small farm operations, Extension would be taking a more people-oriented approach, be enhancing the equitability of farm income, increase the quality of life in rural communities, and would be helping the most needy farm families (2, 40, 49).

During the 1970's and 1980's, Extension has expanded their outreach to small farm families through special programs (49). Trained paraprofessionals are being used in over 20 states to expand the outreach of Extension agents. These, and other small farm programs have been very successful. A survey of 23 small farm programs in 14 Southern states showed that these programs have aided small farms in numerous activities, including increasing levels of home food production, and accelerating the adoption of recommended production practices. These small farm programs have also been successful in helping farm families develop skills in farm planning, record-keeping, and marketing. It has also been shown that once small farm

operators work with Extension staff they are more comfortable in initiating contacts with other local government agencies (29, 30).

These special Extension programs aside, the land-grant system has inadequately addressed the needs of small farm operators. Certain deficiencies in the land-grant approach have surfaced: a lack of communication among land-grant staff and small farm operators; poor interaction among research and Extension units; and the neglect of socio-economic impacts in technological development. In response to these shortcomings a complementary approach to rural development has been developed, commonly termed Farming Systems Research & Extension.

4.3. Farming Systems Research & Extension

Farming Systems Research & Extension (FSR/E) is a development methodology which was formed after other development strategies failed to generate appropriate technology for small farms (28, 35, 61). This dynamic methodology identifies constraints in agricultural production and then develops solutions to these constraints. Multidisciplinary teams work directly with the farm families to ensure that the developed technology are relevant and useful. The following is a brief description of the four stages of FSR/E methodology; a more detailed description is presented by Shaner *et al.* (41).

Diagnosis

Rapid rural reconnaissances are used to collect information on the target area's farming practices. Farm components (crops, livestock, and household activities), non-farm components (markets, government policies), and their interactions are examined. Efforts are also made to understand the motivations, concerns, and aspirations of the farm families. The sum of all this information is then used by the multidisciplinary research team to identify the constraints of the target area's farms.

Design

Intervention strategies are formulated and prioritized using the collected information. The importance of the identified problems, the potential of success for the proposed solutions, resource availabilities, and the ease of implementing intervention strategies are all considered in the prioritization process. On-farm experiments are designed by the research team with the cooperation of farm families. On-station experiments may also be designed to complement the on-farm trials.

Testing

The intervention strategies are evaluated under actual farm conditions to determine their suitability in remedying the identified constraints. Testing usually is done in two substages. The first substage involves *researcher-managed trials*. These on-farm trials evaluate a broad array of experimental treatments under the joint management

of the researchers and farm families. The second substage involves *farmer-managed trials*. These trials evaluate the most promising treatments which came out of previous research. Farmer-managed trials are generally planted in large field plots and, as their name suggests, are under the principal management of the farm families themselves.

Extension

Results from the successful farmer-managed trials are disseminated to the public. The adoption of the newly-developed technologies by other farm families should be accelerated since the technologies were tested under local farm management.

FSR/E Projects in the U.S.

Although most FSR/E projects have been undertaken overseas, a few projects have been initiated domestically. Concentrating on serving the needs of small farm families, these projects have focused on the improvement of crop and livestock production practices (3, 7, 12, 46), and the improvement of marketing strategies (44, 60). In addition, efforts have been made to evaluate the integration of FSR/E into the existing land-grant system (7), and also to assess the role of women on small farms (36).

The following section of this dissertation shall address the vegetable research efforts of a FSR/E project in East Central Virginia. The target area of the project shall be described in the next chapter, followed by a presentation of research results.

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SECTION II.

CASE STUDY

5. DESCRIPTION OF TARGET AREA

Nottoway and Lunenburg Counties are located on the Eastern Piedmont Plateau of East Central Virginia (Figure 5.1). These counties share a colorful history, beginning with Native American settlement, and then highlighted by conflicts against the British in the Revolutionary War. Throughout this area's history, the production of tobacco on small farms has served as the catalyst behind economic growth. Recently, however, the effects of the changing structure of farming in America are beginning to affect the vitality of these rural counties. The following is an up-to-date assessment of the natural resources and the socio-economic characteristics of Nottoway and Lunenburg Counties.

5.1. The Natural Environment

The Nottoway/Lunenburg area has a temperate climate that is marked by humid summers and cool winters. Precipitation is evenly distributed throughout the year,

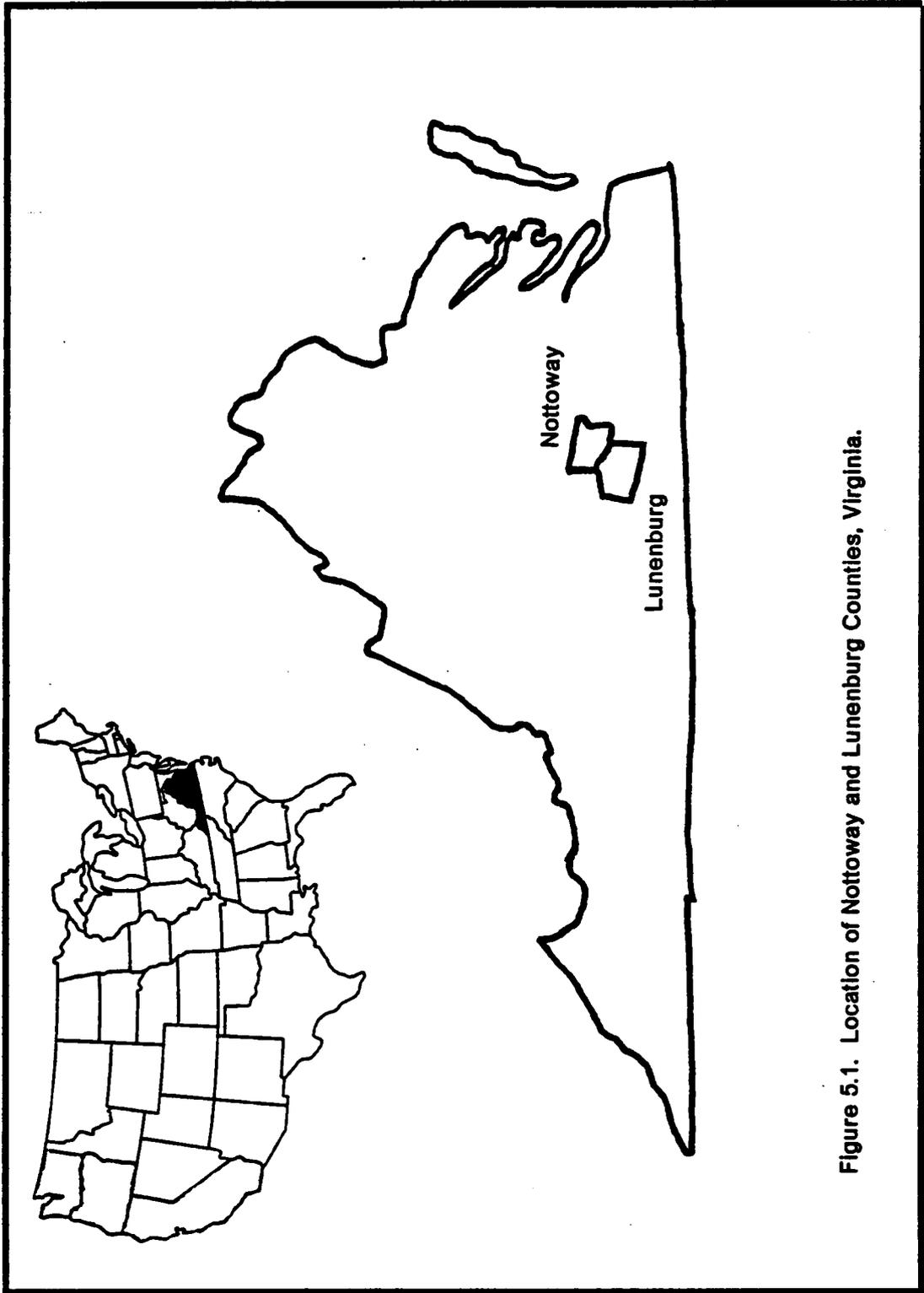


Figure 5.1. Location of Nottoway and Lunenburg Counties, Virginia.

and averages a total of 106 cm annually. The frost-free period is approximately 190 days, generally from mid-April to late October (see Appendix D)(14).

Soils of the area are generally well-drained, acidic, and naturally infertile. There are over 30 different soil series represented in these two counties, with most soils having a sandy loam or loam texture (see Appendix E). The terrain of the area is gently rolling, with elevations ranging from 60-180 m above sea level (2, 5).

A diverse mixture of hardwood and softwood trees cover over 60% of the land in the area. Dominant hardwood species include red oak, white oak, yellow poplar, and hard maple. Dominant softwood species include shortleaf pine, loblolly pine, Virginia pine, and red cedar (16, 17).

5.2. The Socio-Economic Environment

Demography

Nottoway and Lunenburg Counties have a combined population of approximately 27,000 persons (9). Major towns include Blackstone and Crewe in Nottoway County, and Kenbridge and Victoria in Lunenburg County.

The residents of these counties are relatively old compared to the national average (Table 5.1), and there are indications that the average age of the population is increasing. Fifty-six percent of the families no longer have their children living at

home, and the population growth of these counties is relatively stagnant (Table 5.1)(9).

Income

The residents of the Nottoway/Lunenburg area earn relatively low levels of income. The per capita income and median family income of area residents in 1979 were both approximately 25% less than the national average (Table 5.1). In addition, the residents of these rural counties suffer from a poverty rate that is substantially higher than the national average (9).

Health and Education

The infant mortality rate of the Nottoway/Lunenburg area in 1983 was twice as high as the national average (Table 5.1). This statistic is indicative of the poor health, welfare, educational, and nutritional status of the residents. The infant mortality rate of the black population within these counties was 2.5 times that of the white population (Table 5.2)(15).

In reference to education, the area's adults over the age of 25 have less formal education than other Americans, averaging only 10.8 years in 1980 (Table 5.1). In addition, only 38.4% of these people had graduated from high school, as compared to 66.1% of the nation's population (9).

Table 5.1. Socio-economic characteristics of Nottoway and Lunenburg Counties of Virginia, as compared to the United States.

Characteristic	Nottoway/ Lunenburg	United States
Demographic, 1980:		
Median age (yrs)	34.3	30.0
Population growth, 1970-80 (%)	3.2	11.5
Black population (%)	39.2	11.7
Economic, 1979:		
Per capita income (\$)	5,325	7,298
Median family income (\$)	15,003	19,917
Poverty rate (% persons)	17.9	12.4
Unemployed during year (% labor force)	16.0	18.6
Health and Education:		
Infant mortality rate, 1983 (per 1000 live births)	26.0	13.0
Of adults over 25 yrs, 1979:		
Median education level (yrs)	10.8	12.5
High school graduates (%)	38.4	66.1

Sources: (9, 15).

Black Residents

Nearly 40% of the population in Nottoway and Lunenburg Counties are black. As a group, the black population is relatively poor, earning a 46% lower per capita income, and a 38% lower median family income than the white population in 1979 (Table 5.2). In addition, black residents suffer from significantly higher rates of poverty and unemployment as compared to white residents (9).

The black population also has less formal education than the white population, with only 26% of its adults over the age of 25 graduating from high school (9). This low graduation rate is at least partly attributable to the resistance of the white-dominated communities in East Central Virginia to integrate black children into their public schools.

Racial discrimination, indeed, has been a major factor impeding the socio-economic development of the black community in the area. Although black citizens throughout the nation obtained their civil rights over 20 years ago, the racial prejudice that permeates throughout much of this area's society is unmistakable. Albeit slowly, the barriers constraining the socio-economic development of the black population are coming down. As evidence, judicial courts have recently called for the town of Blackstone to realign its voting districts, as they were found to discriminate against the election of blacks in local government.

Table 5.2. Socio-economic characteristics of the black and white population in Nottoway and Lunenburg Counties, Virginia.

Characteristic	Black	White
<u>Economic, 1979:</u>		
Per capita income (\$)	3,487	6,510
Median family income (\$)	10,950	17,600
Poverty rate (% persons)	29.9	10.8
Unemployed during year (% labor force)	21.6	12.5
<u>Health and Education:</u>		
Infant mortality rate, 1983 (per 1000 live births)	40.8	16.3
Of adults over 25 yrs, 1979:		
Median education level (yrs)	8.5	11.6
High school graduates (%)	26.2	46.1

Sources: (9, 15).

5.3. Characteristics of Farms

Characteristics of Farm Families

Nearly 90% of the farms in Nottoway and Lunenburg Counties are operated by families. The men, women, and children of the farm families all serve valuable roles on the farms, with responsibilities generally apportioned as follows:

Men are typically involved in tractor-based activities, including field preparation, cultivation, and the harvesting of crops. Men are also involved in livestock production activities and in off-farm employment.

Women generally participate in crop and livestock activities, and may also work off the farm for income. In addition, women generally have the bulk of the responsibility for child care, housework, recordkeeping, and gardening activities.

The children generally make contributions to livestock management and housework activities. Children may also make important contributions in the management of crops, especially for such labor-intensive crops as tobacco and vegetables.

Characteristics of Farm Operators

The farm operators in Nottoway and Lunenburg Counties are generally people who are relatively old and have significant farm experience. The average farm operator was 53.4 years old in 1982, 2.9 years older than the national average. Farm operators

in this area also had an average of 18.8 years of farm experience, 1.5 years more than the national average (12).

As is the case for the rest of the nation, there is a lack of families in the Nottoway/Lunenburg area who are entering the farming profession. In 1982, only 28% of farm operators were 44 years old or less, and only 17% of operators had less than 5 years of farm experience (12). The dim prospects for farming in the area, the overall depressed rural economy, and the need for substantial amounts of capital to compete in today's farm sector are all major factors responsible for this lack of young families going into farming. In fact, the Nottoway/Lunenburg area suffered a 3.1% decline in farm numbers from 1978-1982, 3.5 times the rate of decline for the nation as whole (11, 12).

Farm Income

Over 80% of the farms in Nottoway and Lunenburg Counties are small in scale (Figure 5.2). Median farm income for the area was \$6360 in 1982, requiring many farm families to work off the farm to keep farming operations solvent. In fact, 58% of farm operators work off the farm for 200 or more days per year (12).

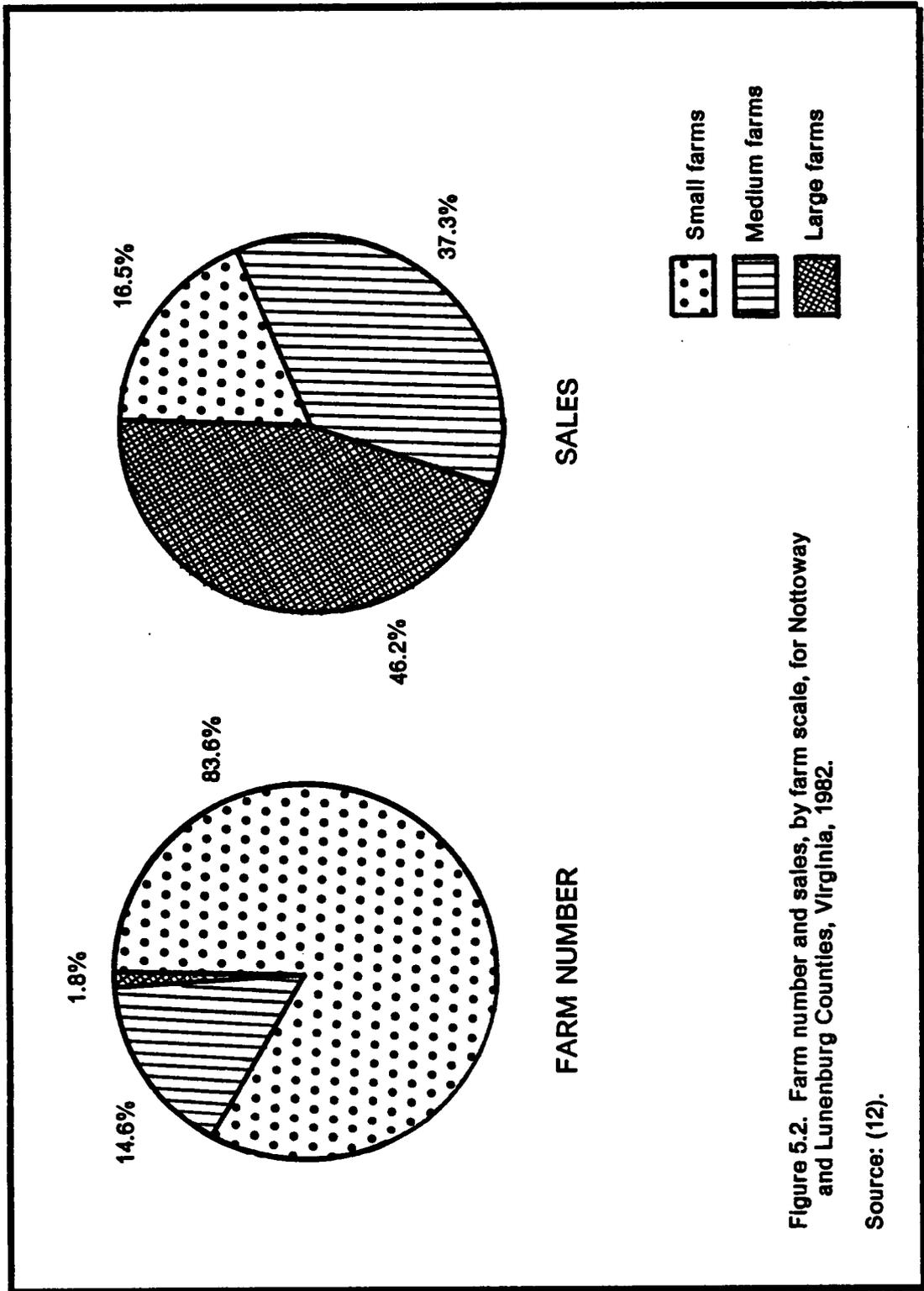


Figure 5.2. Farm number and sales, by farm scale, for Nottoway and Lunenburg Counties, Virginia, 1982.

Source: (12).

Black-Operated Farms

Black farm families operated 13.1% of the farms in Nottoway and Lunenburg Counties in 1982. In general, these farms represented the poorest and the smallest of the area's farms.

The median farm sales for black-operated farms was only \$3120 in 1982, less than half that of the median farm sales for white-operated farms, \$6860 (Table 5.3). In addition, only 14.5% of black-operated farms generated more than \$10,000 in annual farm sales, compared with 40% of the white-operated farms. In reference to land resources, the average black-operated farm had only one-third the farmland, and one-fourth the harvested cropland of white-operated farms (12).

These resource limitations of black farm operators make it difficult for them to compete in today's farm sector. Moreover, their lack of education and the detrimental effects of racial discrimination further add to their problems. As one would expect, the net result of these hardships has often been farm bankruptcy and the displacement of black families from their farms. Indeed, the number of black-operated farms in the area declined by 18.4% from 1978-1982, more than 30 times the rate of decline for white-operated farms in the area, 0.5% (11, 12).

Table 5.3. Characteristics of the black- and white-operated farms in Nottoway and Lunenburg Counties, Virginia, 1982.

Characteristic	Black	White
Median farm sales (\$)	3120	6860
Farms with sales of \$10,000 or more (%)	14.5	40.0
Mean farmland (ha)	26.7	76.0
Mean harvested cropland (ha)	4.7	20.1
Rate of decline from 1978-82	18.4	0.5

Sources: (11, 12).

Enterprise Mix

A structural model of the farming systems for the Nottoway/Lunenburg area is presented in Figure 5.3. The median farm of the area in 1982 was 43 ha in size, with 20 ha of the land in harvested crops. Tobacco has historically been the major crop for sale, both in terms of farm number and sales (Figures 5.4 and 5.5). Hay and corn are also commonly raised, with much of this production going to feed livestock. Other major crops include soybeans and wheat (12).

Livestock sales make up an important component of the area's overall farm economy (Figures 5.4 and 5.5). Most farm families raise beef cattle, with the median herd size being 30 head (12). Beef cattle production provides meat and farm income to the families, and its low labor demand allows farm operators to work off the farm. Poultry production was the largest moneymaker of the area's farm economy in 1982, but only 4% of farms marketed these products. Other major livestock enterprises for the area include swine, dairy cattle and sheep (12).

Most area farms (64%) have pastureland for their livestock to graze from. Woodland is on 75% of area farms, and is commonly used by livestock producers for sheltering livestock from the summer heat and winter winds. Most woodland is not carefully managed, yet it still provides many families with fuelwood for the winter. Families also sell timber from their woodlands, especially when other sources of income are lacking.

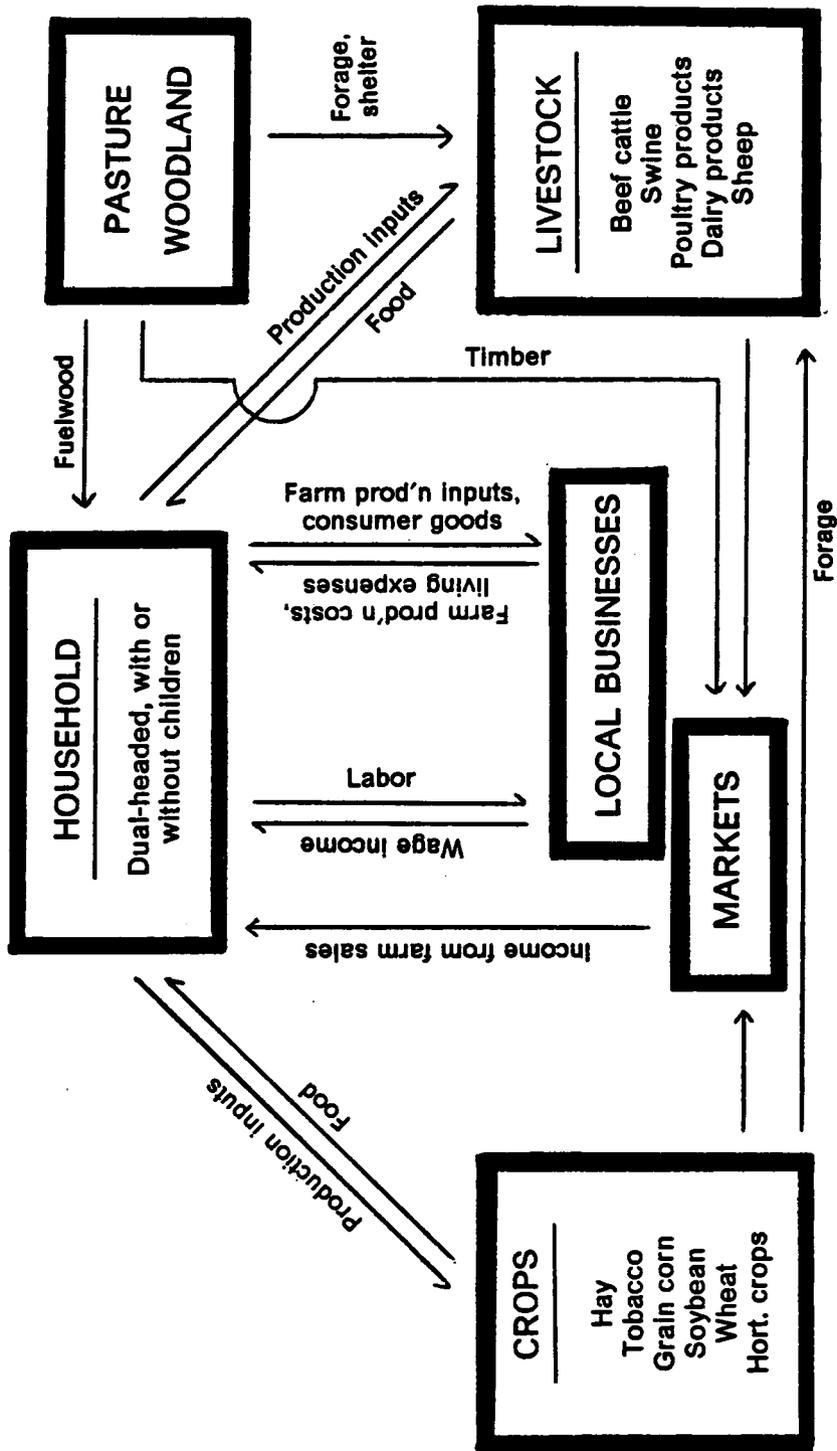


Figure 5.3. Structural model of major farming systems in Nottoway and Lunenburg Counties, Virginia.

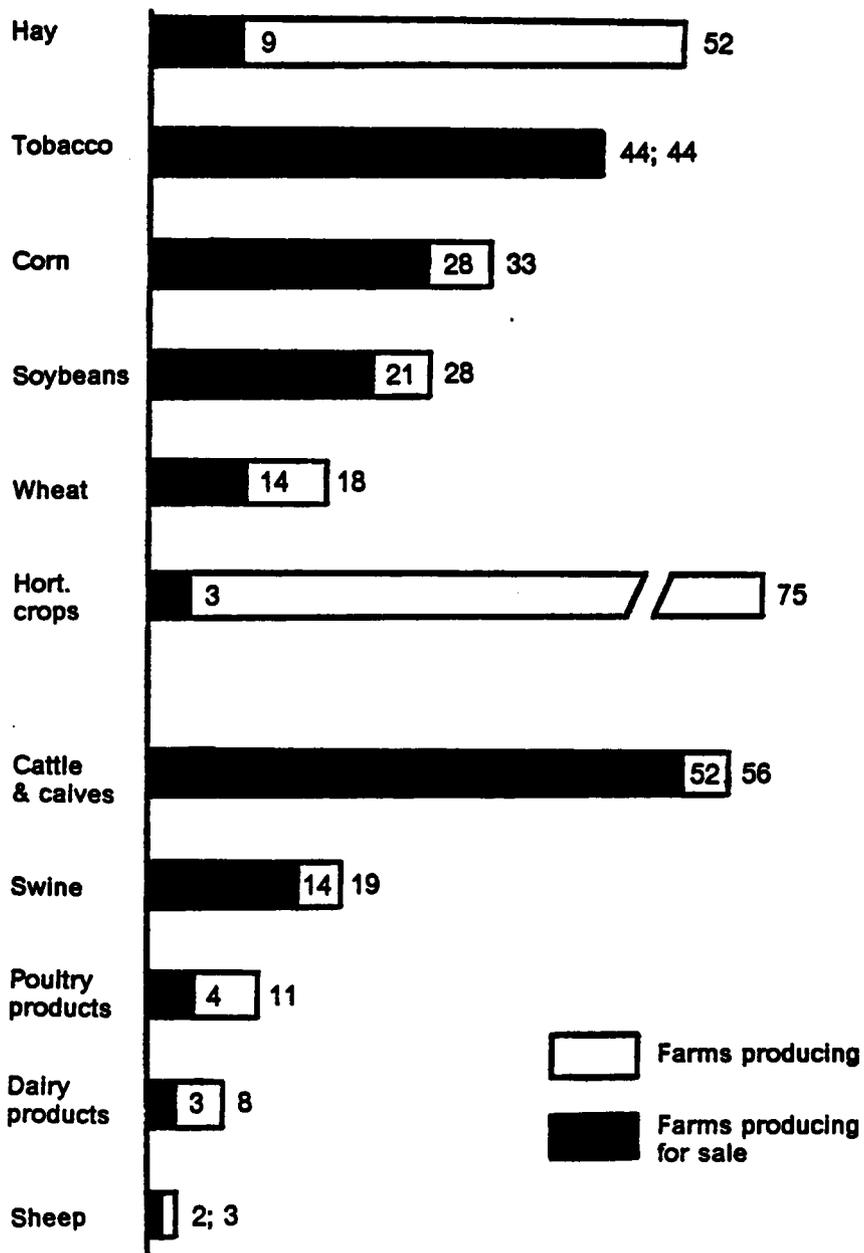


Figure 5.4. Percentage of farms in Nottoway and Lunenburg Counties of Virginia which produce commodities, by commodity, 1982.

Sources: (6, 12).

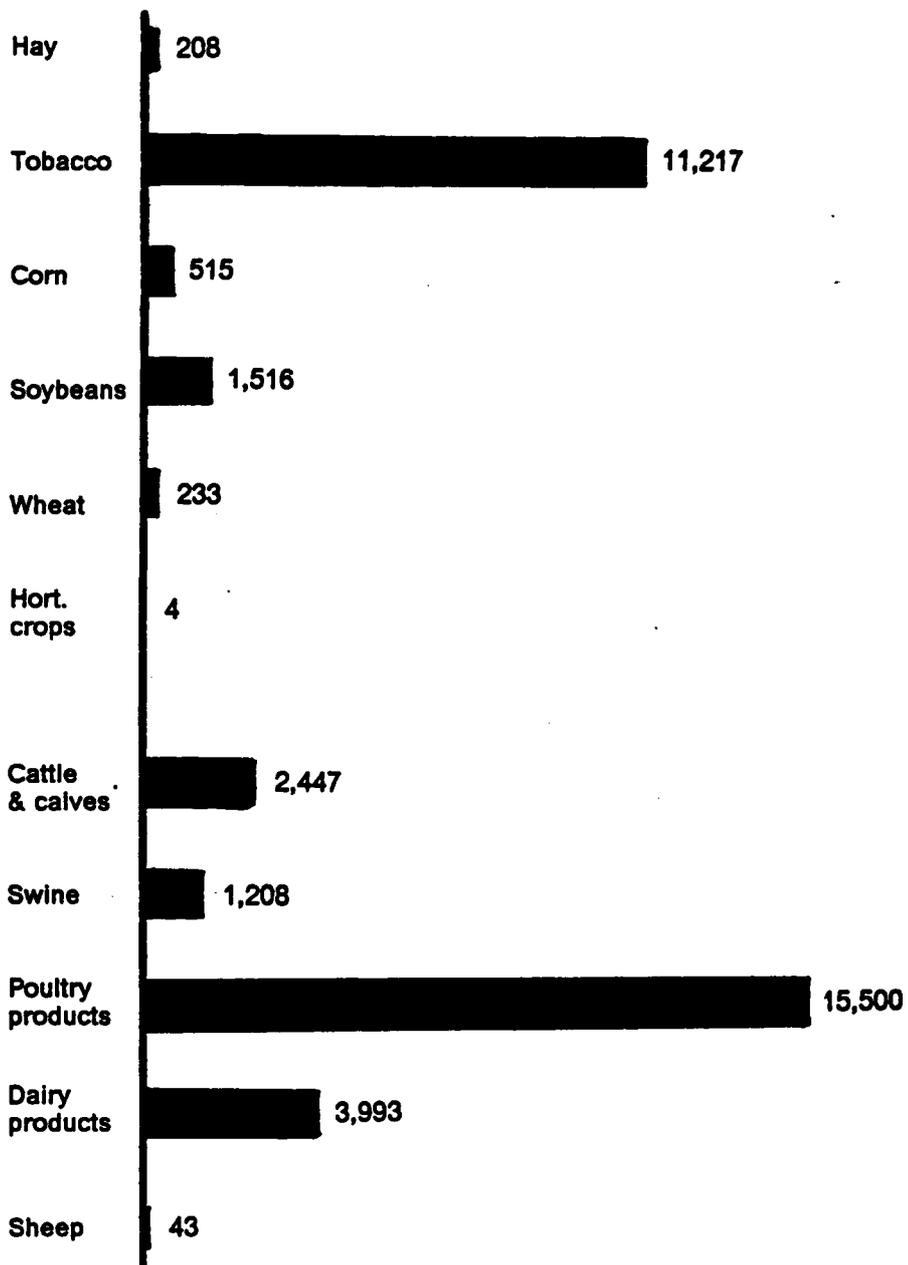


Figure 5.5. Sales (\$1000) of agricultural commodities produced in Nottoway and Lunenburg Counties of Virginia, by commodity, 1982.

Source: (12).

5.4. The Need for Diversity

Flue-cured and/or fire-cured tobacco were grown by over 400 farm families in Nottoway and Lunenburg Counties in 1982. Excluding the lucrative poultry industry, the production of tobacco accounted for 52% of the area's farm sales. Tobacco production is labor-intensive, and for that reason has historically been limited to small plots for production. Indeed, the median tobacco planting in the Nottoway/Lunenburg area was only 0.8 ha in 1982. Nevertheless, the hundreds of families who raise tobacco are very dependent on the income they receive from this Government-subsidized crop. In fact, 40% of these families generate less than \$10,000 in total farm sales (12).

In recent years, however, the tobacco subsidy program has increasingly come under debate in the U.S. Congress. Pressures have come from the general public to halt the Federal Government's involvement with tobacco, especially since the commodity has been shown to endanger life. Moreover, there is political pressure coming from within the industry to relax the allotment restrictions and permit the development of a free domestic market for tobacco. In the past, the tobacco lobbies have been effective in eliminating restrictions on intra-county leasing of allotments, as well as establishing the less laborious loose-leaf marketing of flue-cured tobacco (3).

The dissolution of this supply control program would allow the growers in the Carolinas to take advantage of their superior production resources. These resources, including more fertile soils and a larger labor pool (4), would be expected to provide the Carolina growers with a greater share of the marketplace.

In addition, the increased utilization of mechanical tobacco harvesters is providing an advantage to those large farm operators who can afford this technology. This harvester, developed through a cooperative effort of agribusiness and North Carolina State University, was developed for growers with 20 ha or more of tobacco (3). Since only 3.5% of tobacco farms in North Carolina, and 0.7% of tobacco farms in Virginia cultivate this size of planting (12), this harvester represents another example of how capital-intensive technology may threaten the viability of the traditional family farm. This threat manifests itself in two principal ways: 1) a reduction in the competitiveness of traditional farms; and 2) a reduction in employment opportunities for those small farm operators who rely on off-farm income. Indeed, this technology has already eliminated tens of thousands of employment opportunities in the Southeastern U.S. (8).

Needless to say, the farm families in Nottoway and Lunenburg Counties have neither the fertile soils nor the financial resources which are needed to effectively compete in a free domestic tobacco market. Due to the great dependence of many small farm families on the cash they receive from their tobacco plots, these recent developments in tobacco production threaten the vitality of the farm sector in these counties. As is, the depressed tobacco market has created a severe decline in the income going to Virginia tobacco growers, with a 46% drop recorded from 1984-1986 alone (10).

Many concerned farm families of the Piedmont region have begun growing vegetables to supplement farm income. Cooperatives have been successfully developed in Western North Carolina to market tomatoes (1), and a cooperative in South Central Virginia has successfully marketed broccoli and muskmelon (7).

In responding to the needs of area growers, the East Central District of the Virginia Cooperative Extension Service has established the Nottoway Teaching/Demonstration Farm (13). This farm is being developed to demonstrate the production of vegetables, small fruits, and Christmas trees to those farm families looking for alternative enterprises. As part of this effort, the District Extension staff have instituted a teaching curriculum for small farm families, and have assisted in the establishment of a cooperative specializing in the marketing of cherry tomatoes and bell peppers. These Extension personnel have also participated in a Farming Systems Research & Extension (FSR/E) project in association with the faculty of Virginia's two land-grant institutions, Virginia State University and Virginia Polytechnic Institute & State University. The following three chapters describe the vegetable research efforts of this FSR/E project.

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6. CHERRY TOMATO RESEARCH

6.1. Literature Review

Cherry tomato is a selection of the domesticated tomato (*Lycopersicon esculentum* Mill.) that is characterized by globular, small-sized (3.81 cm or less in diameter) fruit (34). The following literature review shall discuss those aspects of production which were considered in the research of the East Central Virginia FSR/E Project.

Irrigation

Supplemental irrigation has been shown in numerous studies to increase tomato yields (4, 8, 22, 25, 26, 30, 44, 49, 51). This increase in yield is reported to be primarily due to an increase in individual fruit size, rather than an increase in fruit set (4, 30). Irrigation has also been reported to increase vegetative growth (26, 30, 49) and delay maturation of fruit (30, 44, 49).

In regard to fruit quality, studies have reported both positive and negative effects to irrigation during the period of fruit maturation. Positive effects include an enlargement of fruit size (30) and a lower incidence of blossom end rot (4, 30). Negative effects include a higher incidence of soft rot (4, 30) and a reduction in the total and soluble solids of fruits (30, 49, 51). Irrigation has also been reported to increase the incidence of cracked fruit (2, 13, 30). In this regard, the hydration of the locular cavity and the abnormal pressure placed on the ovary wall is responsible for the increase in cracking (13).

In favorable growing environments, the method of irrigation does not significantly affect tomato yield (8, 25). In a saline environment, however, trickle irrigation is a superior method of irrigation as it provides for a more favorable salt balance in the foliage and requires the utilization of less water than alternative irrigation methods (8, 15, 25).

Soaker hoses also use water efficiently. These hoses are composed of a porous, canvas-like material that emits water under pressure. This method of irrigation is similar to trickle irrigation in that it directs water only to the soil surrounding the row of plants. This reduces runoff problems, decreases weed populations between rows, and also lowers the incidence of foliar blights. Soaker hoses are also easy to manage and relatively inexpensive (\$109/ha compared to approximately \$2000/ha for trickle irrigation)(31, 46).

Nitrogen Rate

Applied nitrogen (N) has been reported to significantly affect plant development (7), days to maturity (48), flower formation, fruit set (14), and yield in tomato (7, 14, 18, 21, 48). Maximum tomato yields have been attained with N applications ranging from 55 to 138 kg/ha (7, 14, 18, 21, 48). Much higher application rates (260-288 kg/ha) are reported to not significantly affect flower formation, fruit set (14), nor marketable yield (7, 14). Higher N rates, however, are reported to affect fruit quality by reducing the percentage of large fruits (7), lessening shelf life (37), and reducing fruit firmness (23, 30).

Unlike most vegetable crops, tomatoes do not respond to sidedressings of N except in areas where severe leaching occurs (14, 47). Therefore, it has been recommended that all fertilizer be applied early in the season to ensure a sufficient amount of N for early fruit set (14).

The Virginia Cooperative Extension Service (VCES) recommends a total application of 90 kg/ha for fresh market tomato production. On loam and silt loam soils, it is recommended that the N be broadcasted preplant. On sandy loam and loamy sand soils (where leaching may be a problem), it is recommended that the first application, 56 kg/ha, be applied at time of first cultivation. A sidedressing of 34 kg/ha is recommended on all soil types at the time when first fruits are setting (40).

Mulching

Mulching of tomato leads to greater vine weight, increased basal growth, earlier flowering, more flower clusters (47), and significantly higher yields (10, 21, 24, 27, 33, 45, 47).

Black plastic mulch (BPM) may provide for higher N levels in the soil by reducing the leaching of soluble N, and by increasing mineralization processes (21, 27, 45). This enhancement of mineralization under BPM is reported to be due to the higher levels of moisture, aeration, and temperature within the topsoil. By maintaining higher N levels in the soil, the utilization of BPM permits for lower application rates of nitrogen. For example, Jones reported that 138 kg/ha of applied N is needed to attain the highest yields in bare-ground plantings, but only 60 kg/ha of applied N would be needed to maximize tomato yields in BPM plantings (21).

The higher levels of moisture, aeration, and N in the topsoil under BPM have been reported to affect the rooting systems of tomato. Tomato rooting systems under BPM tend to be shallower, possess more fibrous root tissue, and have greater secondary root development than those found in bare-ground plantings (3, 24). Under BPM, the highest N concentrations in the soil exist at 15 cm below the surface, whereas the peak N concentrations in bare-ground tomato plantings are at 45 cm below the surface (21).

In regard to other mulches, paper mulch is reported to conserve soil moisture, maintain higher N levels in the soil, and lessen soil compaction, but in all cases to a lesser degree than BPM (27, 45). Straw mulch (SM) is also reported to conserve soil moisture, as well as to buffer soil temperatures (1, 39). In contrast to other mulches,

clear plastic mulch (CPM) does not significantly influence either soil moisture (21) or N levels (24, 48). In the case of soil moisture, the moisture retentive properties of CPM are reported to be offset by higher evapo-transpiration rates (21). In the case of soil N levels, the excessive temperatures which are built up under CPM inhibit both nitrification and the release of carbon dioxide in the soil (24). These higher temperatures, however, do provide for significantly higher yields in the early season as compared to bare-ground plantings (48).

Among the mulches, BPM is most commonly used in commercial tomato production. Costs are estimated to be \$730/ha for the mulching material (46), and \$151/ha for the operating and fixed costs of the machinery used to lay the mulching (31).

Plant Population

Plant population levels of 14,000-28,000 plants/ha have been reported to increase early and overall yields when compared to plant population levels of 4500-7000 plants/ha (5, 12, 32, 35, 42, 43, 50). These reported increases in early yields are mainly a function of the increased number of first flower clusters per unit area, while increases in overall yields are primarily due to an increased number of fruits produced per unit area.

In these studies, higher plant populations are also reported to reduce fruit size and lower the number of fruits produced per plant (5, 35, 42, 43). The reduction of fruit size in high population plantings, however, may be compensated for by irrigation (30).

Plant population has also been reported to influence fruit quality. On the plus side, the increased shading of plants within closely-spaced plantings contributes to a greater intensity of fruit color and an increase in fruit pH (30). On the negative side, the reduced leaf area per plant in closely-spaced plantings contributes to lower soluble solids in fruit (52).

Staking

The benefits of the pruning and staking of tomato vines include increased fruit size, higher early yields (5, 6, 9, 16, 28, 36), less manual strain in harvesting, and less incidence of fruits damaged by slugs and soil-borne pathogens (17). Staking and pruning operations, however, may also be detrimental in tomato production since they reduce late season yields (16), make plants more susceptible to soil moisture stress, and increase the incidences of fruit cracking and blossom end rot (16, 17, 22, 26).

The determinate vine habit, a compact growth form in which shoot tips terminate in flower clusters, may be used to eliminate the need for staking and pruning operations. Determinate cultivars may also provide for an earlier and more concentrated fruit set than indeterminate cultivars, thereby increasing the net economic returns of production (20, 38). Indeed, the production of non-staked determinate cultivars are reported to be more profitable than the production of both staked and non-staked indeterminate cultivars (6).

Three staking systems are used in the tomato industry: single-plant staking, short-wire caging, and string-weaving. The latter method is increasingly being used throughout Virginia (19). With string-weave systems, stakes are placed approximately 2 m apart within the plant row. Strings are then woven around the plants, thereby creating a "wall" of vines (Figure 6.1). The advantages to this method of staking are its low cost and the low demand for labor in construction. Disadvantages to string-weave systems are that the stringing operations take skill to be done efficiently, string-weave trellises fall down in high winds or under excessive soil moisture conditions, and that the tomato foliage becomes compacted, making the harvest of fruits difficult at times (19).

6.2. Materials and Methods

1985 Trial

A 2⁶ factorial experiment was designed to test for the effects of irrigation, N rate, mulching, plant population, staking, and cultivar on cherry tomato production.

In this experiment, the farm families were asked to select a plot of land near to their home residences. For the irrigation treatment, garden hoses were attached to the outside water spigot of each family's home and then extended out to the plot. A soaker hose was then attached to the garden hose. The families were requested to irrigate the designated plots at their own discretion.

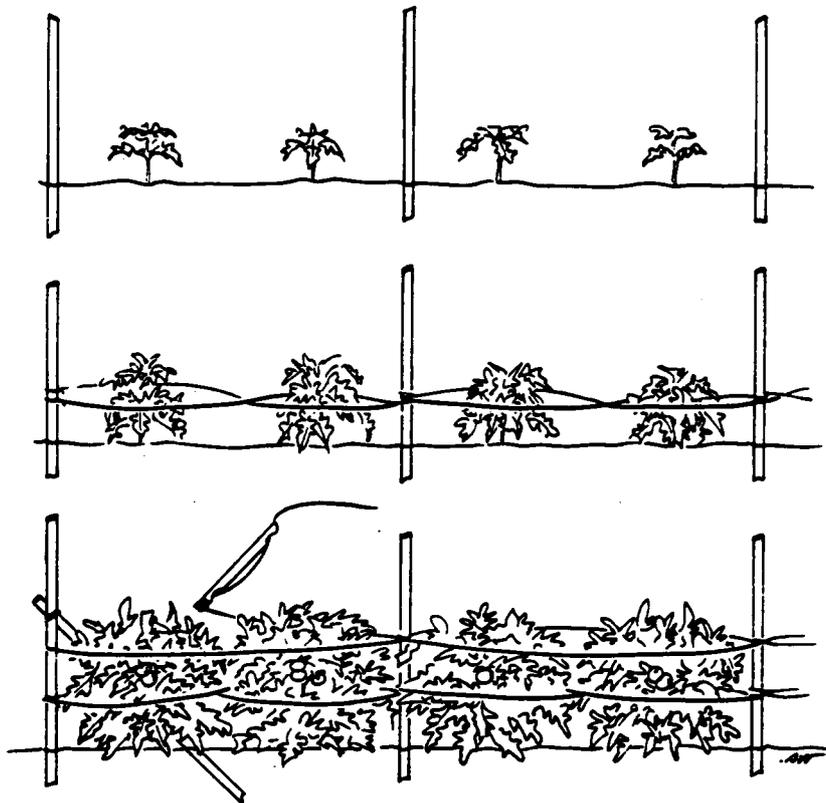


Figure 6.1. String-weave method of trellising tomatoes.

Source: (34).

To study for the effects of N, application rates of 84 and 168 kg of N/ha were chosen. Sixty percent of the N rate was broadcasted preplant, with the remainder sidedressed after the first fruit set. Ammonium nitrate was used as the N source. Phosphorous, potassium, and boron fertilizers were also applied before planting at rates recommended in recent soil tests.

To measure the effects of plant population, plants were spaced 46 and 61 cm apart within rows. Using 1.22 m row centers, this provided for populations of 17,930 and 13,450 plants/ha, respectively.

Among the other treatments, string-weaving was used to evaluate the effect of staking versus no staking (34). Black plastic mulch was selected as the mulching treatment, and *Cherry Challenger* and *Cherry Grande* were chosen to test for cultivar effects.

This factorial experiment was planted on 8 area farms in mid-May. An incomplete block design with the confounding of treatments was used to accommodate the numerous treatments. In this experimental design, plots were first randomly divided into irrigation treatments, then by N rates, and then by mulching. Within these sub-subplots, the plant population, staking, and cultivar treatments were confounded and randomly distributed. At each site, 16 of the 64 total treatments were planted, with 4 treatments replicated at each site to obtain the measurement of farm by treatment interactions. As was the case for all cherry tomato experiments, individual treatment plots were spaced 1.22 m apart in rows 6.10 m long.

1986 Trials

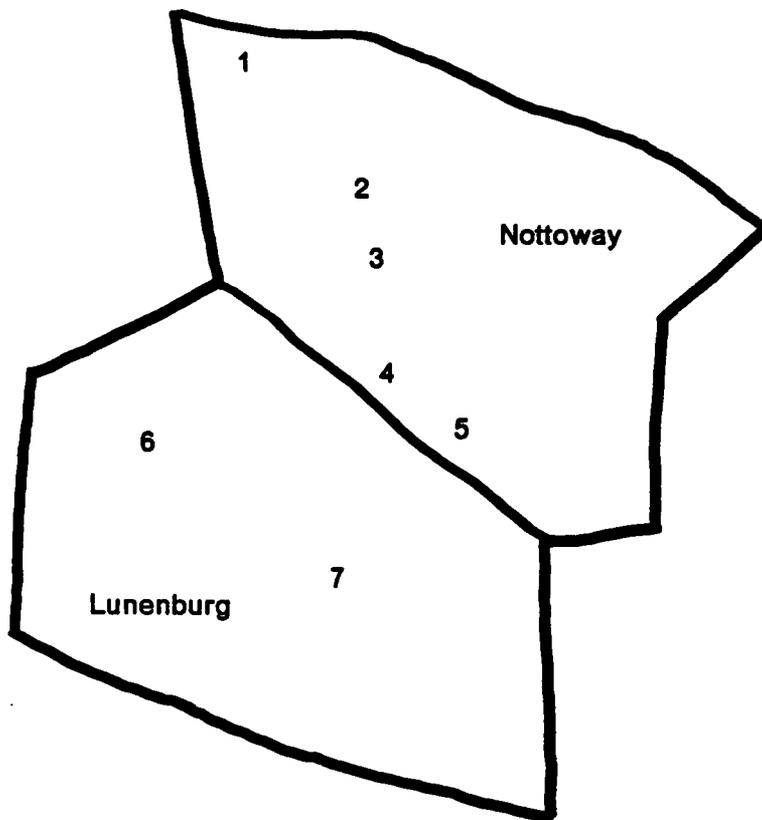
The 1986 trials were marked by simpler experimental designs and the utilization of a field research station, the Nottoway Teaching/Demonstration Farm (NTDF).

Rather than using a single large-scale factorial design, 4 simpler trials were implemented. The first trial evaluated 10 cultivars. All 10 cultivars were set out at the NTDF, using a randomized complete block design (RCBD) with 3 replications. From these 10 cultivars, 4 were selected for on-farm testing. These 4 cultivars, *Castlette*, *Sweet 100*, *Red Cherry (small strain)*, and *Small Fry*, were set out on 3 area farms (Figure 6.2).

In these cultivar trials, special attention was directed toward fruit quality characteristics. *Marketable fruit* was defined as that crack-free fruit which was of the size preferred by the local cooperative (1.91-3.18 cm). Approximately 30 fruit were harvested from each plot during the main harvesting season to determine the percentage of fruits which fell into this size range. This percentage was subsequently factored into yield totals to obtain a measurement of marketable yield. Fruit shape measurements were also taken at this time.

In this and other 1986 trials, a measurement of *early yield* was also taken. This yield included that fruit which ripened during the first week of harvesting. From the perspective of area farm families, this early yield was particularly important as they were most assured of being able to market their produce at this time of the year.

Besides cultivar testing, 3 other experiments were also set out on the 3 area farms: 1) string-weave staking was tested versus no staking for a second year; 2) 3 mulch



Farm No.	Farm operator	Soil Type	Years participated
1	Christopher	Iredell-Mecklenburg loam	1985, 1986
2	E. Austin	Appling sandy loam	1985
3	NTDF	Appling sandy loam	1986
4	Pennell	Appling sandy loam	1986
5	Bledsoe	Madison clay loam	1985
6	Edwards	Cecil sandy loam	1985, 1986
7	Kellam	Georgeville loam	1985

Figure 6.2. Sites of successful cherry tomato research.

treatments (SM, BPM, and none) were compared; and 3) a 2 x 2 factorial experiment was designed to evaluate the main and interactive effects of 2 rates of N (55 and 90 kg/ha) with 2 mulch treatments (SM and none).

In these on-farm tests, 1 complete replication of each experiment was planted at each site. Control treatments (treatments which represented the traditional cultural practice for the region) were replicated in all experiments.

As was the case for all on-farm trials, the farm families were involved in all stages of testing. They assisted in land preparation, fertilization, mulching, transplanting, spraying, cultivating, and harvesting operations. The families were also trained to record the yields from each treatment plot. A member from the research team would visit the family weekly to gather data and to discuss the progress of the trial.

Partial budget analyses were done for both years of trials using information from the VCES (31), local input prices, and the commodity prices received by the local marketing cooperative (see Appendixes A and B). Analyses of variances were done on the yield and economic data, with general linear models used to analyze unbalanced data.

6.3. Results and Discussion

Two external factors influenced the results of the experiments. The first factor was the unreliable market for cherry tomatoes. This market was strong in 1984, and growers were confident that they could sell all the tomatoes they produced in 1985.

But this market never materialized, and many hectares of tomatoes went unharvested. Included among these abandoned hectares were 3 research plots, subsequently eliminated from analysis (the locations of the 5 successful research plots are shown in Figure 6.2).

The second external factor was the climate. The growing season of 1985 began dry, but then more than adequate amounts of precipitation fell during the growing season (see Appendix D). Crop yields were excellent that year. In 1986, the growing season also began dry, but then it remained dry through mid-July. In fact, precipitation amounts from April through mid-July were only 35% of normal levels (41). Crops of the area were stressed under the drought, and yields suffered.

Irrigation

The effects of irrigation on yield and net economic returns in the 1985 trial were beneficial, but at non-significant levels ($p = .40$ and $p = .44$, resp.)(Figures 6.3 and 6.4). This lack of significance was influenced by the regular and adequate amounts of precipitation that fell that summer. In addition, cherry tomato is tolerant of moisture stress, as it flowers prolifically and has an expansive rooting system.

Although differences among the farms were highly significant for all treatments, irrigation was the only treatment to have interacted with the farms ($p = .01$). The significance of this interaction was due to the different responses of farm families toward the unfavorable marketing situation. Those farm families with tobacco allotments decided to abandon their tomato plots and instead concentrate their labors

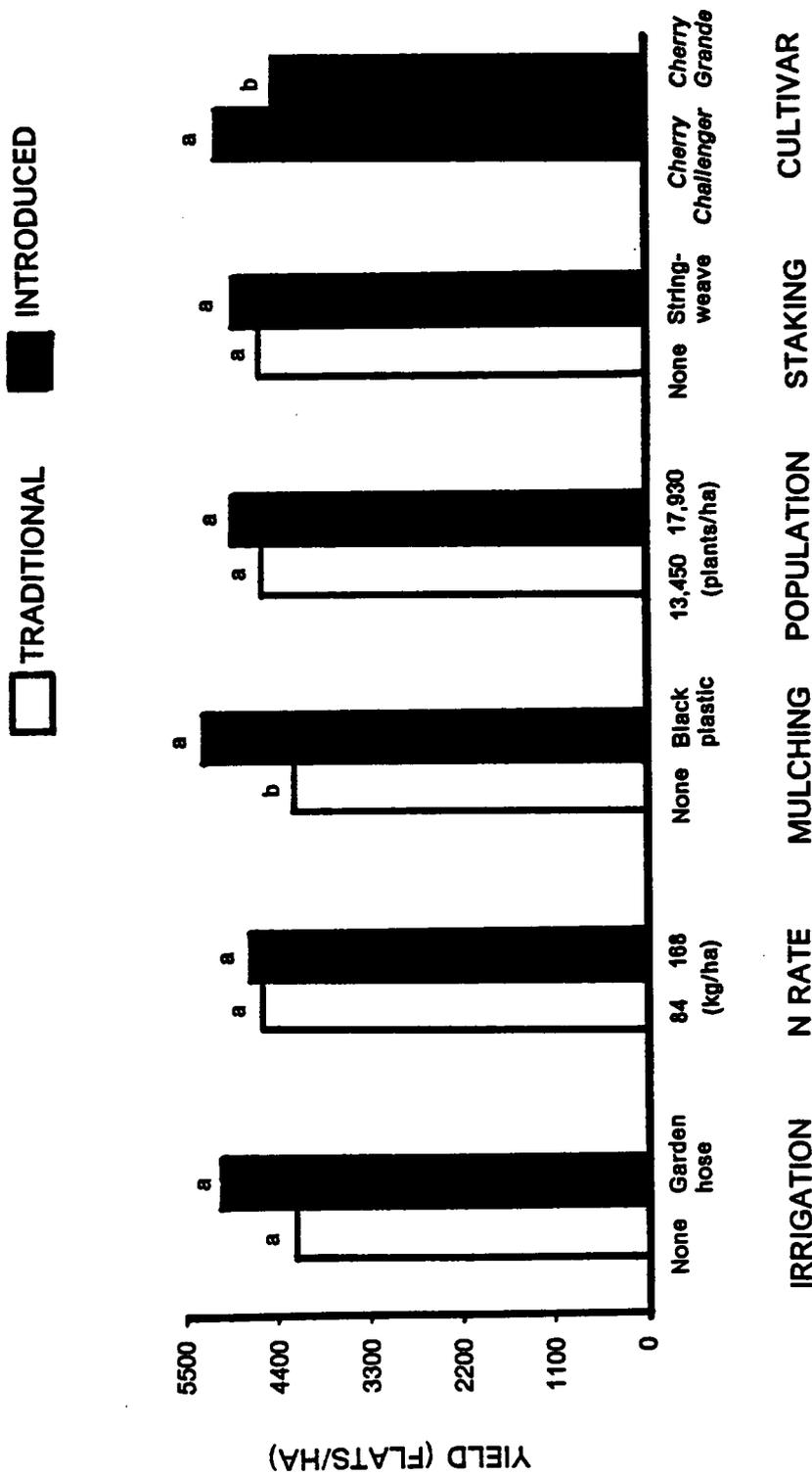


Figure 6.3. Effect of traditional and introduced treatments on the yield of cherry tomato in on-farm testing conducted in East Central Virginia, 1985. Mean separation for each production factor was done using single degree of freedom contrasts, 5% level.

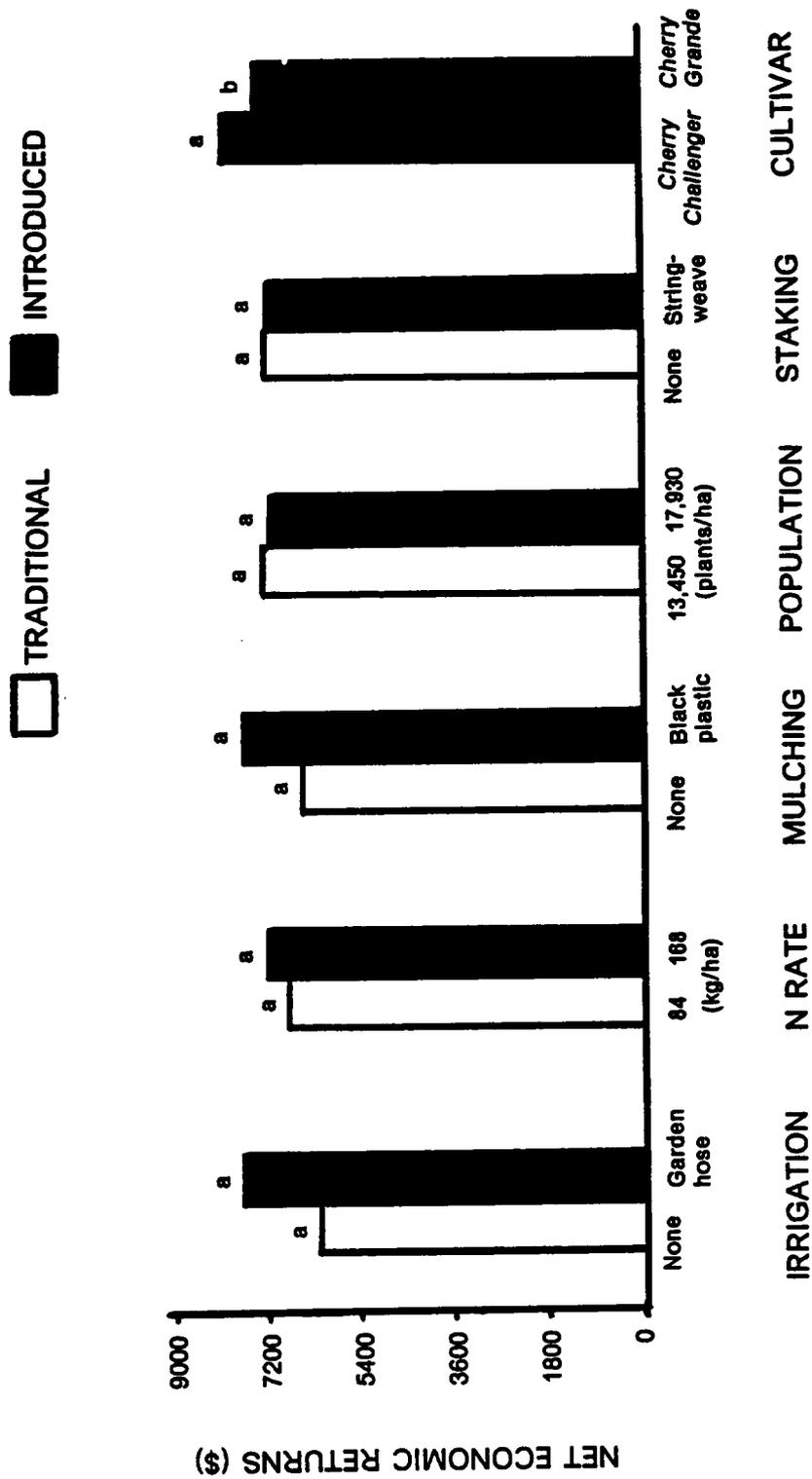


Figure 6.4. Effect of traditional and introduced treatments on the net economic returns of cherry tomato production in on-farm testing conducted in East Central Virginia, 1985. Mean separation for each production factor was done using single degree of freedom contrasts, 5% level. Labor costs are not included; estimated labor needs are 2200 hours/ha.

on tobacco. The irrigation and harvesting operations of these families' plots were done irregularly, and in some cases, only out of a sense of obligation to the project. In contrast, those farm families without tobacco allotments continued to irrigate and harvest their tomato plots regularly, and thus, these families attained higher yields. Contrasts between these two groups of families showed significant differences for both yield and net economic returns ($p < .001$).

The soaker hose irrigation system itself was not without its problems. Some families felt that it was too time consuming to move the soaker hose from row to row every 5 minutes. In order to conserve time, 2 farm families substituted their own lawn sprinklers for the soaker hoses. Another identified problem with the soaker hose was that the end attached to the garden hose emitted more water than the distal end, especially if the distal end was at a higher elevation.

With respect to interactions among the treatments, a significant interaction occurred between irrigation and N rate ($p < .05$). The irrigation of plants led to higher yields for both N rates, but there was a dramatic yield increase among the irrigated plants with the high N rate treatment (Figure 6.5). This interaction suggests that 84 kg/ha of applied N may be inadequate for plantings which are irrigated in years of normal rainfall. This inadequacy is likely to be due to the increased leaching of N caused by irrigation.

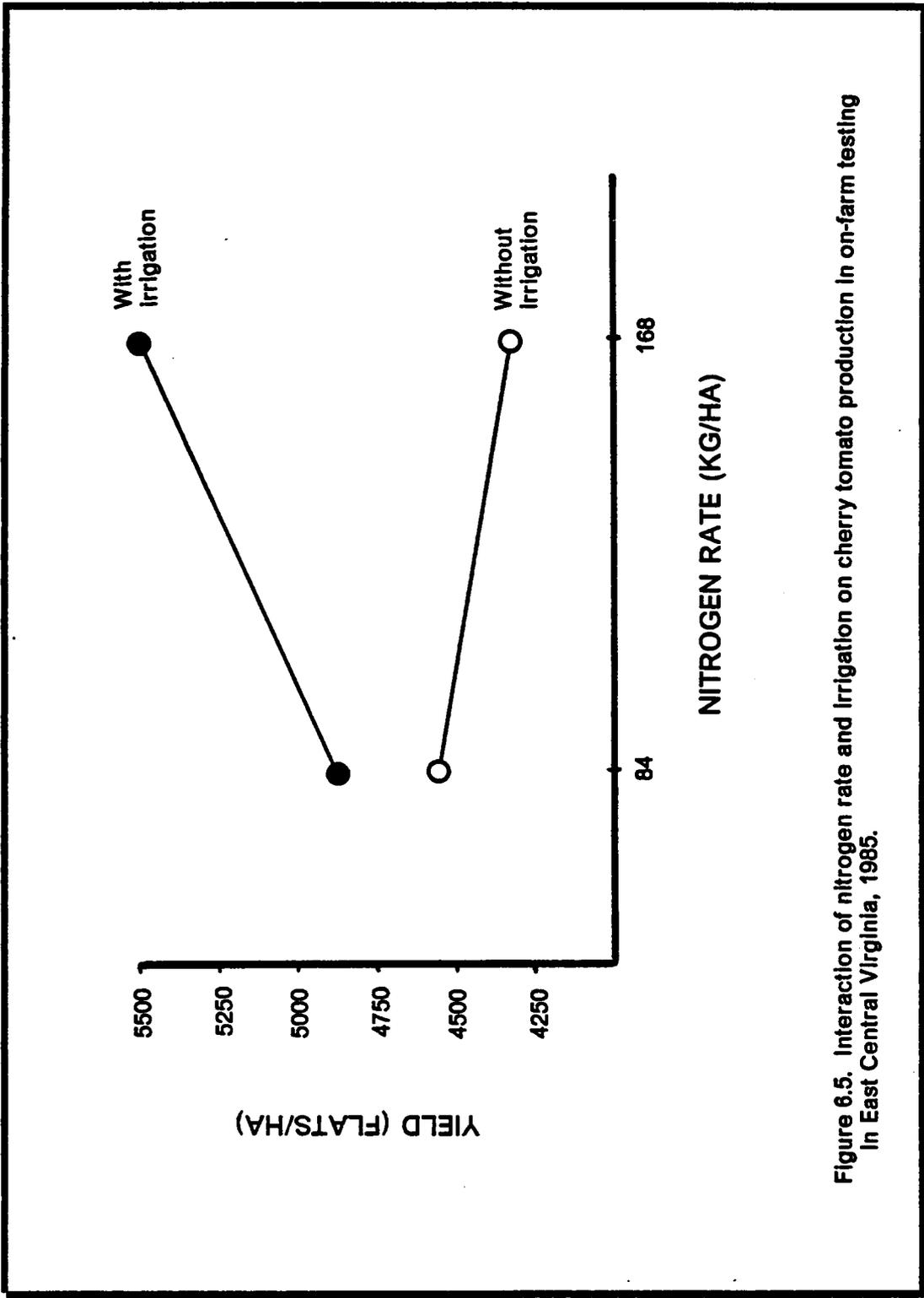


Figure 6.5. Interaction of nitrogen rate and Irrigation on cherry tomato production in on-farm testing In East Central Virginia, 1985.

Nitrogen Rate

Testing in 1985 showed no significant differences among 84 and 168 kg/ha of applied N ($p = .38$ for yield and $p = .46$ for net economic returns)(Figures 6.3 and 6.4). This finding is in agreement with previous research that has found that the most cost-efficient application rates of N range from 56-138 kg/ha (7, 14, 18, 21, 48).

The trials in 1986 looked at lower N rates, 56 and 90 kg/ha, and again detected no significant differences for either yield or net economic returns ($p = .49$ for early yield, $p = .56$ for total yield, and $p = .79$ for net economic returns)(Table 6.1). It should be noted, however, that in this year of research the dry weather minimized the usual losses of N to leaching, and also reduced the demands for N by the stressed plants.

Mulching

Black plastic mulch in the 1985 trial led to significantly higher yields, increasing yields on average by 26% (Figures 6.3 and 6.4). Its higher costs, however, reduced the significance of its economic benefits in production ($p = .06$).

Results from the 1986 mulching trials again showed the benefits of mulching. Black plastic and straw mulches both significantly increased total yields compared to bare-ground plantings (Table 6.2). The BPM furthermore provided for significantly higher early yields than the bare-ground plantings. Economic analysis, however, shows that the cost of these mulches eliminates any yield advantage that they provide. These results support those of previous research in North Carolina (11).

Table 6.1. Effect of nitrogen and straw mulch on cherry tomato production in on-farm testing in East Central Virginia, 1986.

Factor	Treatment	Early yield (flats/ha)	Total yield (flats/ha)	Net ^a economic returns (\$/ha)
Nitrogen	56 kg/ha	442 NS	1385 NS	1327 NS
	101 kg/ha	375	1435	1263
Mulch	Straw	398 NS	1554 **	1307 NS
	None	416	1197	1118

^aLabor costs not included. Estimated labor needs are 2200 hours/ha.

NS, *, **, *** Non-significant (NS) or significant at the 5%, 1%, or 0.1% level, respectively.

Table 6.2. Effect of mulch on cherry tomato production in on-farm testing in East Central Virginia, 1986.

Mulch	Early yield (flats/ha)	Total yield (flats/ha)	Net ^a economic returns (\$/ha)
Black plastic	683 a ^b	1615 a	1320 a
Straw	408 b	1587 a	1359 a
None	403 b	1283 b	1263 a
Significance	*	**	NS

^aLabor costs not included. Estimated labor needs are 2200 hours/ha.

^bMean separation in columns by Duncan's Multiple Range Test, 5% level.

NS, *, **, *** Non-significant (NS) or significant at the 5%, 1%, or 0.1% level, respectively.

The SM and N rate factorial study in 1986 reinforced the findings of this project's other mulching research. The SM in this experiment provided for significantly higher total yields, but it did not influence either early season yield or net economic returns ($p = .95$ and $p = .56$, resp.)(Table 6.1). The interaction of mulch and N rate in this experiment was also non-significant for all characteristics ($p = .17$ for early yield, $p = .37$ for total yield, and $p = .31$ for net economic returns).

Plant Population

The higher plant population evaluated in 1985 provided for greater yields and net economic returns, but at non-significant levels ($p = .17$ and $p = .33$, resp.)(Figures 6.3 and 6.4). This yield advantage for the high population treatment was directly related to the greater number of plants per hectare. Indeed, on a per plant basis, the low population plantings had significantly higher yields per plant (0.337 flats/plant) than the high population plantings (0.274 flats/plant)($p < .01$).

Staking

Both years of research showed little advantage to the staking of determinate-vined cultivars. In 1985 (under normal rainfall conditions), staking did not significantly impact on either the yield or the net economic returns in production ($p = .25$ and $p = .87$, resp.)(Figures 6.3 and 6.4). In 1986 (under droughty conditions), staking had a significantly negative impact on early yield and net economic returns, and a negative impact on total season yields ($p = .33$)(Table 6.3).

Table 6.3. Effect of staking on cherry tomato production in on-farm testing in East Central Virginia, 1986.

Treatment	Early yield (flats/ha)	Total yield (flats/ha)	Net* economic returns (\$/ha)
String-weave	238	971	379
None	645	1388	1326
Significance	*	NS	*

*Labor costs not included. Estimated labor needs are 2200 hours/ha.

NS, *, **, *** Non-significant (NS) or significant at the 5%, 1%, or 0.1% level, respectively.

Individual farm analyses of the 1986 research show that the effects of staking were affected by both moisture stress and farm management factors. Staking has been reported to increase moisture stress on plants by exposing the surrounding soil to greater levels of heat and evaporation (16, 17, 22, 26). In this study, the yields on the lighter, sandy loam soils were reduced by staking (Table 6.4). These soils have relatively low water holding abilities, and thus, crops raised on these soils are more susceptible to moisture stress (29). In contrast, staking provided for an increase in yield on the heavier, loam soil. This soil type has a relatively high water holding ability, and crops raised on this soil are less susceptible to moisture stress.

But besides soil type, the management of these plots also influenced yields. An advantage to staking is that it keeps the fruit off the ground and thus reduces the incidence of rot. Fruit rot is usually of less concern with cherry tomato fruit, as they are generally firmer than standard tomatoes, and also mature more rapidly. In this experiment, the plantings on the lighter soils were carefully managed, and the incidence of fruit rot was negligible. The field plot on the heavier soil, however, was not well managed, and rotted fruit covered the soil surface below the plants. The incidence of fruit rot for this poorly-managed site was at least partially remedied through the supporting of fruit off the ground by staking.

Table 6.4. Effect of staking on cherry tomato production for 3 soil types of East Central Virginia, 1986.

Soil type	AWC ² (cm/cm)	Total yield		Staking effect (%)
		Staked (flats/ha)	Not staked (flats/ha)	
Cecil sandy loam	0.13	1274	2641	-51.7
Appling sandy loam	0.14	1099	1203	-8.7
Iredell-Mecklenburg loam	0.17	539	318	+69.5

²AWC = Available Water Capacity (29).

Cultivar

Cherry Challenger significantly outyielded *Cherry Grande* in the 1985 research (Figures 6.3 and 6.4). The fruit of both of these cultivars, however, were too large for the market identified by the local cooperative.

Results from the 1986 trials identified 2 superior cultivars, *Castlette* and *Small Fry*. *Castlette* was the highest yielder in the trial (Table 6.5). Its vines produced heavy yields of fruits in the early season, and then continued to bear impressively up until frost. The fruit of this cultivar were firm, resistant to cracking, well-sized, and slow to redden (Table 6.6). This latter characteristic is especially important as it provides growers with greater flexibility in harvesting operations. It also provides additional time for the local cooperative to locate buyers for the produce.

The performance of *Small Fry* was also outstanding. Its yields were very high, especially in the early season. The fruit quality of this commonly-planted cultivar was superb, with good fruit color, shape, and an ideal fruit size (2.54 cm). *Small Fry* is also the only cultivar in the study with resistance to root knot nematode, a problem for some farm families in the area.

Among the other cultivars, *Cherry Challenger* was judged to be appropriate for those markets which prefer a relatively large-sized fruit (3.18-3.81 cm in diameter). The yields of this cultivar were impressive, and its fruits were firm, crack-resistant, and slow to redden.

There is a significant gap between these 3 cultivars and the others. In fact, when labor at the NTFD became inadequate in September, only these 3 cultivars were

Table 6.5. Yield by season, and the net economic returns of cherry tomato cultivars grown at the Nottoway Teaching/Demonstration Farm in East Central Virginia, 1986.

Cultivar	Yield (flats/ha)			Net economic returns (\$/ha) ²		
	Early	Early + main	All-season	Early + main	All-season	
Castlette	1018 b ^y	4050 a	4792 a	6597 a	8032 a	
Cherry Challenger	565 cd	2620 bc	3006 a	3837 bc	4584 a	
Cherry Grande	299 de	764 e		254 e		
Early Cherry	283 de	785 e		294 e		
Gardener's Delight	902 bc	2759 bc		4104 bc		
Red Cherry (small)	577 bcd	1310 de		1307 de		
Small Fry	1413 abc	3367 ab	3547 a	5277 ab	5630 a	
Sundrop	98 d	775 e		275 e		
Sweet Cherry	535 bcd	1982 cd		2604 cd		
Sweet 100	372 cd	972 de		656 de		
Significance	***	***	NS	***	NS	NS

²Labor costs not included. Estimated labor needs are 2200 hours/ha.

^yMean separation in columns by Duncan's Multiple Range Test, 5% level.

NS, *, **, *** Nonsignificant (NS), or significant at the 5%, 1%, or 0.1% level, respectively.

Table 6.6. Fruit quality and plant characteristics of cherry tomato cultivars grown at the Nottoway Teaching/Demonstration Farm in East Central Virginia, 1986.

Cultivar	Crack ² resistance	Market ³ ability	Fruit diameter (cm)	Fruit ⁴ shape	Fruit ⁵ color	Relative ⁶ maturity	Vine ⁷ type	Disease ⁸ resistance
Castlette	73.0 ab [*]	82.3 c	2.92 b	0.97 c	1	M	D	VF
Cherry Challenger	74.8 a	57.9 d	3.05 b	1.05 b	1	ME	D	VF
Cherry Grande	54.6 de	28.7 f	3.32 a	0.94 cd	1	ME	D	
Early Cherry	49.5 e	63.1 d	2.91 b	1.12 a	1	E	D	
Gardener's Delight	62.1 cd	99.6 a	2.25 d	0.90 e	2	ME	I	
Red Cherry (small)	69.3 abc	77.6 c	2.02 e	0.94 cd	1	M	I	
Small Fry	60.8 cd	90.0 b	2.54 c	0.92 de	1	E	D	VFN
Sundrop	63.2 cd	28.9 f	3.40 a	1.02 b	3	L	I	
Sweet Cherry	47.4 e	93.7 b	2.64 c	0.93 de	2	M	D	
Sweet 100	64.6 bc	43.8 e	1.87 f	0.95 cd	1	M	I	
Significance	***	***	***	***				

¹Percent of harvested fruits without cracks.

²Percent of crack-free fruits with diameters between 190 and 318 cm.

³Longitudinal diameter/latitudinal diameter.

⁴1 - bright reddish-orange, 2 - flat reddish-orange, 3 - light orange.

⁵E - early, ME - medium-early, M - medium, L - late.

⁶D - determinate, I - indeterminate.

⁷V - Verticillium wilt, F - Fusarium wilt (race 1), N - root knot nematode.

⁸Mean separation in columns by Duncan's Multiple Range Test, 5% level.

NS, *, **, ***: Nonsignificant (NS), or significant at the 5%, 1%, or 0.1% level, respectively.

deemed worthy of harvesting until frost. Measurements of the all-season yields for these cultivars are presented in Table 6.5.

Among the remaining determinate lines, *Cherry Grande* was high yielding, but its fruits were much too large in size. In fact, only the smallest 26.7% of its fruits were marketable (Table 6.6). *Early Cherry* also performed unsatisfactorily, as its yields were only fair and its fruit quality was poor. Indeed, the fruits of this cultivar were undesirably oblate in shape and highly susceptible to cracking. Similarly, the fruit of *Sweet Cherry* were also very susceptible to cracking. Otherwise, this cultivar was not noteworthy, good or bad, for any characteristic.

Among the indeterminate cultivars, *Gardener's Delight* was the most impressive. Its yields were outstanding throughout the summer, and both its fruit shape and size were excellent. Furthermore, the taste of this cultivar seemed to be sweeter than the others in the trial. Indeed, the only drawback to this cultivar was the lack of luster in the color of its fruit.

With regard to fruit color, the most unusually colored fruit in the trial belonged to *Sundrop*. Its orange color is widely believed to indicate lower acidity, however, this is not based on scientific evidence (33). With respect to the other qualities of *Sundrop*, its fruits were too large for marketing, and its susceptibility to blossom end rot severely reduced its early yields.

The results of the on-farm testing in 1986 supported the data from the NTDF. *Castlette* was the highest yielder at all farms, and its fruit quality was favorable for marketing purposes. *Small Fry* also produced good yields at the well-managed sites, however, its yields were relatively low at the poorly-managed site (Figure 6.6). This drop off in

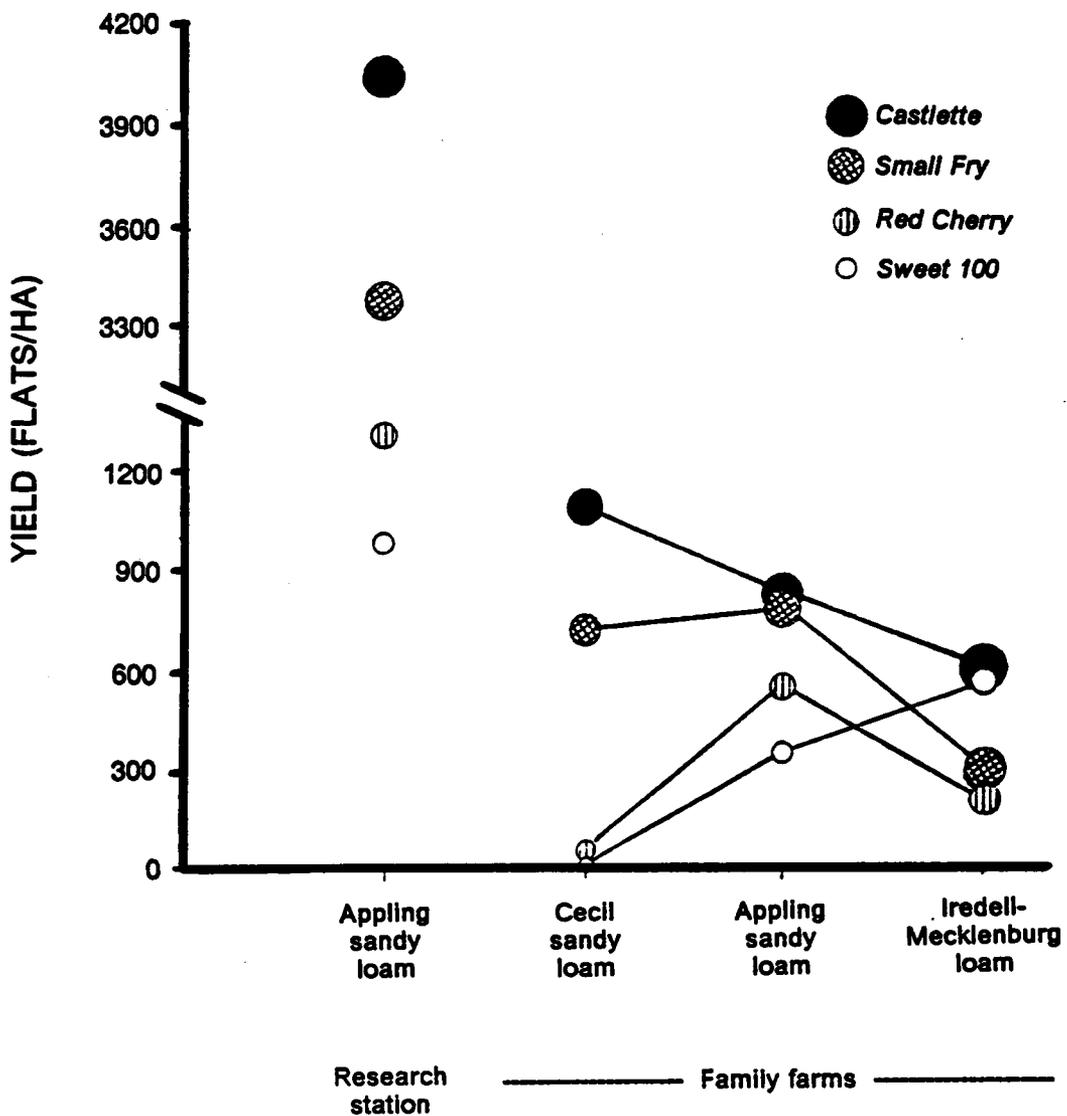


Figure 6.6. Yield of cherry tomato cultivars grown at 4 sites in East Central Virginia, 1986. The diameters of data points are drawn to represent the relative fruit sizes of cultivars from site to site.

yield was due to the infrequency of harvests at this farm. Indeed, the rapid reddening habit of *Small Fry* caused a disproportionately high amount of its fruit to be lost due to overripeness.

The two indeterminate cultivars in the on-farm trials, *Sweet 100* and *Red Cherry*, were judged to be not suitable for production in the area. The farm families who participated in the trials did not have the time to prune the vigorous vines of these cultivars, and this made harvesting operations difficult. In addition, the fruit sizes of these cultivars on the sandy loam soils were generally too small for marketing. On the loam soil, however, *Sweet 100* responded especially well, producing good yields of glossy, well-sized fruits.

6.4. Recommendations

The following recommendations can be made after 2 years of research on area farms:

Irrigation

Although cherry tomato is relatively tolerant to moisture stress, the positive response of plants to irrigation in 1985 shows that irrigation may be beneficial in years with normal precipitation. Furthermore, the dramatic decline in on-farm yields from 1985 to 1986 indicates that during droughty years, irrigation may be most important in producing a profitable crop.

Irrigation operations should be conducted throughout the growing season, and especially before fruit set. After fruit set, irrigation operations should be done in moderation, and only when necessary. This is because the reported benefits to irrigation during fruit development (a lower incidence of blossom end rot and a greater fruit size) are of little concern to cherry tomato growers in the area. Indeed, blossom end rot was never seen on either of the 2 superior cultivars in the trials, *Castlette* and *Small Fry*. In addition, there is no benefit in enlarging the fruit sizes of these cultivars. In fact, the enlargement of *Castlette* may jeopardize its marketability. It should also be noted that irrigation during fruit development leads to an increase in cracking (2, 13, 30). This has already been cited as a problem with *Small Fry* plantings in the area after thunderstorms.

With respect to the method of irrigation, small farm families should choose a plot of land near to their home residences and use garden hoses. Soaker hoses or lawn sprinklers can then be attached to the garden hoses. In comparing these 2 irrigation methods, the advantages of using a soaker hose are: 1) greater efficiency in the utilization of water; 2) a deeper soaking of water near the plants; and 3) a reduction in weed populations between the rows. The advantages of using a lawn sprinkler are: 1) less time needed to move the irrigation hoses within the plot, and 2) lower production costs, as families are likely to already have a lawn sprinkler in their possession. The purchasing of a trickle irrigation system is not yet justified due to its higher expense and the unpredictability of the cherry tomato market.

Nitrogen Rate

This research supports the current recommendation of the VCES, 90 kg/ha. The 1985 experiment detected no significant benefit to higher N rates, except in irrigated plantings. With respect to lower N rates, the 1986 research was inconclusive, as the droughty weather reduced leaching and N uptake that year.

In reference to the timing of N applications, the availability of N is reported to be most critical during the juvenile stage of plant development (14). This suggests the need for fertilization just prior to planting or immediately after transplants are established. Sidedressings will likely be of benefit in the well-drained lighter soils of the area, but not in the heavier soils.

Mulching

Results from these trials indicate that springtime plantings of cherry tomato will not need mulching for maximum net economic returns. Both BPM and SM will increase yields, but their high cost and the unpredictability of the market precludes them from being recommended at this time.

Plant Population

A plant population of 13,450 plants/ha is recommended at this time. This population in 1985 provided similar yields and net economic returns as the higher plant

population evaluated, 17,930 plants/ha, and was 25% less costly to plant. Further savings may be gained by using the lower plant population since it will permit for more air movement among plants. This may reduce the incidence of pathogens, and in turn, reduce expenses on fungicide sprays. Lower plant populations remain to be tested.

Staking

There is no significant yield advantage to staking. In fact, those growers with lighter soils are likely to reduce their yields by staking. Nevertheless, many growers still prefer to stake their tomatoes because it will reduce the strain on their backs during harvesting, keep the fruit clean, and reduce the time needed in harvesting operations.

Cultivar

Castlette and *Small Fry* are clearly the most suitable cultivars for the area. These cultivars are both high-yielding, produce fruits of marketable size, and are determinate-vined. When compared against one another, *Castlette* provides for higher main season and late season yields, higher net economic returns, and has fruit which are firmer, more crack-resistant, and slower to redden. *Small Fry* provides for higher early season yields, genetic resistance to the root knot nematode, and a slightly smaller fruit size.

The principal concern with *Castlette* is that its fruit may become slightly larger than what is preferred when grown on heavy soils or in wet weather. This problem will be most pronounced in the early season when fruits are naturally larger. Another concern with *Castlette* is its genetic instability. Approximately 5% of the plants produced oblate-shaped fruits. This problem, however, can be easily remedied by culling these plants during the first harvest. The principal concerns with *Small Fry* are its susceptibility to cracking and the rapid reddening of its fruit.

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7. BELL PEPPER RESEARCH

7.1. Literature Review

Bell pepper is the botanical variety of pepper (*Capsicum annuum* L.) that is characterized by bell-shaped, thick-walled, and non-pungent fruit (1, 6). This literature review shall discuss those factors of production which were considered in the research of the East Central Virginia FSR/E Project.

Nitrogen Rate

Nitrogen (N) has been reported to affect the foliar growth, fruit set, fruit quality, and the incidence of blossom end rot in bell pepper (2, 9, 11, 12, 14). The uptake of N by bell pepper plants has been shown to be related to plant ontogeny. Studies indicate that the uptake of N is relatively low in the juvenile plant stage, followed by rapid increases during the development of first fruits, and a subsequent tapering off of consumption until frost (9, 12). This pattern of N uptake suggests the suitability of

split applications for N fertilization. Indeed, benefits of split applications have been reported in the literature (2, 9), as have the benefits of slow-release N sources (9).

Studies of application rates for N report that approximately 110 kg/ha is most cost-efficient for springtime plantings (2, 12). Locascio reported yield increases with applications of up to 224 kg/ha of N for isobutyldene diurea and sulfur-coated urea, and up to 140 kg of N/ha for more soluble N sources. Higher applications of the soluble N sources (urea, ammonium nitrate and ammonium sulfate) were said to cause excessive soluble salt levels (9). The Virginia Cooperative Extension Service (VCES) recommends a total of 146 kg/ha of applied N: 56 kg/ha broadcasted preplant, followed with sidedressings of 56 kg/ha after initial fruit set, and then 34 kg/ha 3 weeks later (17). Calcium nitrate is often recommended as the source of N for sidedressings, as the deficiency of calcium is largely responsible for blossom end rot (11).

Nitrogen deficiency symptoms in bell pepper include the chlorosis of leaves and fruit, and a stunting of plant growth (11). Deficiencies of N may also lead to a reduction in flower number and fruit set during the early harvest season (10). In contrast, excessive N levels will cause fruits to be dark green, short, thick, and somewhat round in shape (11). Excessive N levels may also contribute to more expansive foliar growth, and thus, a greater protection of fruits from sunscalding (14).

Pepper plants fertilized with ammoniated fertilizers are reported to have higher incidences of blossom end rot, largely due to the antagonism between ammonium and calcium ions. Nitrogen is also reported to share antagonistic relationships with potassium, calcium, and magnesium (11). In contrast to these antagonisms, N and

phosphorous are reported to have a synergistic interaction in bell pepper production (16).

Mulching

The mulching of bell pepper may increase yield, improve fruit quality, promote earliness, conserve soil moisture, reduce nutrient leaching, and modify soil temperatures (4, 5, 8). Widely used mulching materials include an array of reflective mulches, as well as black plastic mulch (BPM).

Reflective mulches have been reported to have several beneficial effects in bell pepper production. Peppers grown with white polyethylene mulch have been reported to initiate more flowers, fruit earlier, and produce higher yields than bare-ground plantings (4). Peppers grown with aluminum-painted mulch have been reported to outyield both BPM and bare-ground plantings, as the reflectivity of the mulching increases the amount of photosynthetic radiation around the plants (15). Aluminum-painted mulch is also reported to repel virus-transmitting aphids (3). In summer-sown plantings, reflective mulches are reported to increase both germination rates and the subsequent yield of bell peppers by reducing soil temperatures (5).

As is the case with the reflective mulches, BPM is reported to conserve moisture, maintain higher N levels in the soil, and also lead to higher yields than bare-ground plantings (8). But in contrast to the reflective mulches, BPM is reported to increase

soil temperatures (3, 4, 7), enhance the utilization of applied and soil-derived N (4, 8), and contribute to secondary root formation (4, 7).

Plant Population

There have been 2 major studies of plant population effects on bell pepper, 1 on bare-ground beds and the other with mulching. On bare-ground beds, twin- and triple-row patterns of 40,000 plants/ha have been reported to outyield twin-row patterns of 27,000 plants/ha, and also be more cost-efficient than triple-row patterns of 67,000 plants/ha (2). In this study, the effects of plant population were reported to be more significant than the effects of planting geometry.

On mulched beds, twin-row plantings with 2 plants per hill (86,072 plants/ha) are reported to outyield twin-row plantings with 1 plant per hill (43,056 plants/ha). In turn, both of these twin-row plantings outyielded the single-row planting of 1 plant per hill (21,518 plants/ha). Fruit size, however, was significantly larger with the lowest population level (15).

In East Central Virginia, the most widely used transplanting pattern is a single-row pattern with an in-row spacing of 41 cm. Using the most common row spacing of 1.07 m, this transplanting pattern has a plant population level of 23,050 plants/ha.

7.2. Materials and Methods

1985 Trial

A 3 x 2 x 4 x 3 factorial experiment was designed to test for the effects of N rate, BPM, plant population, and cultivar on bell pepper production.

In the evaluation of N rates, applications of 79, 158, and 236 kg/ha of N were chosen. Fifty-five percent of the N rate was broadcasted preplant, using ammonium nitrate as the N source. This was followed by 2 sidedressings of calcium nitrate, the first application coming after fruit set and the second being 3 weeks later. As was the case for all experiments, applications of phosphorus, potassium, and boron were broadcasted preplant using those rates recommended in recent soil tests.

Plant population effects were evaluated utilizing both single- and twin-row systems. For the single-row systems, plants were spaced 38 and 23 cm apart within rows which were spaced 1.07 m apart. This provided for plant populations of 24,600 and 41,000 plants/ha, respectively. The twin-row systems had twin-rows separated 30 cm apart, also on 1.07 m row centers. Plants within these rows were planted offset of one another, with plants within each twin-row spaced either 46 or 30 cm apart. These patterns provided for plant population levels of 41,000 and 61,470 plants/ha, respectively.

For the other treatments, BPM was used to test for the effects of mulching. In the evaluation of cultivar effects, a newly introduced line, *Cadice*, was matched up with two commonly planted lines, *Keystone Resistant Giant #3* and *Lady Bell*.

This factorial experiment was planted on 6 farms in mid-May. An incomplete block design was used to accommodate the numerous treatments. The field sites were first divided randomly by N rate and BPM treatments. Within these sub-subplots, the plant population and cultivar treatments were randomly distributed. At each site, 36 of the 72 total treatments were planted, and 3 treatments were replicated to obtain the measurement of farm by treatment interactions. The treatment plots within each site were 3.96 m long.

Harvested peppers were graded out as large (U.S. Fancy and U.S. #1 grades), medium (U.S. #2), or small (U.S. #3). The yield total of each plot was then converted to commercial production units for data analysis (see Appendix A). Partial budget analyses were done for both years of research using information from the VCES (13), local input prices, and the commodity prices received by the local cooperative (see Appendix B). Analyses of variances were done on the yield and economic characteristics, using general linear models for the unbalanced data of 1985.

1986 Trials

In response to the wishes of the farm families, research efforts in 1986 concentrated on the evaluation of cultivars and single-row plant spacings. With respect to cultivar testing, 29 large-fruited bell pepper cultivars were chosen for evaluation. All cultivars were set out at the Nottoway Teaching/Demonstration Farm (NTDF), using a randomized complete block design (RCBD) and 3 replications. This experiment was supplemented by 6 on-farm trials. In these on-farm trials, growers were offered the opportunity to select from 5-10 cultivars, with 2 replications of each selection planted.

In the evaluation of single-row plant spacings, *Keystone Resistant Giant #3* plants were set out at 20, 30, 41, 51, and 61 cm spacings. Using RCBD, 3 replications of this experiment were planted at the NTDF, and 2 replications were planted at each of 4 area farms. In this and other 1986 bell pepper research, treatment plots were 6.10 m long, and were set out on 1.07 m row centers.

As was the case for all vegetable experiments, the participating farm families were provided with the production inputs (plants, fertilizers, mulches, herbicides, etc.) they needed for testing. In turn, the farm families were responsible for the management of the plots, including the harvesting of crops and the recording of yield and fruit quality information. A member of the project team visited each farm every week to discuss the progress of the trial with the farm families. The families were permitted to keep the harvested crops either for home consumption or for marketing.

7.3. Results and Discussion

In contrast to the unpredictable marketing environment for cherry tomato, the sales of bell pepper through the local cooperative were both stable and strong. Nevertheless, 2 of the 6 plots planted in 1985 went unmanaged. One of these plots went neglected from the very beginning, the other plot was plowed under in midseason when the farm operator was embarrassed by the performance of some of the treatments. The location of all managed pepper trials are shown in Figure 7.1.

In 1986, the droughty climate had a devastating effect on the on-farm trials. Bell pepper has a restricted root system and is therefore highly susceptible to moisture

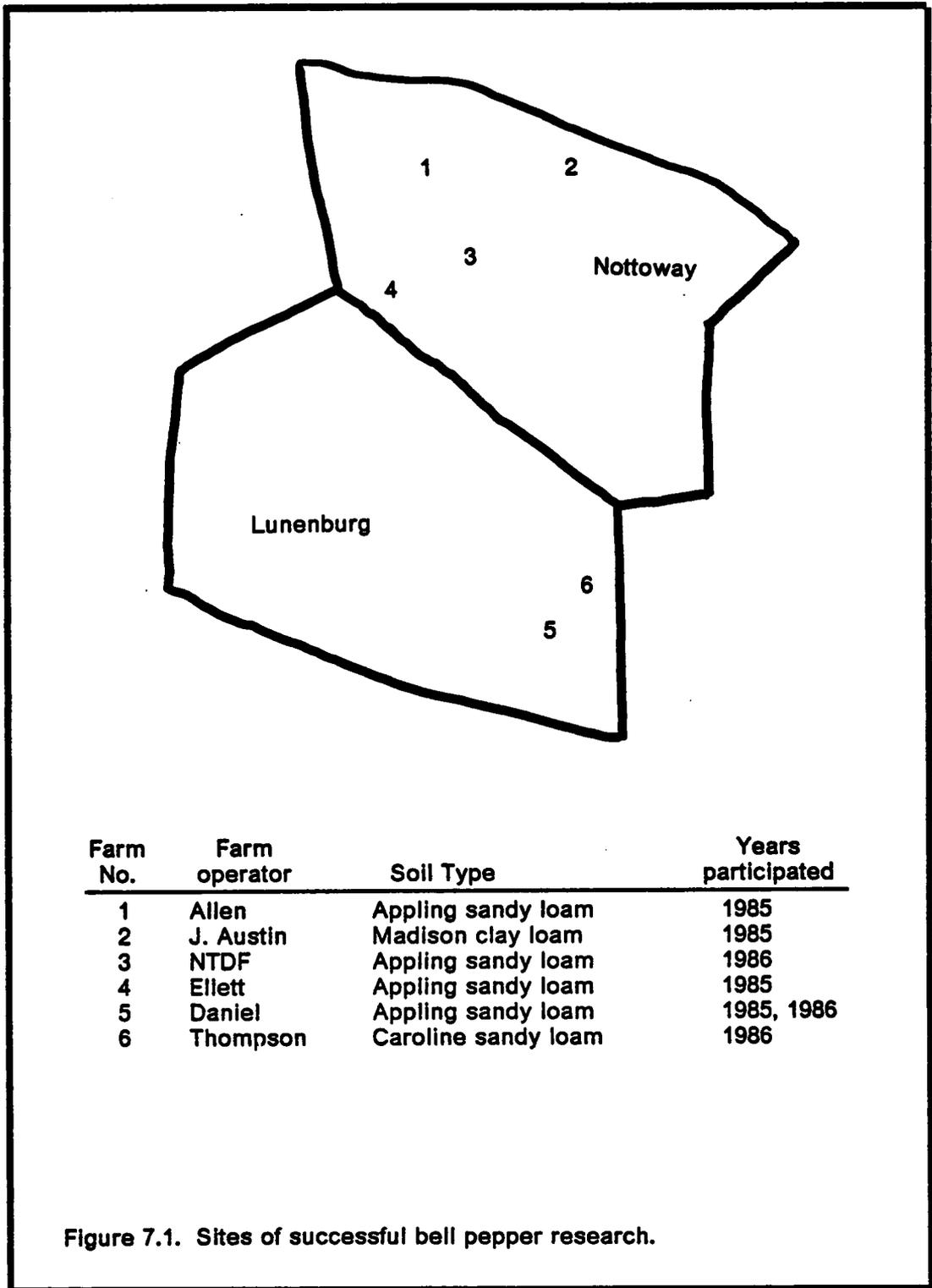


Figure 7.1. Sites of successful bell pepper research.

stress. Sufficient data was obtained only at the NTDF and at 2 farms located near the eastern boundary of Lunenburg County. All 3 of these sites had overhead irrigation systems and were also fortunate to receive the spotty rain that fell during the summer.

Nitrogen Rate

Results from the 1985 trial showed a positive, but non-significant response to the higher N rates ($p = .62$ for large pepper yield, $p = .18$ for medium pepper yield, and $p = .52$ for net economic returns)(Figures 7.2, 7.3, and 7.4).

Mean yields and net economic returns were low in 1985, as 1 of the farm plots was insufficiently limed, while another was not cultivated regularly. As was the case for all bell pepper experiments in both years of research, differences among farms were significant for all evaluated characteristics. Farm by treatment interactions were non-significant for all treatments in 1985, as were all interactions among the treatments themselves.

Mulching

Black plastic mulch significantly increased the yields and net economic returns in production (Figures 7.2, 7.3, and 7.4). Large pepper yields increased an average of 99%, and medium pepper yields rose 46%. The conservation of moisture by the BPM was the principal reason behind this increase in yield. Indeed, field observations

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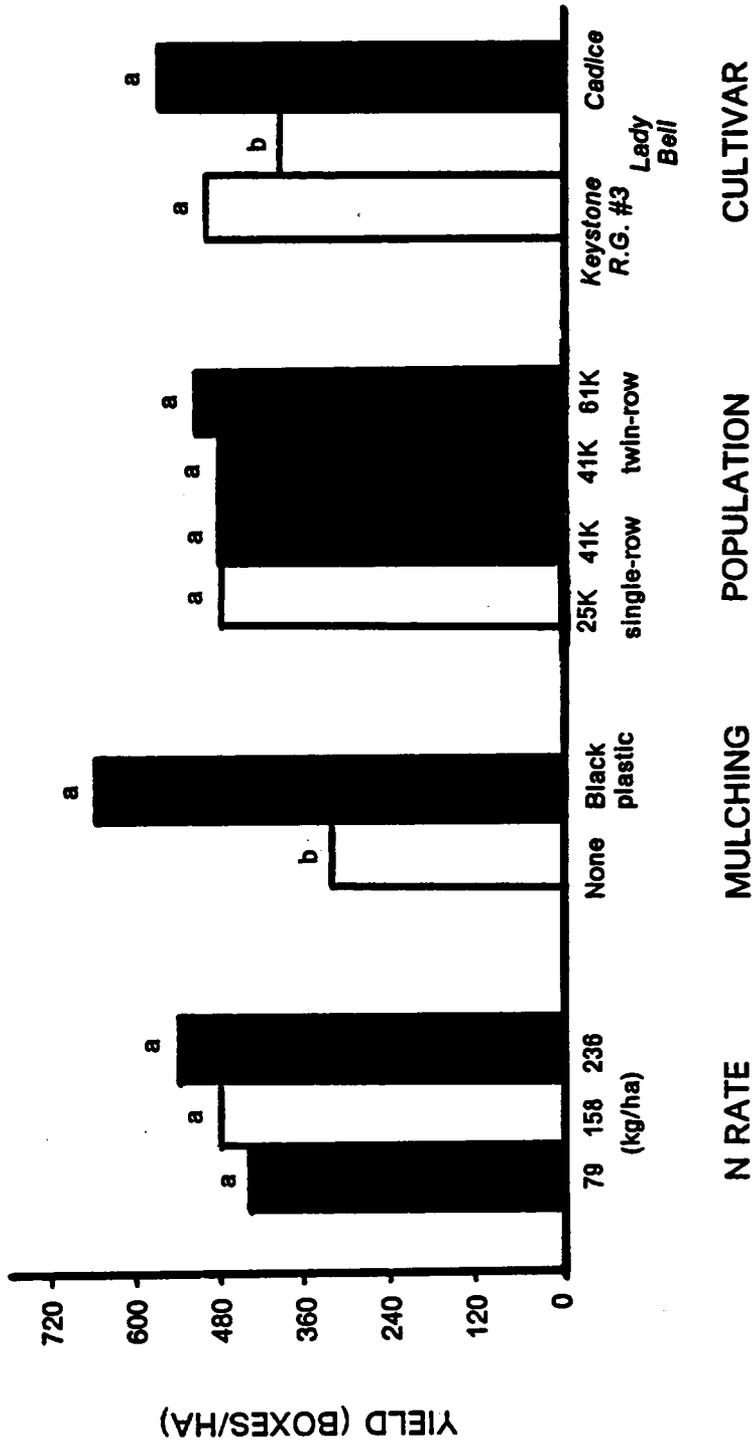


Figure 7.2. Effect of traditional and introduced treatments on the yield of U.S. Fancy and U.S. #1 grade bell peppers in on-farm testing conducted in East Central Virginia, 1985. Plant populations are rounded to the nearest 1000 plants. Mean separation for each production factor was done using single degree of freedom contrasts, 5% level.

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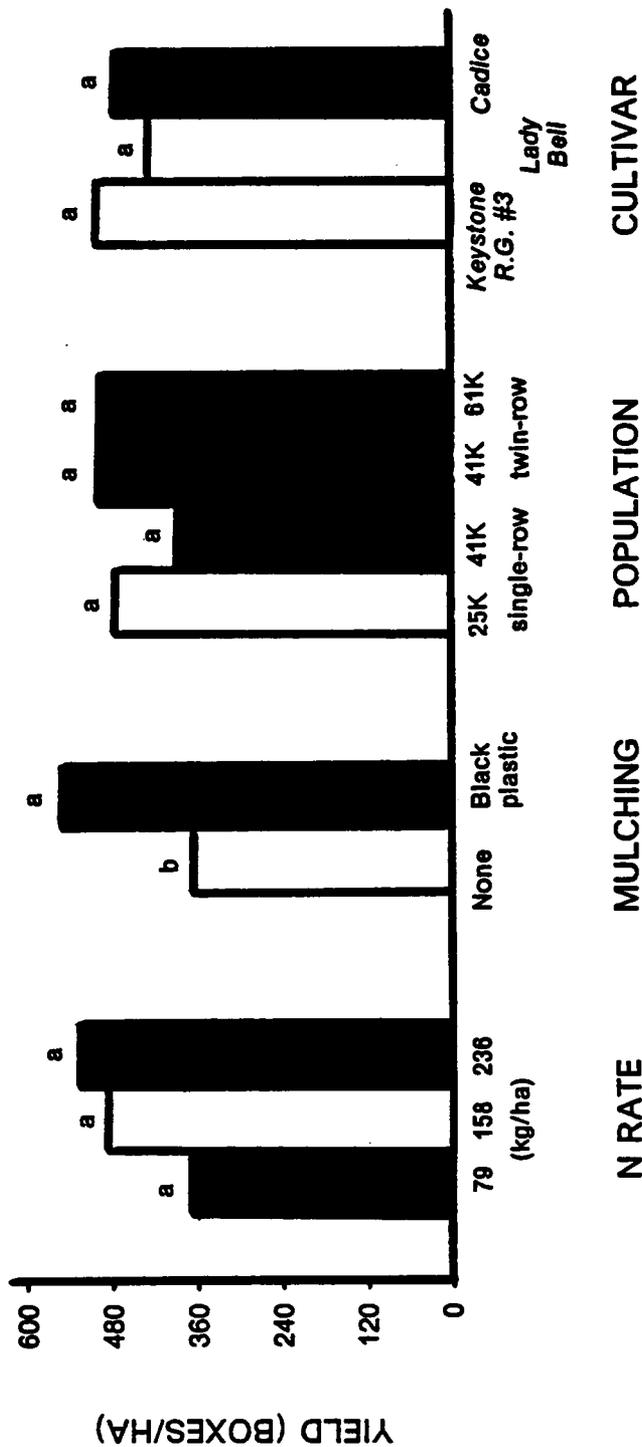


Figure 7.3. Effect of traditional and introduced treatments on the yield of U.S. #2 grade bell pepper in on-farm testing conducted in East Central Virginia, 1985. Plant populations are rounded to the nearest 1000 plants. Mean separation for each production factor was done using single degree of freedom contrasts, 5% level.

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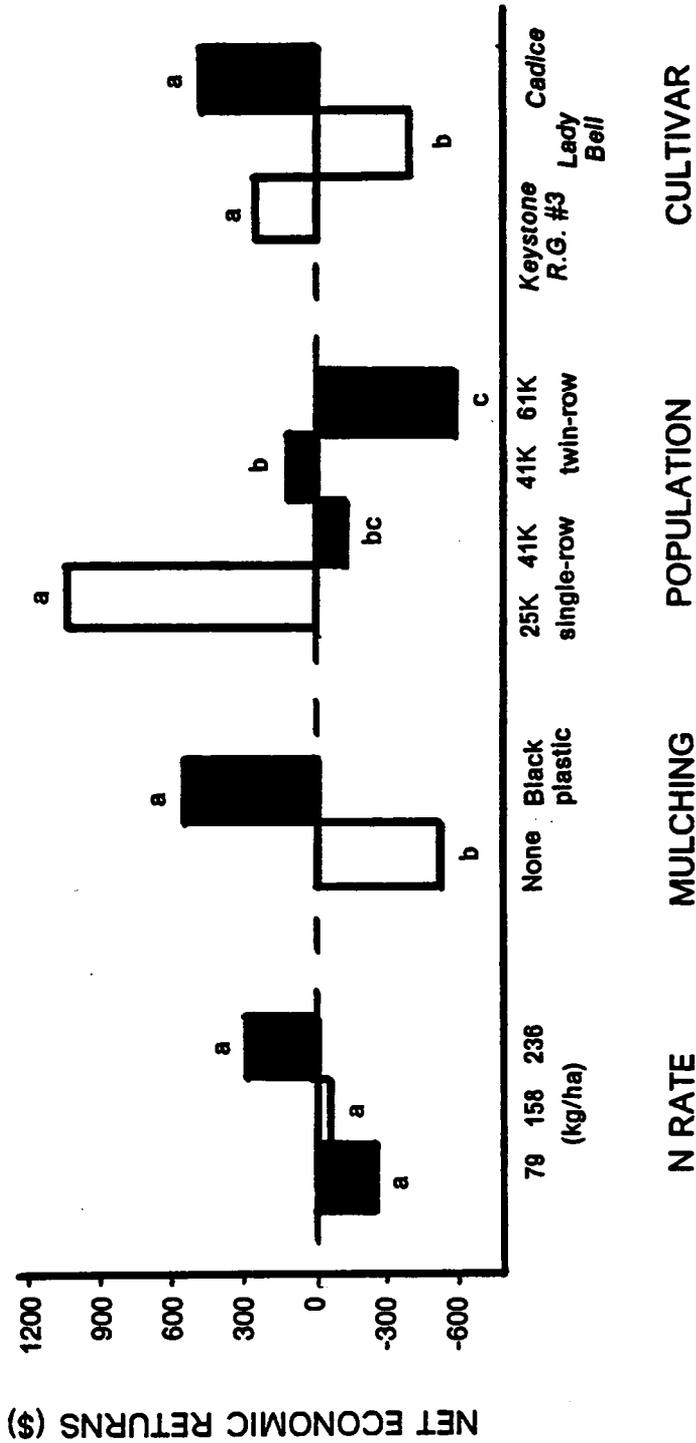


Figure 7.4. Effect of traditional and introduced treatments on the net economic returns of bell pepper production in on-farm testing conducted in East Central Virginia, 1985. Plant populations are rounded to the nearest 1000 plants. Mean separation for each production factor was done using single degree of freedom contrasts, 5% level. Labor costs are not included; estimated labor needs are 360 hours/ha.

during the midday showed a remarkable difference in the turgidity of plants between the mulched and bare-ground plantings.

Plant Population

The effects of plant population on yield were non-significant in the 1985 testing ($p = .89$ for large pepper yield, and $p = .13$ for medium pepper yield). The higher costs associated with the higher population treatments, however, made the sparsest population treatment the most economical (Figures 7.2, 7.3, and 7.4).

Discussions with the farm families identified a strong preference for the single-row patterns of planting. Many of these farm families raised tobacco (which is raised in single-rows), and they preferred not having to adjust their cultivating equipment as they went from their tobacco fields to their pepper planting. With this in mind, the trials in 1986 concentrated on determining the most desirable in-row spacing for single-row systems.

Results from these trials showed the 41 cm spacing to be clearly superior, both in terms of large pepper yields and net economic returns (Table 7.1). Closer plant spacings (20 and 31 cm) also produced high yields per unit area, but intra-plant competition significantly impacted on both the fruit size and the individual plant production at these spacings. Indeed, the 20 cm spacing produced more small fruits than any other spacing (Table 7.2). With respect to net economic returns, the higher input costs of these relatively dense populations made them the least economical.

Table 7.1. Effect of in-row plant spacing, per hectare, on bell pepper production in East Central Virginia, 1986.

In-row spacing (cm)	Plant population (plants/ha)	Yield			Net econ. ² returns (\$/ha)
		U.S. Fancy & U.S. #1 (boxes/ha)	U.S. #2 (boxes/ha)	U.S. #3 (boxes/ha)	
20	46,110	28.6 b ¹	19.6 a	20.2 a	657 c
30	30,740	24.8 b	18.2 a	8.0 b	994 bc
41	23,050	42.4 a	21.8 a	5.8 b	3396 a
51	18,440	21.4 b	18.6 a	5.0 b	1325 bc
61	15,370	27.2 b	20.2 a	8.0 b	2162 ab
Significance		**	NS	***	**

¹Labor costs not included. Estimated labor needs are 360 hours/ha.

²Mean separation in columns by Duncan's Multiple Range Test, 5% level.

NS, *, **, *** Non-significant (NS) or significant at the 5%, 1%, or 0.1% level, respectively.

Table 7.2. Effect of in-row plant spacing, per plant, on bell pepper production in East Central Virginia, 1986.

In-row spacing (cm)	Plant population (plants/ha)	Yield		
		U.S. Fancy & U.S. #1 (fruits/plant)	U.S. #2 (fruits/plant)	U.S. #3 (fruits/plant)
20	46,110	0.96 c [*]	0.65 c	0.67 a
30	30,740	1.24 bc	0.91 bc	0.40 b
41	23,050	2.83 a	1.46 ab	0.39 b
51	18,440	1.79 b	1.55 a	0.42 b
61	15,370	2.71 a	2.02 a	0.80 a
Significance		***	***	***

*Mean separation in columns by Duncan's Multiple Range Test, 5% level.

NS, *, **, *** Non-significant (NS) or significant at the 5%, 1%, or 0.1% level, respectively.

In contrast, the wider plant spacings (51 and 61 cm) were found to be relatively economical. The high productivity of the individual plants, as well as the low input costs of these wide spacings were responsible for their cost-efficiency.

The 41 cm spacing, however, seemed to be ideal in all respects. Its high yields and net economic returns per unit area indicate that this spacing provides for the most efficient utilization of sunlight, soil moisture, soil nutrients, and the applied inputs in production. As shown in Table 7.2, this spacing did not suffer from intra-plant competition. In fact, its superior yields over the 51 cm spacing indicates that plants spaced 41 cm apart actually complement each other in their growth and development. This may be due to numerous reasons, including an increase in the shading of the soil, which reduces both heat and the evaporation of soil moisture. It is also likely to involve an increase in the shading of fruits within the canopy of the plant row, which reduces the incidence of sunscalding.

Cultivar

In the 1985 research, *Cadice* outyielded both *Keystone Resistant Giant #3* and *Lady Bell*, the latter by a significant margin (Figures 7.2, 7.3, and 7.4). The high susceptibility of *Lady Bell* to blossom end rot substantially reduced its yields, particularly in the early season. The fruit quality of all 3 cultivars were judged to be fine for marketing, but some concerns were raised as to the elongated fruit shape of *Cadice*.

In 1986, these 3 cultivars were joined by 26 others in extensive cultivar testing on area farms. These trials identified 14 cultivars with satisfactory yield and fruit quality characteristics (Table 7.3). Among these cultivars, *Gator Belle* was the most impressive. Its yields were outstanding throughout the summer, both at the NTDF (Table 7.3) and in on-farm testing (Table 7.4). Moreover, its fruit quality was excellent, with fruits being large, blocky, 4-lobed, smooth-skinned, and bright green.

The highest yielding cultivar in the trial was *Giant Ace*. The yields of this cultivar, however, were only average during the early summer drought, and it wasn't until the arrival of the late summer rains that this cultivar showed its tremendous yield potential. Indeed, the yields of *Giant Ace* during the late season were outstanding, and furthermore, the quality of its fruit was judged to be fine for marketing.

The cultivar which showed the greatest resistance to the drought was *Midway*. Its vigorous vines produced the heaviest yields during the early season dryness. The fruit quality of this cultivar, however, warrants concern, as its fruits are rough-skinned, and also have a squarish, rather than a smooth blocky shape.

Summer Sweet 860 also performed well in the trial. The plants of this cultivar were especially vigorous and healthy, and its fruits were perfectly shaped. The immature green fruit color of this cultivar, however, is not as dark as preferred.

Bell Captain produced high yields, but there is some concern that its fruits may be more elongated than desired. *Crispy* was the heaviest yielder of marketable fruits in the trial. However, the local marketing cooperative currently places a premium on large peppers, and the fruits of this cultivar are generally not large enough. Although

Table 7.3. Relative maturity, marketable yield, net economic returns, and fruit quality of "satisfactory" bell pepper cultivars grown at the Nottoway Teaching/Demonstration Farm in East Central Virginia, 1988.

Cultivar	Relative ^z maturity	Marketable yield		Net econ. ^y returns (\$/ha)	Fruit ^x quality
		U.S. Fancy & U.S. #1 (boxes/ha)	U.S. #2 (boxes/ha)		
Giant Ace	ME	1625 ab ^w	653 abc	7302 a	Good
Gator Belle	M	1544 abc	442 bc	6339 abc	Excellent
Midway	E	1310 abcd	724 ab	6034 abcd	Satisfactory
Summer Sweet 880	M	1164 abcde	525 bc	4801 abcdef	Good
Bell Captain	ME	1157 abcde	352 bc	4286 abcdef	Good
Crispy	E	1127 abcde	1083 a	6180 abcd	Satisfactory
Pro Bell II	ME	952 abcde	538 bc	4028 abcdef	Satisfactory
Emerald Giant	L	930 abcde	423 bc	3427 abcdef	Satisfactory
Keystone R.G. #3	L	834 bcde	474 bc	3127 abcdef	Good
Lady Bell	E	820 bcde	461 bc	3023 abcdef	Satisfactory
Jupiter	E	805 bcde	314 bc	2545 bcdef	Good
Skipper	M	805 bcde	673 abc	3543 abcdef	Good
Grande Rio 66	L	805 bcde	621 abc	3400 abcdef	Satisfactory
Pip	M	710 cde	461 bc	2512 bcdef	Excellent
Significance		***	***	***	

^zE=early, ME=medium-early, M=medium, L=late.

^yLabor costs not included. Estimated labor needs are 360 hours/ha.

^xFruits which are large, blocky, 4-lobed, and bright dark green were considered excellent. Satisfactory fruits are marketable, but have some characteristic which warrants concerns. Good fruit quality is intermediate between the two.

^wMean separation in columns by Tukey's HSD Test, 5% level.

NS, *, **, ***Nonsignificant (NS), or significant at the 5%, 1%, or 0.1% level, respectively.

Table 7.4. Marketable yield and net economic returns of bell pepper cultivars grown on farms in East Central Virginia, 1986.

Cultivar	Marketable yield		Net econ. ² returns (\$/ha)
	U.S. Fancy & U.S. #1 (boxes/ha)	U.S. #2 (boxes/ha)	
Gator Belle	675 a ¹	399 b	2177 a
Keystone R.G. #3	478 ab	341 b	1098 ab
Early Calwonder	445 ab	173 c	477 bc
Bell Boy	412 abc	365 b	858 ab
Yolo Wonder L	357 bc	601 a	1217 ab
Cadice	181 co	202 c	-668 c
Significance	*	***	**

¹Labor costs not included. Estimated labor needs are 360 hours/ha.

²Mean separation in columns by Duncan's Multiple Range Test, 5% level.

NS, *,**,***Non-significant (NS) or significant at the 5%, 1%, or 0.1% level, respectively.

Crispy may not be appropriate for commercial plantings, this cultivar would be a fine choice for the home garden.

The performances of *Pro Bell II*, *Emerald Giant*, *Skipper*, *Grande Rio 66*, and *Jupiter* were satisfactory for yield and fruit quality characteristics, but not noteworthy. Researchers, however, were impressed by the fruit quality of *Pip*. The fruits of this cultivar were blocky and a pleasing color of dark green, maturing to a bright scarlet.

Among the 2 traditional cultivars, *Keystone* was judged superior to *Lady Bell* in early yield, overall yield, and fruit quality characteristics. With respect to fruit quality, the fruit of *Keystone* were large, blocky, and dark green in color. The fruit size and shape of *Lady Bell* fruits were also of good quality, however, they turned red rather quickly. This characteristic would be desirable for a red pepper market, but for the more stable green pepper market, this quick reddening reduces the flexibility of growers in the timing of their harvests.

Fifteen cultivars were deemed unsatisfactory, 10 due to their inadequate production of large peppers. These cultivars, listed from highest to lowest yielding, are *Tasty*, *California Wonder 300*, *Florida VR-2*, *Valley Giant*, *Bell Boy*, *Golden Bell*, *Resistant Giant #4*, *Yolo Wonder L*, and *Golden Calwonder* (Table 7.5).

The fruit quality of some cultivars was also judged to be unsatisfactory. The fruit of *Pro Bell*, *Greene Belle*, *Tasty*, and *Golden Calwonder* were generally too small for marketing. The fruit of *Tambel 2* were judged as unsatisfactory due their unattractive, mottled reddening pattern. The fruit of *Golden Bell* were also unacceptable, as they were often elongated, curled, and twisted. The fruit of *Yolo Wonder L* were undesirably small and pointy, and the fruit of *Gedeon* were more pendant than blocky.

Table 7.5. Relative maturity, marketable yield, net economic returns, and deficiencies of 'unsatisfactory' bell pepper cultivars grown at the Nottoway Teaching/Demonstration Farm in East Central Virginia, 1988.

Cultivar	Relative ^a maturity	Marketable yield		Net econ. ^b returns (\$/ha)	Deficiency ^c
		U.S. Fancy & U.S. #1 (boxes/ha)	U.S. #2 (boxes/ha)		
Bell Boy	ME	520 de ^w	634 abc	2108 cdef	UY
Cadice	ME	1369 abcd	570 bc	5879 abcde	SMS
California Wonder 300	M	659 cde	468 bc	2292 bcdef	UY
Early Calwonder	E	668 cde	455 bc	2290 bcdef	STMV
Florida VR-2	M	659 cde	468 bc	2292 bcdef	UY
Gedeeon	L	1815 a	173 c	6851 ab	UFQ
Golden Bell	E	600 de	641 abc	2501 bcdef	UY, UFQ
Golden Calwonder	M	293 e	557 bc	839 f	UY, UFQ
Greene Belle	M	725 cde	775 ab	3430 abcdef	UFQ
Pro Bell	M	798 bcde	589 abc	3277 abcdef	UFQ
Resistant Giant #4	L	388 e	320 bc	623 f	UY
Tambel 2	M	959 abcde	500 bc	3777 abcdef	UFQ
Tasty	ME	674 cde	820 ab	3340 abcdef	UY, UFQ
Valley Giant	M	608 de	327 bc	1662 def	UY
Yolo Wonder L	M	366 e	634 abc	1394 ef	UY, UFQ
Significance		***	***	***	

^aE= early, ME= medium-early, M= medium, L=late.

^bLabor costs not included. Estimated labor needs are 360 hours/ha.

^cUY = unsatisfactory yield, UFQ = unsatisfactory fruit quality, SMS = susceptible to moisture stress, STMV = susceptible to Tobacco Mosaic Virus.

^wMean separation in columns by Tukey's HSD Test, 5% level.

NS, **, ***, **** Nonsignificant (NS), or significant at the 5%, 1%, or 0.1% level, respectively.

Among the other unsatisfactory cultivars, *Cadice* was identified in the on-farm testing to be highly susceptible to moisture stress (Table 7.4). *Early Calwonder* was declared unsatisfactory due to its susceptibility to Tobacco Mosaic Virus, a potential problem in this tobacco-producing area.

7.4. Recommendations

The following recommendations may be made after 2 years of testing on area farms:

Nitrogen Rate

Although the differences among the 3 N rates evaluated (79, 158 and 236 kg/ha) were non-significant, the positive response of the plants to higher N rates cannot be totally dismissed. The low rate in the trial, therefore, cannot be recommended at this time, and farm families would be well advised to continue using the current recommendation rate of 146 kg/ha.

Besides the application rate, the timing and the source of N in these fertilizations are also critically important. Since peppers utilize little N before fruit set, growers should follow the recommendation of the VCES and apply only 56 kg/ha before fruits are set. But once fruits are set, it is imperative that applications of calcium nitrate are worked into the soil immediately. This will satisfy the great demand for N that plants have at this time, and also reduce the incidence of blossom end rot.

Mulching

Even though BPM provides for higher yields and net economic returns, its high cost precludes it from being recommended to the traditional farming operations of the area. For the larger-scaled operations, however, the utilization of BPM may be a justifiable expense, and it warrants further testing.

This justification for future BPM testing is based on the stable market for bell pepper. As time passes on, growers can better predict the strength of this market, and then respond accordingly. If the market remains strong, limited-resource farm families could also be able to profit from the use of BPM if the cooperative purchased the mulching in bulk for its members, and also if low-interest loans were made available to these families.

Plant Population

A single-row pattern with an in-row spacing of 41 cm is strongly recommended. This spacing is both the highest yielding and the most economical of all the plant populations evaluated in this research. Families on especially tight budgets may find the 61 cm row spacing more appropriate, as it will provide for good yields and is 33% less expensive than the recommended spacing. Wider in-row spacings remain to be tested.

With respect to the other plant populations, the single-row patterns with in-row spacings of 20 or 30 cm are not suitable, as they reduce fruit size and significantly

decrease net economic returns. The twin-row patterns are neither economical nor do they suit the crop management systems of area farms.

Cultivar

Gator Belle and *Keystone Resistant Giant #3* are recommended. *Gator Belle* produced heavy yields in the trials, both at the NTFD and on the 2 area farms. Its fruit quality is excellent. With respect to *Keystone*, it is a proven performer in the area. Its vigorous plants consistently produced good yields of fine quality fruit. In fact, this cultivar outyielded the other commonly-planted cultivar of the area, *Lady Bell*, at all locations in both years of testing. In the case of *Lady Bell*, discussions with area growers indicate that it should only be planted on farms with irrigation and fertile, well-limed soils. Its noted susceptibility to blossom end rot adds credence to these discussions.

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8. FUTURE VEGETABLE RESEARCH

The technological advances made in this FSR/E project mark only the beginning of what must be a long-term commitment to the development of vegetable production technology for small farms in East Central Virginia. It is the purpose of this chapter to assist these future efforts by noting a few areas of vegetable research which remain to be addressed.

8.1. Cherry Tomato Research

Reducing Transplant Costs

The unpredictable market for cherry tomato and the limited resources of most farm families make it imperative that production costs are held to a minimum. As shown in Appendix B, approximately 55% of the standard production costs for cherry tomato comes in the purchasing of transplants. This expense may be substantially reduced

if farm families grow their own transplants. Using the same methods as they use in growing their tobacco transplants, growers could grow their own tomato transplants and reduce their total production costs by approximately 15-25%, depending on cultivar (see Appendix C)(9). This has already been successfully done by one of the farm families in the trials.

In this testing, super-imposed trial designs (11) may be used to evaluate plant establishment, maturity, and yield characteristics of the home-grown transplants versus those transplants purchased from the greenhouse. Bare-root transplants purchased from a regional distributor may also be included in this study. Similar research is recommended for bell pepper production, where it could also lead to reductions in transplant costs (see Appendix C).

Fertilizer Trials

The tobacco growers of the area have found that their crops respond favorably to sidedressings of 15-0-14. Since cherry tomato is in the same botanical family of tobacco, it may also respond favorably to this fertilizer. A second experiment could evaluate the benefits of sidedressing on different soil types, using the recommended rate of N (90 kg/ha).

Cultivar Testing

Castlette should be compared with *Small Fry* in large-scale, on-farm testing. Since most newly-developed cultivars produce fruit which are too large for the identified market, there may be no other cultivars which warrant testing at this time.

8.2. Bell Pepper Research

Besides the previously mentioned trial concerning home-grown transplants, there are two additional areas of research that need to be addressed: cultivar testing and the control of blossom end rot.

Cultivar Testing

On-farm testing is recommended for *Gator Belle*, *Keystone Resistant Giant #3*, *Giant Ace*, *Bell Captain*, *Skipper*, and *Jupiter*. All these cultivars have performed well in cultivar trials conducted throughout the state (14), including those of this project. Besides this on-farm testing, it is recommended that all 14 cultivars which performed satisfactorily in the 1986 trials be evaluated again at the NTFD. This on-station research might also include some cultivars which have not yet been evaluated in the area. These include *Galaxy*, *Liberty Belle*, *Ma Belle*, *Memphis*, *New Ace*, *Park Whopper*, and *Ringer* (1, 6, 10).

It should also be noted that today's consumers are looking for color and variety in their foods. With this in mind, there are numerous bell pepper cultivars which produce unusually-colored fruits. The research in 1986 showed *Summer Sweet 860* to be the class of the yellow-fruited bell peppers, but the cultivars *Gold Crest*, *Golden Summer*, *Honeybelle*, *Marengo*, and *Orobelle* have yet to be evaluated (1, 2, 5, 6). Among other novelty cultivars, the fruits of *Purple Belle* turn purple, the fruits of *Chocolate Bell* turn brown, and the fruits of the 1988 All-America Award Winner *Mexibell* have a mildly pungent taste (1, 4, 6).

Controlling Blossom End Rot

The first setting of fruits in the pepper plantings of these counties are commonly damaged by blossom end rot, all but eliminating the early harvest. This rot is largely caused by the deficiency of calcium in the cellular walls of fruit tissue. This deficiency may be remedied by farm families through the use of sidedressings of calcium nitrate fertilizer and/or foliar sprays of calcium. Both these practices warrant investigation.

In a broader context, the incidence of blossom end rot is related to moisture stress. Since calcium is transported to the plant roots through diffusive processes within the soil solution, its deficiency is often associated with the inadequacy of soil moisture. Irrigation, therefore, is a useful strategy in lessening the incidence of this rot. Irrigation equipment, however, is lacking on most farms in the area. Indeed, only 7.1% of the area's farms, and only 2.8% of those family farms with gross sales of \$10,000 or less (which represented 63.4% of the area's farms) had irrigation

equipment in 1982 (13). This lack of irrigation on small farms in the area may preclude these family operations from participating in the expanding vegetable production industry of East Central Virginia. Thus, irrigation systems which are inexpensive and simple to operate need to be developed and tested for the area's limited-resource farms.

The incidence of blossom end rot may also be associated with the strong acidity of the area's soils. Calcium ions become less available to plants as soil pH decreases below 7.0 (7). Since most soils of Nottoway and Lunenburg Counties have natural pH's ranging from 4.5-5.5, liming will be a necessary practice if the incidence of this rot is to be reduced.

8.3. Additional Vegetable Research

Liming Trials

All vegetables which are commercially grown in the area (bell pepper, cherry tomato, standard tomato, broccoli, onion, muskmelon, cabbage and okra) prefer a soil pH which is higher than what is naturally found in the soils of these counties. Liming, therefore, should become a standard practice for vegetable farms in the area. It is proposed that a large research plot be initiated at the NTDF to evaluate the effects of liming. The soil pH's in these replicated treatment plots at the site may be adjusted to various levels (pH's of 4.4, 5.0, 5.6, and 6.2 are recommended), and a variety of vegetables subsequently planted under each pH.

Sweet Corn

The production of sweet corn may be the most viable alternative for those independent growers who are dissatisfied with the current status of the marketing cooperative. Sweet corn is one of the most popular fresh market vegetables, and it lends itself well to direct marketing. Indeed, markets for this crop may be established with local grocery stores and through farmers' markets. Roadside stands may also be set up on busy roadways.

At this time, the growers of the area plant *Silver Queen*, a white-kernel cultivar that is renown for its fine taste. But this traditional cultivar is among the latest maturing of all sweet corn cultivars, and therefore, does not take advantage of the strong early-season market for this crop.

Recent advances in plant breeding have led to the development of numerous high quality cultivars which are earlier ripening. Cultivars which may deserve testing include *Chalice*, *How Sweet It Is*, *Platinum Lady*, *Quicksilver*, *Silverado*, *Snowbelle*, *Summer Sweet 8601*, *Summer Sweet 8701*, and *White Lightnin* (1, 2, 4, 5, 12, 14). Many of these cultivars possess supersweet genes, which provide for higher sugar contents and a slower conversion of sugars to starches in the kernels after harvesting. There are also numerous yellow- and bicolor-kernel cultivars which may be evaluated, depending upon grower preference.

Lastly, it should be noted that the production of sweet corn is just one of many alternatives to bell pepper and cherry tomato production that the area growers have. The NTDF annually conducts demonstrations in the production of numerous vegetable crops. It is recommended that these efforts be continued.

Gardening Trials

Nationwide, approximately 60% of rural families, and 75% of farm families raise a garden (8). These gardens provide a good supply of high-quality, nutritious food at low cost to families.

It is proposed that gardening research be directed at the low-income families in the area to improve the status of their nutrition. This concern seems to be justified, as the residents of the area suffer from high incidences of poverty (which leads to malnutrition), and infant mortality (often the result of maternal malnutrition).

Working with the Expanded Food and Nutrition Education Program (EFNEP) agents in Nottoway County, these families could be readily identified and interviewed. In these interviews, information may be gathered on the nutritional needs of the area, food preferences, and the current gardening practices. The subsequent research may introduce new vegetable crops, identify superior cultivars, and improve general gardening skills. This type of research has already been successfully implemented in the state (3).

To be most effective, it is recommended that these efforts be accompanied by the establishment of a gardening cooperative for low-income families. This cooperative could purchase seed in bulk, and then distribute it at reduced cost to low-income families. Fertilizers and canning materials could also be distributed through this cooperative.

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SECTION III.

POLICY CONSIDERATIONS IN SMALL FARM DEVELOPMENT

9. POLICY IMPLICATIONS OF PROJECT RESEARCH

Besides the production data analyses, there are additional findings from this vegetable research which may have implications in the broader context of rural development. These findings concern institutional linkages, communicating with small farm families, experimental design, and marketing. Each of these subjects are briefly addressed in this chapter.

9.1. Institutional Linkages

The weak linkage between the research and Extension components of the Virginia land-grant system was quite evident in the beginning of this project. For although the project generated \$75,000 of funds for project activities, the Extension personnel were initially hesitant to participate. This carried on into the FSR/E workshop in January

1985, when the District Extension personnel were generally not receptive to the FSR/E presentations.

In this workshop, it was clear that Extension personnel did not understand the FSR/E approach. Some staff did not perceive the differences of FSR/E with current Extension approaches. Others were skeptical of the FSR/E demand for low-input farming systems (for example, one agent asked "Does this mean that we will be putting up fences for sheep which are old and have holes in them?"). The emphasis in commercial production in the workshop caused the local EFNEP personnel to wonder why they were even invited to attend.

This lack of understanding among the research and Extension personnel continued into the first year of research trials. The project meetings that year were marked with tension and arguments. In addition, it was common for Extension personnel to sit together around one corner of the table, separating themselves from the researchers.

Looking back, Extension had reasons to be hesitant in working with the project. First of all, these local Extension agents had spent their whole careers in these counties, and they did not know what effect this project might have on their reputations. Or, to put it another way, these agents were concerned that the failure of this project would hurt the rest of their programs. Secondly, the management of the marketing cooperative had not gone as well as expected, causing much frustration among all project personnel.

But despite all these misunderstandings, a relationship began to form between the researchers and Extension staff. From the perspective of the researchers, they gained an appreciation for the resource constraints that Extension staff operate

under, the need of Extension agents to document tangible results in their work, and the importance of these agents to community development.

From the perspective of Extension, these people genuinely appreciated the research efforts of the university scientists. The Extension personnel developed an acceptance for the project, and then actively supported its work. This support was evident when the Extension agents gave the project a large plot of land at the NTDF, when they asked the vegetable research coordinator to speak at the Extension Field Day activities at the NTDF, and when they participated in presentations to Government agencies and visiting guests.

The linkage between the 1862 and 1890 institutions was also more strongly forged through the project's activities. The project itself had begun when Virginia State University (VSU) received funds from the the Office of International Cooperation and Development. This 1890 institution, however, did not have the human resources needed to conduct this research. Virginia State reached out to its land-grant partner, Virginia Polytechnic Institute & State University (VPI&SU). The relations between these institutions, partly because of the good relationship among the institution leaders, was excellent.

9.2. Reaching Out to Small Farm Families

The selection of the farm families for the on-farm testing was the responsibility of Extension, and therefore, the farm families who participated in the project are a reflection of their clientele. Among the families selected for this research project,

most were not small farm operators. This was despite the fact that the objective of this project was to serve small farm families, and that small farm families represent 85% of the farms in the area (7).

In addition, the majority of the participating farm operators were college-educated; this is despite the fact that 88% of the farm operators in the area have not attended college (6). These findings support the arguments that highly educated, medium- and large-scale farm operators are disproportionately served in Extension programs.

In the future, research projects directed at small farm development should utilize, but not limit themselves to Extension for the identification of participating families. Feed store owners, community leaders, local social service agencies, and religious groups should also be contacted. Researchers can also find the farm families themselves by driving through the countryside.

The researchers in this project also experienced the difficulties that Extension staff face in reaching out to small farm families. Small farm operators were more likely to work off the farm during normal working hours (and even sometimes at night), necessitating researchers to work unconventional hours. In addition, the small farm families were more reluctant to attend the only educational/social program of this FSR/E project, the awards banquet at the end of each year. The absence of these families at the banquets were due to family commitments, night-time employment, the lack of transportation, and a sense of being uncomfortable in this social setting.

Although the small farm families were somewhat difficult to work with, they were also among the best participants. Indeed, when the market for cherry tomatoes deteriorated in 1985, nearly all of the small farm families continued to manage and

harvest their plots. The operators of the larger-scaled farms, however, were more likely to abandon their tomato plots and tend to their other farm enterprises, typically tobacco.

This difficulty in reaching out to small farm families has been remedied in numerous states through the use of paraprofessionals (4). In this project, the paraprofessionals were found to be valuable in three ways. First, they helped to identify new small farm families for the research trials. Being residents of the local area, the paraprofessionals had numerous contacts with the farming community. With the support of the Extension agents, the paraprofessionals identified small farm families for the second year of testing.

Second, the paraprofessionals helped researchers to communicate with the farm families. In this regard, the female paraprofessional was especially helpful in facilitating conversations between the farm wives and the male researchers.

Third, the paraprofessionals helped to improve communications between the researchers and Extension personnel. As employees of their Extension units, the paraprofessionals could keep the Extension agents informed on the daily activities of the project.

9.3. Experimental Design

As shown in Appendix F, the proposal of Extension for the vegetable research in 1985 was both thorough and simple. It called for the testing of numerous production factors through a series of small, independent experiments.

Researchers in this project took this proposal and built upon it. With the assistance of the Head of the Department of Statistics at VPI&SU, complex factorial designs were conceived and utilized. The main advantage in using these factorial designs was the ability to analyze the interactions among the factors, including the farm by treatment interactions. In addition, these factorial designs provided for an evaluation of all experimental treatments at all farms (1).

But these designs also had their disadvantages. First, these designs were quite fragile in the sense that when the trials at some farms failed, the analysis of the whole experiment became extremely complicated. Secondly, these designs were quite confusing to the farm families (not to mention nearly all of the researchers). Indeed, none of the families had a real appreciation for all the factors and interactions being analyzed in the trials. Those farm operators who studied the trial designs at their farms could not understand why some treatments were planted on their farm, while other treatments were planted on other farms. The complexity of these high-order factorial experiments also inhibited the discussions of the trials between the farm families and researchers.

Different approaches in experimental design were taken in the second year of testing. Randomized complete block designs were used, and there was a reduction in the number of treatments in the experiments. The farm families were also more involved

in the designing of the trials, and they were permitted to select from a menu of experiments they developed with the researchers and Extension.

These new approaches helped to make the experiments easier to understand, thereby facilitating conversations between the project personnel and farm families. In addition, these designs were found to be very resilient, as the failure of research on one farm did not jeopardize the analysis of the whole experiment.

With respect to other experimental design considerations, the utilization of a field station, in this case the Nottoway Teaching/Demonstration Farm (NTDF), was found to be useful for numerous reasons. First, the availability of labor and irrigation equipment at this site increased the likelihood that analyzable data would be obtained. Second, the experimental plots were found to be useful in educating the regional farming community on the project's activities. And third, the utilization of this station permitted the testing of risky treatments that may not produce marketable fruit.

It was the farm families themselves who requested the use of this field station after the trials in 1985. In that year, the planting of two untested (and unsuitable) cherry tomato cultivars in the trials caused most of the fruit in these plots to be unmarketable. These cultivars had been tested at a vegetable research station on the sandy, coastal soils of Virginia, where they performed impressively. But research results from this area of the state, and for that matter from the mountainous region of the state where VPI&SU is located, are not necessarily a good gauge as to their probable performances in East Central Virginia. Indeed, the farms of the Nottoway/Lunenburg area have their own soils, climate, farming practices, and

markets. Therefore, the results from this research support the implementation of locally-based research.

These locally-based research efforts should include on-farm testing whenever possible. Indeed, the results of the research done at the NTDF were not always consistent with the results at the on-farm sites. For example, the yields of experiments at the NTDF were significantly greater than on the family farms ($p < .001$). The fertile soil, greater availability of irrigation and labor, and the excellent management of the trials by the NTDF staff contributed to the tremendous yields at this site. These excellent yields at the NTDF were impressive, but they were also misrepresentative of the yields that farm families are likely to attain.

In addition, there were some individual treatments that performed very differently at the NTDF as compared to on the family farms. For example, *Cadice* produced outstanding yields at the NTDF, but this cultivar's susceptibility to moisture stress was borne out in the on-farm tests, where it yielded poorly.

Farm families are very aware of the limitations of field station research, and thus, they are often hesitant in adopting technology which has not been tested on area farms. On-farm testing, therefore, can accelerate the adoption of new technology into the farming systems of a community. In the research of this project, *Gator Belle* performed well at both the NTDF *and* at the on-farm sites. This consistency led to its immediate adoption by the participating farm families the following year. In addition, Extension agents were also impressed by the performance of this cultivar, and recommended it to other cooperative members. Many of these growers accepted these recommendations and planted the cultivar the following spring.

In other experimental considerations, of all the production factors evaluated, the small farm families were most interested in cultivar testing. This testing is especially appropriate in small farm research, since: 1) the purchase of seed is a necessary expense, and 2) the selection of an outstanding cultivar may prove to be no more expensive than an unsuitable one. Furthermore, the rewards of this cultivar testing may be significant, as they were in this project. Indeed, the introduction of *Castlette* to the area increased the net economic returns in cherry tomato production by more than 40%. Likewise, the introduction of *Gator Belle* to the area increased the net economic returns in bell pepper production by 100%.

The fact that cultivar testing is generally not publishable in the professional journals underlies the fact that there are times when fulfilling the contemporary needs of farm families may not be in the best self-interest of a researcher. This calls for the modification of the existing reward system within the land-grant system, placing greater weight on Extension publications.

9.4. Marketing

Recent decades have brought about a profound change in agriculture. From a historical standpoint, the emphasis in agricultural research for centuries has been on increasing productivity. In fact, more than 250 years ago, author Jonathan Swift wrote on the importance of such agricultural research:

... whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together (5).

This statement was later paraphrased by the first president of the American Society for Horticultural Science, L.H. Bailey, who wrote that it was a responsibility of horticultural scientists to make two blades of grass grow where only one grew before (3).

But if the researchers of this project learned anything about contemporary farming, it is that the major concerns of farm families relate to marketing, not production. Or to put it another way, farm families do not need as much help in growing the blades of grass anymore, but rather in marketing the grass for a price that will provide them with an acceptable quality of life.

Cooperatives can be instrumental in strengthening the marketing power of small farms. They have been successfully established in the neighboring state of Kentucky (2), and their development should be a priority for the land-grant universities in Virginia.

As is the case for all small farm development efforts, the establishment of cooperatives will require a broad-based commitment from the land-grant system. Horticulturalists will be needed to improve the quality and marketability of vegetables, as they did in this project. Agricultural engineers are needed to develop low-cost irrigation systems, cooling facilities, and packaging technology for small farms. Farm management specialists may aid farm families in applying for credit and then using it wisely. Marketing and agribusiness specialists can help the cooperatives in their management practices. Social scientists are needed to identify the resources and motivations of farm families, and to improve communication among the project staff, farm families, and community leaders.

This chapter marks the beginning of this dissertation's discussion of policy considerations in small farm development. The following two chapters shall address this subject from a broader perspective, beginning with a discussion of how farm structure relates to the agricultural and food policies of the U.S. Government.

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10. AGRICULTURAL AND FOOD POLICY: CONSIDERATIONS

The agricultural and food policies of the U.S. Government are directed toward two major objectives: 1) the development of a stable, productive, and prosperous farm sector; and 2) the availability of nutritious food at reasonable cost to all consumers (26). These policy goals are certainly appropriate, but they have such a breadth of scope that they are not fully useful in developing Government programs. Accordingly, rural development planners in the USDA have established a framework of criteria from which to design agendas for future agricultural and food policies.

These criteria include:

1. the quality of life in rural communities;
2. the level of income for farm families;
3. the efficiency of food production;
4. the resiliency of production systems to adversity;
5. the sustainability of production systems; and
6. the nutritional well-being of the population (26).

The following is a discussion of the effect that farm structure has on these criteria.

10.1. Quality of Life in Rural Communities

In a landmark study evaluating the effects of farming scale on rural community development, Goldschmidt reported that the quality of life in a community surrounded by small farms was superior to that in a nearby community surrounded by larger, more industrialized farms in all measurable ways: higher median income, more small businesses and retail trade, more self-employment, less poverty, more and better quality schools, more public services, and more newspapers, civic groups, churches and parks (8). This 1944 study (the first and last USDA-sponsored study of its kind) was prematurely halted by the USDA, as the Department was pressured by the corporate farm lobbies to discontinue research (9). In 1977, however, state-supported researchers revisited the two communities, and found that the differences documented by Goldschmidt had become even greater (22).

Regional studies in the 1980's have since evaluated the effects of farm structure on the quality of life in rural communities. These reports indicate that the effects of the increasing scales of agriculture differ across regions. But, in general, it has been reported that:

1. Traditional farms support rural community development.
2. Medium-scale farms provide for the highest quality of life in communities that are highly dependent on agriculture, and where labor-extensive agricultural enterprises predominate.
3. Large-scale farms do not maximize the quality of life in any region of the nation. Furthermore, large farms often have a significantly negative impact on rural community development in those communities where labor-intensive agricultural enterprises predominate.

The following is an overview of the effects of farm structure on rural community development, by region:

CATF (California, Arizona, Texas and Florida). As agricultural production in this region becomes increasingly concentrated among large farm operations, there are reported to be increased incidences of poverty, substandard housing, and labor exploitation. Public institutions in large-farm communities, including the schools, recreational facilities, and police protection units, are also reported to be weaker than those found in traditional farm communities (13).

South. The coastal zone of this region has a "substantial potential" for experiencing those negative effects of structural change which are occurring in the CATF region. Throughout the South, dramatic increases in farm scale have been shown to have negative effects on the welfare of rural communities. Indeed, those counties which experienced the greatest rise in mean farm scale from 1970-1980 also suffered from the greatest rise in poverty. In addition, those Southern counties which experienced the greatest drop in farm families (often related to the expansion of large farm operations) also suffered from increases in unemployment, poverty, and decreases in median family incomes. It is also noted that medium-scale farms provide for the highest rate of employment (20).

A survey of rural communities in Alabama reported that those counties with a predominance of large farms had lower total agricultural production, lower median income for both farm families and hired farm workers, fewer paved roads, lower expenditures for public education, and more substandard housing than counties predominated by small farms (12).

Northeast. Although agriculture is a minor industry in this region, the increasing presence of corporate farms is reported to increase the incidence of poverty and decrease median incomes in rural counties (5).

Midwest. The major effects of structural change in the rural communities of this region likely occurred with the mass outmigration of farm families in the 1950's and 1960's. In more recent years, most indicators of social welfare have risen as farm structure increased from small, part-time farms to medium- and large-scale farms. Although not directly compared, it is hypothesized from existing data that medium-scale farm economies would lead to a higher quality of life than large-scale farm economies (6).

The presence of employment opportunities in the manufacturing and service sectors is reported to buffer the potentially negative effects of the increasing scales of agriculture in this region. But in the far western portions of this region, where local economies are highly dependent on agriculture, the increasing scales of farm operations are projected to reduce median income, decrease retail trade, and lead to outmigration (6, 23).

Great Plains & West. Current economies of scale and the lack of economic diversification in these communities favor the development of larger farming systems, especially in terms of farm size, if not farm sales. The lack of off-farm employment opportunities and the labor-extensive farm enterprises which are common in this region impede small farm development. In contrasting the remaining two farm classes, medium-scale farms are reported to promote social welfare more so than large-scale farms, since they provide for greater employment and more retail sales (7).

10.2. Income for Farm Families

The maintenance of a stable and prosperous farm sector requires the payment of acceptable levels of income to its workers. Historically, farm families have been willing to accept low returns for their work in return for the non-financial rewards of farming: worker independence, the opportunity to work in a natural setting, and the peacefulness of living in the country. In the 1980's, the earnings of farm families have remained relatively low: the median family income for farm families was \$21,853 in 1986, 22% less than the median family income of non-farm families, \$27,881 (25). This disparity of earnings between farm and non-farm families has widened from its 1979 level of 11%, reflecting the economic stress within the rural economy (24).

This increased disparity of earnings, however, does not necessarily call for public intervention. Indeed, farm operators have the freedom to choose other occupations if they wish to do so. Nevertheless, all working Americans should receive an adequate level of income to provide for the basic necessities of life. And, most certainly, public intervention is called for when:

1. working Americans are becoming increasingly impoverished;
2. their opportunities for supplementary employment are declining; and
3. public assistance programs are either not available or not being implemented.

All three of these justifications for intervention are today occurring in rural America, and the increasing scales of farming have played a significant role. First, in the case of farm poverty, large farm communities have been reported to have lower median family incomes and higher incidences of poverty than traditional farm communities

(8, 9, 12, 13). Second, in reference to supplementary employment, large farm communities support fewer local businesses, provide for less retail trade, and are more dependent on labor-saving technology in agricultural production. All these factors reduce opportunities for supplementary employment in rural areas. Third, in regard to the issue of public assistance, large farm communities are reported to have weaker public and private institutions (3, 8, 9, 13). Such institutions are essential in providing social services to low-income families.

10.3. Production Efficiency

The development of a farm sector that efficiently produces food is clearly in the best interest of society. However, the manifestation of much efficiency research to date, *ie.*, the development of capital-intensive technology, has often had negative effects on many farm families and rural communities, not to mention the environment. It is, therefore, the challenge of policymakers to balance the benefits of efficient farming systems along with their potentially negative impacts on rural society.

Economic studies have shown that most economies of scale in production may be achieved through a mechanized family farm operation (1, 26, 30). In fact, a review of the seven major crop farms in the U.S. showed that 90% of maximum economic efficiency in production may be obtained with 127 ha of cropland and farm sales of \$45,000. Maximum, 100% economic efficiency in this study was attained by a medium-scaled farm, with 468 ha of cropland and \$133,400 in farm sales.

Most recently, economic analyses have expanded production efficiency studies to account for such external factors as marketing, the purchasing of inputs, and access to credit. These studies report that these external factors cause the economies of scale in farming to increase further (21), but still primarily within the range of medium-scale family farms (30).

The development of farm scales which are larger than those needed to attain these levels of maximum efficiency are not likely to benefit society (26). And as previously documented in this dissertation, the quality of life in rural communities becomes lower through the development of large-scale agriculture. Therefore, it is questionable whether agricultural policies should support large-scale farms. The USOTA has already recommended eliminating direct payments and subsidies from the Government to these operations (30).

In looking to the future, it should be noted that the current economies of scale operating in U.S. agriculture are in large part due to the past focus of public research on capital-intensive, labor-saving, and non-sustainable technology. A redirection of public research on the development of appropriate technology for small farms may reduce the economies of scale, and thereby create a more pluralistic farm economy (26). This would help to revitalize rural communities while providing for an affordable supply of food to the general population.

10.4. Resiliency

Economic resiliency

The economic resiliency of the American farm has historically been linked to its utilization of farm-based resources (26). That is to say, the resiliency of a farm is strengthened by its access to those resources on the farm, including family members for labor, manures for crop fertilization, crops and livestock for dietary sustenance, and woodlands for construction and heating purposes. With respect to farm structure, small farms have a greater dependence on these farm based-resources than do larger-scaled farms, thereby adding to their resiliency.

Other factors that contribute to the economic resiliency of farms is their diversity of farm enterprises and income sources. The diversity of farm enterprises helps farm families survive a depressed market for any one particular farm product, as they have other enterprises to rely on. Small farms are generally diverse in their enterprises, again, contributing to their resiliency. In contrast, large-scale farms are renown for their specialization of production, since their large-scale, capital-intensive technologies require large tracts of land or large numbers of livestock in production to justify their expense. In this specialization of production, large farm operators may increase their profits, but they also decrease their resiliency in the process.

With regard to the diversity of income sources, small farm operators are more likely to work off the farm than large farm operators (27). This, again, contributes to their resiliency, especially when it provides for a source of income from outside the farm sector.

With respect to large farm operations, these farms are also economically resilient, but primarily for different reasons. For although these farms are more dependent on non-farm resources in production, they also have the financial resources needed to survive short-term economic adversities. These financial resources include a greater access to credit and a greater ability to self-finance farming operations. In addition, large farm operators have greater control over their marketing activities, since they are more likely to have established contracts with markets, and they also have better access to marketing information (11). Furthermore, large farm operators generally have non-farm skills, and would be likely to supplement their farm incomes with non-farm income if necessary. Finally, large farm operators also have the political linkages needed to effectively implement a political response to economic adversities.

In short, both small- and large-scale farm operations are economically resilient. It is, in fact, those intermediate-level farm operations which are least resilient. These medium-scale farms are less resilient than small farms because they are more dependent on non-farm resources in production, and they also have less diversity in their sources of income. In addition, the operators of medium-scale farms do not have the financial resources, non-farm employment skills, nor the political linkages of large farm operators. Indeed, it is this lack of resiliency among medium-scale farms that makes this class of farms the one in most decline. This, in turn, is fueling the polarization of the U.S. farm economy (30).

Natural resiliency

Besides economic resiliency, a stable farm economy calls for resiliency under natural disasters as well. The development of technology which promotes large-scale farming, *e.g.*, the mechanical tomato picker, has, in turn, led to the development of a geographically-concentrated, monoculturally-based farm sector (19, 30). Such developments increase the susceptibility of crops to regional natural disasters, including droughts or out-of season frosts. These developments also contribute to the build-up of large insect and disease populations, requiring greater dependence on the use of pesticides. The development of a traditional farm-based, geographically-extensive production industry may reduce the impact and likelihood of these natural catastrophes.

In addition, the geographic concentration of food production leads to the planting of crops with narrow genetic bases. This increases the vulnerability of a nation's food supply to natural disasters, especially insect or disease epidemics. In the 1840's for example, a common susceptibility of potato cultivars to leaf blight led to widespread famine in Ireland. In more recent times, the T cytoplasm epidemic in 1970 caused a 15% reduction in the production of corn in the U.S. (2). A traditional farm-based, geographically-extensive production economy would promote the planting of a wide array of genotypes, as growers would plant the most desirable cultivar for their particular agro-ecosystem. This, again, demonstrates the superior natural resiliency of a traditional farm economy.

10.5. Sustainability

The rising dominance of large farms in U.S. agriculture during the last 40 years has been largely accomplished through the substitution of renewable production inputs (e.g., human labor, crop rotations, and manures), with non-renewable ones (e.g., fossil fuels and commercial fertilizers). These non-renewable production inputs and the monocultural practices they support are largely responsible for the environmental degradation that is occurring today in rural America (26).

Looking to the future, the key to the development of a sustainable agricultural economy is the development of farming practices based on the utilization of renewable resources under intensive farm management. In the short term, a greater dependence on human labor may be necessary to increase sustainability, indicating the appropriateness of traditional family farms. The sustainable farms of today, including the "organic" and Amish-operated farms, are almost exclusively small-scale, family-operated farms. By the year 2000, the development of capital-extensive biotechnologies may allow for sustainable farming practices on somewhat larger scales (30).

10.6. Nutritional Well-Being

Factors affecting the nutritional well-being of American society include the availability, quality, and production of food. All these factors are affected by the structure of American agriculture.

Availability

The single greatest factor influencing the availability of food is that of cost. With respect to farm structure, large farms are currently more economically efficient than small farms, and therefore, are able to produce food at lower cost to consumers. Heady and Sonka (10) projected in 1974 that the development of a farm economy consisting solely of farms which generated at least \$40,000 in farm sales would reduce per capita food expenditures by 2.9%. To attain this estimate, these economists used a linear programming model that considered regional production practices, resource availabilities, input procurement, transportation costs, and consumer demands across the nation.

More recently, however, concerns have been raised that as the production, processing, and marketing of foods become increasingly concentrated, the adverse price-rising effects of monopolistic practices warrant policy consideration (26). The example of the mechanical tomato harvester supports these concerns. The introduction of this machinery to California increased production efficiencies, and led to the development of an industry that was concentrated among a few large-scale growers in California. But although these large farm operators were more efficient in producing the tomatoes than the previous smaller farm families, these savings were not passed on to consumers. In fact, consumer prices for processing tomatoes rose 111%, compared to 74% for other fruits and vegetables (18).

Nevertheless, it is generally accepted that a small farm-based economy would increase consumer food costs. Heady and Sonka estimated that a farm economy consisting solely of farms which generated \$10,000 or less in gross farm sales would lead to an increase in consumer costs by 3.6% per capita (10).

This dissertation, however, does not call for a farm economy consisting solely of very small farms, but rather one based on the development of small- and medium-scale family farms. But even using Heady and Sonka's extreme example of all farms generating \$10,000 or less in farm sales, this modest increase in food costs would be readily absorbed by most consumers.

In fact, there is evidence that consumers would be willing to accept higher food prices in order to support the development of small family farms. The polling organization of Lou Harris and Associates reported to the USDA that:

... the public's preference is for 'a country which has a relatively large number of small farms' ... Significantly, there is a broad-based consensus on this issue, with strong support in every region of the country and in every significant demographic subgroup of the population (26, p. 16).

It must be noted, however, that any increase in the cost of food would place those families living on marginal incomes at greater risk of becoming malnourished. As is, the Physician Task Force on Hunger in America reports that the incidence of hunger in the U.S. is increasing (17). But this organization further reported that the principal factor behind this increase was not the cost of food, but rather the weakening of social support networks.

Quality

As previously stated, half of all foods marketed in the U.S. have detectable levels of pesticides on them (2), with many of the pesticides being carcinogenic (15), and/or inadequately tested for their toxicities (14). This dependence on agricultural

chemicals in production is in part due to the development of a large farm economy with regional specialization and monocultural practices. The development of a smaller-scaled farm economy based on sustainable production practices may be a significant step forward in providing safe and nutritious food to American consumers.

Furthermore, the development of a large farm economy has contributed to a reduced percentage of food produced locally. For example, Virginia farms have been reported to produce only 40% of the fresh, and less than 25% of the processed, temperate-type fruits and vegetables consumed within the state (31). The remainder of the fruits and vegetables come mostly from large farms located hundreds to thousands of miles away in the CATF region. When the large farms in that region grow fruits and vegetables, there are often forced to pick their crops before they are mature so that they arrive in Virginia in acceptable condition. In harvesting these crops before their natural maturity, quality is generally reduced. In addition, these large farm operations must select those cultivars of fruits and vegetables which ship well (generally possessing hard rinds and bruise-resistant tissue), rather than those cultivars which are best tasting (generally possessing favorable texture and higher soluble solids). A locally-based, traditional farm economy would permit both a greater degree of natural ripening and a greater emphasis on freshness and quality.

Production

Technological advances and the rich natural resource base of the nation have made concerns over adequate food production in the U.S. negligible. In fact, many Government programs are aimed at lowering production levels. In reference to farm

structure, large farms are currently more productive than small farms. This is due to numerous reasons, including their greater physical and financial resources, superior managerial skills, Government policies, the development of capital-intensive technology, and greater attention from land-grant personnel.

Nevertheless, the successes achieved in small farm development programs indicate that small farms can be made more productive through land-grant intervention (16, 29). The future development of appropriate technology by land-grant researchers, in combination with supportive policies by Government policymakers would further contribute to the productivity of these farms.

In summary, a farm economy based on the development of traditional family farms may be in the best interest of the nation. This scale of economy would likely provide for a high quality of life in rural communities, an affordable supply of high quality food to all Americans, resiliency to economic and natural adversities, and serve as an appropriate scale of economy for sustainable practices.

The development of a traditional farm economy will require the resources and support of the land-grant system. The following chapter discusses the research needs of small family farms, which today account for 75% of the traditional farms in America (28).

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11. SMALL FARM RESEARCH AND DEVELOPMENT

The great diversity that exists among America's small farms has made the formulation of supportive research and development policies quite difficult. Thus, the USDA has chosen to concentrate its small farm development programs on those farms with the following characteristics:

1. The operating family or individual must rely on farm income for a substantial share of their livelihood. Hobby farms are excluded.
2. The operating family or individual must manage or control the farm business and must contribute the majority of the farm labor (except in peak seasons).
3. The family or individual income must be below the median nonmetropolitan income in the state where the farm is located (8).

Accepting this as the target group, the following is a discussion of issues pertaining to small farm research and development.

11.1. The Role of the Land-Grant System

The land-grant system was established in 1862 during the Lincoln Administration. Beginning as agricultural trade schools, these institutions strengthened their research functions through the establishment of state agricultural experiment stations. Through the passage of the Hatch Act in 1887, Congress authorized the public funding of these research stations, and specified that these funds be used to:

... aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science ... (20).

Over 100 years later, the Congressionally-defined objectives of these research stations have remained essentially intact:

It shall be the object and the duty of the State agricultural experiment stations ... to conduct original and other researches, investigations, and experiments bearing directly on and contributing to the establishment and maintenance of a permanent and effective agricultural industry of the United States, including researches basic to the problems of agriculture in its broadest aspects, and such investigations as have for their purpose the development and improvement of the rural home and rural life and the maximum contribution by agriculture to the welfare of the consumer ... (see Appendix G for a more complete listing of the original and present-day acts)(19).

The original justification for the public funding of agricultural research, its proponents contended, followed along President Abraham Lincoln's belief that it was the role of Government to reach out to those who cannot adequately serve their own basic needs:

The legitimate object of government, is to do for a community of people, whatever they need to have done,

but cannot do, at all, or cannot so well do, for themselves
- in their separate and individual capacities (7).

Along these lines, the supporters of the Hatch Act argued that, "The farmer's work is not big business ... and he needs the assistance of the government where business and commerce do not" (2, p. 96).

But today's large farm operations certainly are "big businesses," with the average large farm grossing over \$800,000 in sales, and earning nearly \$300,000 in annual net income (22). These farms have the resources and incentives to support themselves, and are not likely to need Government assistance for their sustenance. In addition, the predominance of these farming operations in rural communities generally detracts from, rather than promotes the "improvement of the rural home and rural life," which is specifically called for in the Hatch Act. Thus, it is questionable whether Hatch Act funds should be used to serve the needs of large farm operations. Indeed, the Superior Court of California has recently ruled that the land-grant research in the state was in violation of the Hatch Act. In his ruling, Judge Raymond L. Marsh ordered that research programs supported with Hatch Act funds must give "primary consideration" to the development of small family farms and rural communities (10, 15).

This court ruling reinforces the growing concerns of many agricultural leaders who believe that the land-grant system has lost sight of its mission. These authorities have called for the targeting of agricultural research efforts at satisfying the needs of traditional farm families, including small farm families (13, 19, 23, 24). Former Secretary of Agriculture Robert Berglund agrees with the redirection of public support, stating:

There is little to be gained for society in the continued displacement of either farm operators and farm workers, and that underwriting this displacement therefore should not be a focus of publicly-supported technological research and development Agricultural research, therefore, should be increasingly directed to the particular problems of the small and medium-sized farms (21, p. 151).

In this service to traditional farms, fundamental changes are needed in the approaches of land-grant research and extension. Existing approaches have land-grant staff concentrating their efforts on serving the most receptive farm operators (generally large farm owners), reasoning that the demonstrated benefits of new information or technology would lead to its subsequent adoption by other farm families. This approach favors the receptive operators, as they gain the immediate and substantive portions of the benefits from these technologies. In addition, this service to receptive operators, in turn, leads to the non-service of those families who do not have the sophistication, resources, social status nor political linkages to reach out for services (24).

Furthermore, as land-grant staff primarily communicate with large-scale growers, their research and extension programs come to reflect these operators' needs. The net results of these approaches have been the development of programs that contribute to the dominance of large farm operations (12, 24). Indeed, Secretary Berglund states that "The 'broadside program' approach, perhaps more appropriate in the past, is doing more to concentrate production than it is to protect the farm sector" (21, p. 143).

A redirection of services to traditional farm families shall require the development of programs which specifically address their needs. Thus, the trickle-down approach to

land-grant policies must be dismantled and replaced by alternative approaches that purposefully reach out to the target audience. In this regard, paraprofessional programs have effectively been used in the dissemination of appropriate information to small farm families (11). However, appropriate research strategies have yet to be widely implemented. FSR/E is a comprehensive approach to rural development that was specifically designed for serving the needs of small farm families. The following section describes the potential usefulness of this methodology in the future development of rural America.

11.2. The Value of FSR/E

The integration of FSR/E methodology into the land-grant system will lead to an improved level of service to small farm families. The most beneficial contribution of FSR/E to the system may be its emphasis on meaningful communication among researchers, Extension staff, and farm families.

Communication Between Researchers and Extension Staff

The communication between land-grant researchers and Extension staff is often lacking. Although Extension personnel are responsible to inform researchers as to the needs of their communities, their input carries little weight in the agendas of most land-grant researchers (1). This has consequently compelled the majority of Extension staff to conduct their own research programs (9). A consequence of these

research activities by Extension staff is that they have less time to fulfill their regular extension duties. Thus, this makes their efforts of reaching out to less receptive farm families all the more difficult.

With reference of FSR/E, the diagnostic techniques of its methodology may be especially useful in improving the communication among land-grant personnel. In this, the initial stage of FSR/E methodology, project members work together to identify the needs of farm families in the target area. In doing so, research and Extension staff team up to interview farm families, review secondary sources of information, and discuss perceived needs of the target area.

If done properly, these exercises would be a learning experience for many researchers. For as the farm population dwindles and researchers becoming increasingly specialized within their own disciplines, there is an increasing likelihood that agricultural scientists neither have a farm background nor understand the operations and concerns of traditional farm families.

Furthermore, these exercises will improve the communication among researchers of different disciplines. Current approaches of land-grant research have led to a narrower focus of research within disciplines, and thus, a neglect of the social and economic considerations in technological development. In this regard, FSR/E methodology calls for the integration of the biological, social, and economic sciences in agricultural research and development efforts. This multi-disciplinary approach is certainly warranted, for just as the problems facing farm families today have many facets, so too must be the solutions to these problems.

Communication Between Land-Grant Staff and Farm Families

Busch and Lacy concluded in their survey of land-grant scientists that, "There is a surprising lack of concern for contemporary agricultural issues among agricultural scientists ..." (1, p. 233).

This lack of concern has contributed to the development of a farm sector in which:

1. the majority of farm families lose money in farming activities (22);
2. a disproportionately high amount of farm families live in poverty (18); and
3. the development of technologies which at times do more to displace farming operations than to serve them (4, 15).

FSR/E methodology calls for scientists to work directly with farm families in the designing and testing of research. In these research activities, scientists and farm families work together to implement the testing of potential interventions for the area's farms. By conducting research in the farm families' fields, the family members are more likely to communicate freely with research scientists. This communication is essential in the development of appropriate, useable technologies for these families.

Indeed, in working directly with farm families and requesting their input into the research process, FSR/E shows respect to the knowledge of farm families. It might only be through this respect that farm families respond to research activities, and that relevant technologies may be developed.

In a similar way, by acknowledging the importance of the household in farming activities, FSR/E also shows respect to the role that farm women and children play on farms. A recent national poll of farm women documented that 55% of these persons considered themselves to be a "main operator" of the farm (6). However, the communication of agricultural scientists with farm women is not likely to occur for many reasons, including the male dominance of research positions in agriculture.

This awareness of the role of women on farms is long overdue and still incomplete, but it is nevertheless a positive step in understanding the farming operations of traditional farm families. Indeed, many family farms today could not survive without the contribution of farm women in production activities, off-farm employment, and in the care of the household.

11.3. Research and Extension Needs of Small Farms

Typology

A greater understanding of the status and needs of small farms is needed to formulate appropriate public policies. Data on the following characteristics are needed at national, state and local levels:

Physical Resources: enterprise mixes, farm machinery, and inputs used in production.

Natural Resources: land quality and quantity, land type (cultivated, fallow, pasture or forest), water resources, and wildlife.

Financial Resources: farm income, total income, availability and use of credit, availability of off-farm employment, savings, resource ownership, equity, tenancy, cash flow patterns, liquid assets, and debt to assets ratios.

Human Resources: allocation and availability of family labor, farm management skills, non-farm skills, level of formal education, age, and health.

Motivations: short- and long-term objectives in farming, abilities to train for meaningful off-farm employment, and communication with public agencies (3, 8, 16, 24, 25, 26).

Evaluation of Public Policies

Research is needed to evaluate the distributive impacts of public policies on the farm classes. The effects of the various Government programs on the farm classes should be determined. In all cases, predictive impacts of these programs need to be made to assist in future policymaking efforts (3, 8, 25).

Similarly, research should be done to assess the effects of land-grant policies on the structure of the farm sector. Studies are needed to evaluate how the policymaking, funding, and promotion operations of land-grant institutions affect the various farm classes (8).

Marketing

Research and Extension programs should give greater attention to the marketing, transportation, and storage of agricultural products grown on small farms. The main thrust of this effort should be the development of strong organizations to assist farm families in their marketing operations. As was the case of the Southside Growers Association, the land-grant system may be a valuable asset in numerous ways: bringing small farm families together, assisting them in receiving credit, and providing the cooperative with technical assistance in marketing activities.

Special efforts must also be made to establish farmers' markets within urban areas. These efforts should ensure that these marketplaces are the domain of farm families rather than dealers, and that the commodities sold are locally-grown.

Land-grant personnel should assist growers in developing pick-your-own operations. In addition, listings should be developed of groceries and public institutions which purchase locally-grown products, and of commodity brokers who handle small accounts (5, 8, 21, 27).

Financial Management

Small farm families need assistance in first establishing, and then achieving their financial goals in farming. These families would particularly benefit from training in record-keeping techniques.

Efforts also need to be made to increase the communication of small farm operators with credit lending institutions, especially the FmHA. In addition, farm families should be informed of the availability of credit from other lending institutions, public or private. Furthermore, programs should be developed which inform farm families of the procedures required for the application for credit, as well as ways to use credit most wisely.

Farm families must also receive more information and technical assistance regarding their participation in both federal farm programs and social welfare programs (5, 24).

The Development of Appropriate Technology

Research and extension strategies should be oriented toward the development of technologies that will strengthen the viability of small farms. The developed technologies must take into account the physical, financial, and human resource limitations of these farming operations.

Priorities in these research efforts should focus on the reduction of production costs, the decreased utilization of non-farm inputs, and a lesser reliance on capital in production. In addition, technologies should be developed to minimize the dependence on non-renewable resources in production, and to maximize the compatibility of farming systems with the environment (21). In all research programs, the input of small farm families should be present in the design and implementation stages.

With reference to mechanical technology, versatile equipment should be developed for use on small land areas. This machinery should be inexpensive, simple in design, free of unnecessary gadgets, and easy to maintain. If possible, this machinery should be produced and maintained in rural areas, helping to create local employment opportunities (14).

With reference to agro-biological technology, research in both the applied and basic sciences are needed to reduce dependencies on capital, non-renewable energies, and poisonous chemicals in production. Special efforts need to be made in horticultural research, since the production of horticultural crops is most dependent on these inputs. The following chapter discusses the current directions of horticultural research, and proposes a sampling of research topics that will serve the interests of rural society.

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12. HORTICULTURAL RESEARCH FOR RURAL SOCIETY

The small farms which raise horticultural crops would benefit from those research agendas described in the preceding section. It is the purpose of this section to discuss the current directions of horticultural research, and to propose a greater orientation of research toward social concerns.

12.1. Current Directions of Research

In his recent ASHS Presidential Address, *Horticulture, Science, and Society*, Dr. Jules

Janick states:

We horticulturalists are the original humanists who believe that our science is only useful if it is useful. We are people-oriented. We do not believe in science for science's sake, but science for humanity's sake (8, p. 13).

With all due respect to Dr. Janick, these inspirational words are not borne out by the research activities of most horticulturalists. In fact, horticultural researchers are generally not people-oriented in their approaches to research:

First, in reference to the design of research agendas, horticulturalists are no different from other agricultural scientists in that they place peer evaluation and professional publications over the demands of farm families and the input of Extension staff (5).

Second, in reference to the perceived objectives of research, horticulturalists state that they value agricultural productivity, the development of knowledge, plant protection, and production efficiency over the people-oriented goals of the USDA (Table 12.1)(5). These people-oriented goals (listed in Table 4.1) relate to improving the nutritional status and well-being of Americans, assisting rural Americans in improving their quality of life, and promoting community development.

It should be noted that this orientation of research is by no means limited to horticulturalists. In fact, as shown in Table 12.1, this orientation is commonly shared by other scientists in the agricultural disciplines associated with the production of food (5). Indeed, only basic scientists are less people-oriented in their approach to research, and basic research is becoming an increasing focus of horticultural research today.

Third, a review of 1404 sessions at National ASHS meetings from 1978-1987 reinforces the lack of people-orientation in horticultural research:

- For every session focused on serving the immediate needs of people (e.g., education, extension, socio-horticulture, human nutrition, home horticulture, horticultural therapy, women's issues), there were more than 10 sessions focused on agro-biology.

Table 12.1. Perceived goals of researchers, by academic discipline, 1983.

Goal	Horticulture	Other agro-biological sciences	Basic sciences	Social sciences
Development of knowledge, methodology	5.5 a²	5.6 a	5.9 a	5.6 a
Increase agricultural productivity	5.7 a	5.1 ab	4.0 c	2.2 d
Increase production efficiency	5.1 a	4.5 abc	3.1 e	1.8 f
Improve human nutrition and welfare	3.6 bc	3.4 bc	3.7 b	3.4 bc
Increase rural level of living	3.6 bc	3.3 bc	2.4 d	5.7 a
Development of rural communities	2.8 bcde	2.5 bcdef	1.8 g	5.7 a

¹Mean scores based on a 7 point scale (1 = no importance, 7 = highest importance).
For differences among rows, $p < .001$; for differences among columns, $p < .01$.

²Mean of agronomy, animal science, entomology, environmental sciences, and plant pathology.

Source: (5).

- For every session focused on the nutrition of people, there were 4 sessions focused on the nutrition of plants. The disparity in research presented in these sessions were significantly greater, with 10 times more research presented on plant nutrition as compared to issues pertaining to human nutrition.
- With further regard to nutrition, the increased incidence of human hunger in the nation was not focused on in a single session. Furthermore, whereas there were literally hundreds of sessions discussing the use of chemicals in horticulture, there were 0 research sessions focusing on the threats that these chemicals pose to consumers and farm families.
- There were over 50 sessions focused on the anatomical structure of plants. In contrast, there were 0 sessions focused on the changing structure of horticultural farms and its impact on rural communities.
- Out of more than 1400 sessions there were 0 sessions focused on small farm development, 0 sessions focused on rural community development, 0 sessions focused on the rise in rural poverty, 0 sessions focused on labor displacement, and 0 sessions focused on labor exploitation. Likewise, discussions pertaining to the displacement of farm families by land-grant technologies were also absent (2).

Although it is certainly appropriate for horticultural researchers to concentrate on plant growth processes, their neglect of the sociological impacts in technological development may be improper. Indeed, the current peer-orientation in horticultural research suggests that scientific research may at times be conducted for the sake of science, with its impact on humanity receiving less consideration. Similarly, the orientation toward productivity and efficiency in horticultural research has led to the development of technologies that tend to favor the large farm operations and may harm traditional farm families and rural communities.

The current orientation of horticultural research also seems to be contrary to the land-grant system's mandate to serve the common farm family and rural society. Indeed, when the Superior Court of California found that the land-grant university of the state was in violation of the Hatch Act, the negative social effects of the university's fruit and vegetable research were the major evidence presented by the prosecution (12).

In looking to the future, the integration of the social sciences into horticulture would likely lead to a greater orientation of research toward serving the contemporary needs of farm families. Indeed, social scientists are significantly more oriented toward rural community development, and without sacrificing the pursuit of knowledge (Table 12.1). The following section discusses research topics where the integration of the social sciences into horticulture would be effective in serving the needs of rural society.

12.2. A Sampling of Relevant People-Oriented Issues

Human Nutrition

As previously stated, 20 million Americans go hungry regularly every month, and 500,000 American children are malnourished (11). With respect to horticulture, fruits and vegetables are lacking in many of these hungry persons' diets. Indeed, a study of those families entering the EFNEP in Virginia shows that only 30% of the families consumed the recommended amount of servings for fruits and vegetables upon

entering the program. This percentage was the lowest of all four food groups evaluated in the study (3).

Vegetables are excellent sources of vitamins A and C, iron, and calcium. Low-income households are especially susceptible to the deficiencies of these nutrients in their diets (1), and home gardens have been shown to be an effective strategy to remedy these deficiencies (4, 9). Home gardens have also been shown to have a net economic benefit to families. Therefore, gardens may be used to improve both the social and economic welfare of needy families, as well as to increase the resiliency of small farms (7, 18).

With respect to appropriate research, efforts must be made to improve extension delivery systems to low-income families, to make land available for gardening, and to reduce production costs. Furthermore, agro-biological research needs to focus on the identification of nutritious vegetables which are productive, able to grow under low-input systems, and are acceptable to local dietary habits.

Besides these efforts in gardening research, the distribution of fruits and vegetables to low-income families also needs to be addressed. The supply of fresh fruits and vegetables are chronically low in community food banks and food distribution centers (11). And yet, fruits and vegetables are left rotting in the field if they are slightly blemished or misshapened, or if commodity prices are low. Innovative distribution schemes of fruits and vegetables (e.g., gleaning programs) need to be further developed and documented.

With reference to food safety, there has been inadequate attention directed toward the impacts that chemical-intensive practices have on consumer health. Related to

this discussion is the fact that horticulturalists need to give greater respect to organic production practices and to the development of sustainable farming systems. This has certainly been lacking in the discussions at the National ASHS meetings. For example, in the 1979 meetings there were over 150 presentations discussing the use of chemicals in research and production. However, a tour to a farm practicing sustainable agriculture practices, in this case an Amish farm, was deemed appropriate for spouses and children. From 1978-1987, there was not a single session in the National ASHS meetings which focused on organic production practices (2).

The current dependence on non-renewable resources and pesticides in horticultural crop production not only threatens the health of consumers but it also threatens the health of farm families and farm workers. Furthermore, the development of farming systems dependent on these chemicals favors the capital-rich large farms, disfavors small family farms, and may reduce the quality of life in rural communities.

The Structure of Horticultural Farms

From 1978-1986, there was a 20.9% decline in the number of horticultural farms in the United States. This rate of decline was 3.0 times the rate of decline for other crop farms, which was 7.0% (13, 16).

The cause of this decline was not due to a depressed market. Indeed, the cash receipts for horticultural commodities rose 28.9% over this time period, compared to a 13.9% rise in cash receipts for other crops (15, 16). Rather, this decline in the

number of horticultural farms is due to the increasing presence of corporate and large-scale farming operations.

In the case of corporate farming, the number of horticultural farms controlled by corporations rose 15.4% from 1978-1982 (13, 14). In 1982, corporations controlled 8.6% of horticultural farms and 30.5% of the farmland. In comparison, corporate farms specializing in other field crops accounted for only 2.5% of farms and 10.1% of farmland (14). With regard to large-scale farming, these farms generated 76.0% of horticultural sales in 1986, more than double the percentage for other crop farms, 36.9% (16).

The general consequence of this increasing presence of corporate and large farms, as described in Chapter 10, is a lowering of the quality of life in rural communities. The negative effects of increasing farm scale are most pronounced in the CATF region, where approximately 60% of horticultural production occurs (14). In this region, the USOTA reports that as farm scales go beyond the size manageable by farm families, there are increased incidences of poverty, substandard living conditions, and labor exploitation. In those counties of this region with the greatest concentration of large farms, up to 70% of the population live in poverty and up to 40% live in houses without plumbing (10).

As bad as these developments are, the future looks even bleaker for most family farms raising horticultural crops. The USOTA projects that from 1982-2000 the nation will lose approximately 50% of those farms which gross less than \$200,000 in farm sales (17). Ninety-two percent of horticultural farms fell within this category in 1982 (14).

The suffering that this displacement is currently inflicting on these common farm families does not have to continue. Indeed, through the development of appropriate technology for traditional farms and the enactment of favorable Government policies, these family-based operations may be protected. But this will require a change in the orientation of horticultural research, away from short-term economic efficiency and toward rural community development.

The Social Impacts of Biotechnologies

Whereas mechanical harvesting technologies revolutionized horticultural production in the 1970's and 1980's, it is likely that the development of agricultural biotechnologies will similarly have an impact on horticulture in the future. The USOTA projects that advances in plant breeding and genetic engineering will allow for a reduced dependence on capital expenditures in the agricultural production of the 21st Century (17). Possible breakthroughs in these research efforts include the development of non-leguminous crops which fix atmospheric nitrogen, the control of weeds through natural allelopathic mechanisms, and greater genetic resistance to diseases and insects through the recombination of genetic material within and between plant species.

These advancements which reduce the capital-intensive nature of production could be of tremendous benefit to limited-resource farm families. However, it is currently projected that these biotechnologies will not be used by most of these families, and that these scientific advancements will most likely displace many of them. The USOTA projects that biotechnologies will be used by 70% of large farms, but only by

40% of medium farms, and 10% of small farms. Moreover, most of the economic benefits of these biotechnologies will go to those large farm operators who have the financial resources and managerial skills to readily and effectively incorporate these technologies into their production operations (17).

This projected demise of small farms does not have to occur. For just as horticulturalists had the opportunity to learn from the experiences of the mechanical harvesting of agronomic crops, so too will they have the opportunity to learn from the experiences of another agricultural discipline, in this case animal science. For the USOTA projects that within the next decade biotechnologies will be developed for livestock which will dramatically increase milk and meat production, and will increase the leanness of meat (17). Again, these developments will not be without their impacts on rural society, which at this point are not certain.

While the biotechnologies of horticultural science are still in the development stage, special efforts may be made to understand the impacts that these technologies will have on rural society. Accordingly, research programs may be directed to serve the best interests of traditional farm families and rural communities.

Methodologies which assess the potential impacts of land-grant research on rural society have been developed (6). In fact, this methodology led to the sole article published in the professional horticultural journals which addressed the social impacts of mechanical harvesting (see Chapter 4). This methodology may be used to develop biotechnologies which are affordable, easily managed, minimize the need for purchased inputs in production, and maximize ecological compatibility and sustainability.

12.3. Final Comments

It has been the purpose of this dissertation to discuss those issues pertinent to the development of small farms. The characteristics of these farming operations have been described, and particular attention has been directed toward those factors which are constraining their development. Included among these factors are economic forces, Government policies, marketing limitations, racial discrimination, and the land-grant system. With respect to the latter, this dissertation has documented the system's inadequate service to small farm families and the lack of social orientation in its research.

In looking to the future, the development of small farms will depend on the redirection of public policies away from the needs of large farm operators and toward those farms operated by traditional farm families. Land-grant research will have to lessen its orientation toward peers, short-term economic efficiency and productivity, and increase its orientation towards rural community development and providing for the basic needs of farm families. In this service to rural society, the small farm family will only be served if researchers place their emphasis on the human value and dignity of farm families rather than on their potentials for increased productivity. Furthermore, there must be a strong and genuine commitment to addressing the contemporary needs of farm families. This commitment shall require the following:

- The redirection of funds away from the current 'broadside approach' of research to that which is specifically targeted toward the development of traditional farms and rural communities.
- The integration of farm families, community leaders, and Extension staff into the research process.
- The design and implementation of site-specific, on-farm research.

- A change in the reward system of the land-grant system, rewarding researchers and Extension staff for serving the contemporary needs of rural society.
- Increased emphasis on multi-disciplinary research, and less emphasis on disciplinary specialization. With respect to horticultural research, all horticulturalists, whether they work in applied or basic science, should work with rural sociologists to assess the social impacts of their research programs.
- The development of new technology, and the adaptation of existing technology for use on small farms.
- Increasing the marketing power of small farms through the development of cooperatives and direct marketing channels.
- The development of programs which locate impoverished rural families, identify their basic human needs, and then fulfill these needs.
- The development of effective credit delivery systems to small farm families through the FmHA.
- The formulation of public policies which support the development of traditional farms. Land-grant staff may take the initiative in these efforts by identifying the needs of these farms, evaluating the impact of existing policies, and then assisting in the formulation of future policies.

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SECTION IV.

SUMMARY

13. SUMMARY OF FINDINGS

13.1. The Development of Small Farms

Nearly three out of four farms in the United States are small in scale and operated by families. Although these operations are quite diverse in their characteristics, they generally have low levels of financial, physical, and human resources. The families who live and work on small farms do not net substantive earnings from farming, and thus, they are highly dependent on off-farm income for their welfare. One-third of these families live in poverty, and the number of small farms is expected to decline by 30-40% from 1982-2000.

The development of small farms is currently constrained by Government policies, marketing limitations, racial discrimination, and inadequate land-grant support. With respect to the latter, less than 10% of land-grant research is directed toward small farm development, and less than 20% of research is *people-oriented*. In contrast, the major emphasis of land-grant research is on short-term economic efficiency. This emphasis has led to the development of capital-intensive farming systems which are

increasingly dependent on non-farm inputs in production. This favors large farms, whose increasing presence in the farm sector has been shown to have a generally negative impact on rural community development.

In turn, these developments in agriculture disfavor traditional farms, whose presence has been shown to promote rural community development. Besides this attribute, traditional farms are productive, efficient, competitive, resilient, and serve as an appropriate scale of farming for sustainable production practices.

The development of a strong traditional farm economy will require an increased level of public support to small farms. Small farm programs have been shown to be effective means of increasing the agricultural productivity, earning capacities, and the general welfare of small farm families. They are also among the most effective anti-poverty programs. In addition, since small farm families spend a high percentage of their incomes within the local community, small farm programs are reported to promote rural community development.

FSR/E is a rural development strategy that is directed toward the needs of small farm families. In 1985, a FSR/E project was initiated by the Virginia State University, Virginia Polytechnic Institute & State University, and the Virginia Cooperative Extension Service (VCES). The target area of the study was Nottoway and Lunenburg Counties, located in East Central Virginia.

The farm economy of the target area was found to be based on the production of tobacco on small family farms. Although tobacco is generally grown in small plots, the farm families who produce tobacco are very dependent on the receipts they receive from this crop. The recent decline in the tobacco market, however, has many

of these growers looking for supplementary enterprises. The VCES has responded to these needs by supporting the development of a vegetable marketing cooperative in the area. It was the role of the FSR/E project to conduct on-farm and field station research on the two principal crops of the cooperative, cherry tomato and bell pepper. The following section describes the findings of this vegetable research.

13.2. Findings of Vegetable Production Research

Cherry Tomato Research

Irrigation. Under normal rainfall conditions, irrigation led to higher yields and net economic returns, but at non-significant margins. Although not tested during the droughty summer of 1986, the tremendous drop off in yield for that summer indicates that irrigation may be essential for the profitable and reliable production of cherry tomato.

Nitrogen Rate. Studies indicate that an application rate of approximately 90 kg/ha is most cost-effective. The higher N rate evaluated, 164 kg/ha, did not significantly increase yields. The study with a lower N rate, 56 kg/ha, was inconclusive, since the droughty weather of 1986 reduced leaching and N uptake that year.

Mulching. Black plastic mulch (BPM) and straw mulch (SM) significantly increased total yield compared to bare-ground plantings. Black plastic mulch also significantly increased early season yield. From an economic standpoint, however, the increased costs of these mulches eliminated their yield advantages.

Plant Population. The population level of 13,450 plants/ha provided for similar yields and net economic returns as the population level of 17,930 plants/ha.

Staking. There were no significant yield or economic benefits to the staking of determinate-vined cultivars. In fact, under droughty conditions, staking had a significantly negative impact on early yield and net economic returns, and a negative impact on total yield. Plantings on lighter soils were most susceptible to yield losses due to staking.

Cultivar. *Castlette* and *Small Fry* were found to be suitable for the area. Both cultivars were high yielding and had a high percentage of marketable fruit. When compared against one another, *Castlette* provided for higher total yield and net economic returns, and had fruit which were firmer, more crack-resistant, and slower to redden. *Small Fry* produced higher early yield, had smaller-sized fruit, and was more resistant to the root knot nematode.

Bell Pepper Research

Nitrogen Rate. In a comparison of three N rates (79, 158 and 236 kg/ha), there was a positive, but non-significant response to higher N rates. The current recommendation of the VCES, 146 kg/ha, is recommended. The problem with blossom end rot in the area suggests that the application of calcium nitrate fertilizer immediately after fruit set would be useful.

Mulching. Black plastic mulch provided for significantly higher yield and net economic returns in production. The conservation of moisture under BPM was found

to be most valuable in production. Large pepper yield increased 99%, and net economic returns increased by 45%. The cost of this technology, however, may be prohibitive to small farm families.

Plant Population. A single-row pattern with an in-row spacing of 41 cm was found most desirable. This pattern provided for high yields and maximum net economic returns. Wider in-row spacings may be appropriate for farm families on especially tight budgets. Closer in-row spacings reduced fruit quality and net economic returns. Twin-row patterns were neither economical nor did they suit the crop management systems of area farms.

Cultivar. An evaluation of 29 cultivars indicated that *Gator Belle* may be the superior cultivar for the area. This cultivar produced outstanding yields, and its fruits were of excellent quality. Other promising cultivars include *Giant Ace*, *Bell Captain*, *Summer Sweet 860*, *Jupiter*, and *Skipper*. Among those lines which have been traditionally planted in the area, *Keystone Resistant Giant #3* was found to be superior.

Future Vegetable Research

The objective of future cherry tomato and bell pepper research in the area should be on the production of high quality fruit at low cost to growers. Reducing transplant costs, cultivar testing, and the control of blossom end rot meets this objective. In addition, there needs to be research on the effect of liming on vegetable production, the development of alternative vegetable production enterprises (sweet corn looks

especially promising), and the implementation of gardening research for low-income families.

13.3. Policy Implications of Project Research

Besides the production data analyses, there are additional findings from the vegetable research which may have implications in the broader context of rural development. These findings include:

- The linkage between the research and Extension units of the land-grant system may be weak and open to misunderstandings. But these differences may be bridged to effectively serve small farm families.
- The 1890 institutions have inadequate resources to effectively serve small farm families. This calls for greater funding to these institutions, greater cooperation with the 1862 institutions, and the increased involvement of the 1862 institutions in small farm development.
- Many of the farm families who were selected by Extension to participate in this "small farm" project were college-educated operators of medium- and large-scale farms. These findings support the arguments that highly-educated, medium- to large-scale farm operators are disproportionately served in Extension programs. Future small farm research projects should utilize, but not limit themselves to Extension for the identification of participating families.

- Small farm operators were somewhat inconvenient to work with, but they responded well to research initiatives.
- Paraprofessionals were useful in improving communication among the researchers and farm families, and in identifying small farm families for future research. As Extension employees, they also helped to smooth out differences between researchers and Extension.
- Female project personnel were found to be especially useful in reaching out to farm women.
- Social scientists were helpful in increasing the project staff's awareness of the motivations and limited resources of small farm families. This shows the benefits of the multi-disciplinary approach to research and development activities.
- The input of Extension staff was found to be very valuable in the designing and implementation of research.
- Randomized complete block designs were found to be more resilient and easier to understand than incomplete block designs. The simplicity of these designs also brought about more substantive conversations between the researchers and farm families.
- The availability of a field station for research was valuable. The field station was useful for the screening of high risk treatments, and as an educational tool in regional Extension programs. In addition, the abundance of resources at the

station (e.g., irrigation and other needed farm equipment, high level of management skills, and fertile soils) ensured analyzable results.

- On-farm yields were significantly lower than field station yields. This calls into question the transferability of research results from field stations to family farms.
- On-farm testing identified deficiencies in new technology that were not borne out under the favorable conditions of the field station.
- The exemplary performance of technology in on-farm testing seemed to accelerate its rate of adoption by farm families.
- On-farm testing promoted communication between farm families and researchers. This led to the testing of more appropriate, low-input vegetable production technology in the second year of testing.
- Cultivar selection had the greatest impact of all production factors evaluated. Since cultivar tests are generally not publishable in professional journals, this underlies the fact that there are times when fulfilling the contemporary needs of farm families may not be in the best interests of researchers. This calls for a modification of the reward system, placing greater weight on Extension publications.
- Marketing is the major concern of most farm families. Thus, the development of cooperatives and direct marketing channels for small farm families should be a priority of land-grant research. Appropriate vegetable production technology for

small farms should maximize product quality, but within the limited resource base of these farms.

APPENDIXES

Appendix A. Methods for Field Data Conversion

Cherry Tomato

Volumetric measurements were used in on-farm testing. Farm families were provided with 2 quart containers. Field measurements were then converted to flats/plot, with 6 quarts of fruit making up a flat (12 pint boxes). At the Nottoway Teaching/Demonstration Farm, the availability of a reliable scale allowed for the weighing of yields. Each flat weighed 5.11 kg.

Bell Pepper

Fruits were first graded out and then counted for each treatment plot. Sixty peppers of the U.S. Fancy and U.S. #1 grades were used to fill a box (1.11 bushel). Seventy peppers were used to fill a box of the U.S. #2 grade, and 80 peppers were used to fill a box of the U.S. #3 grade.

In all vegetable experiments, data were converted from yields/plot to yields/ha, using appropriate conversion factors.

Appendix B. Partial Budgets for Vegetable Production

B.1. Cherry Tomato

Costs of Standard Practices:

Item	Unit	Quantity	Unit costs (\$)	Total costs (\$)
<u>Operating Costs:</u>				
Greenhouse transplants	plant	13,450	0.05	672.50
Fertilizers:				
N (NH_4NO_3)	kg	90	0.66	59.40
P	kg	160	0.51	81.60
K	kg	160	0.26	41.60
Lime	MT	1.2	22.00	26.40
Sprays:				
Treflan herbicide	liter	0.8	7.66	6.13
Bravo fungicide	liter	7.6	6.87	52.21
Machinery (see next page):				
Fuel, oil, repairs	\$			30.39
Subtotal	\$			970.23
Operating interest	\$		6.00%	58.21
<u>Fixed Costs:</u>				
Machinery (see next page)	\$			66.88
Land charge	\$	1976	6.00%	118.56
<u>Total Cost:</u>	\$			1213.88

Machinery Costs (using 40 HP tractor):

Implement	Time used (hrs/ha)	Operating Costs		Fixed Costs	
		per hour (\$)	total (\$)	per hour (\$)	total (\$)
Plow	2.47	4.44	10.97	7.58	18.73
Disk	1.24	4.28	5.31	11.13	13.80
Harrow	0.74	3.38	2.50	6.96	5.15
Fertilizer spreader	0.49	3.63	1.78	7.81	3.83
Sprayer	2.47	3.98	9.83	10.27	25.37
Subtotal (Standard Costs)		30.39		66.88	
Mulch layer	10.00	3.78	37.80	11.13	111.30

Additional Treatments and Their Costs:

Item	Unit	Quantity	Unit costs (\$)	Total costs (\$)
Mulching:				
Black plastic (1.22 m X 1219 m X 1.25 ml)	roll	6.72	89.60	602.11
Mulch layer (see Machinery Costs)				158.10
Straw	bale	247	2.00	494.00
Irrigation:				
Garden hose (16 mm X 30.48 m)	hose	7	13.20	92.40
Soaker hose (9.14 m)	hose	1	8.25	8.25
Electricity	\$			50.00
Staking:				
Stakes (5 cm X 5 cm X 1.50 m/5 years)	stake	716	0.50	358.00
Binder twine	kg	112	1.10	123.26

Marketing Costs and Revenues:

Transportation costs	\$0.30/flat
Cooperative costs:	
Membership fee	\$25.00
Commission costs	15% of sales
Commodity sales price	\$3.80/flat

Sources: (1, 5, 7, 11).

B.2. Bell Pepper

Costs of Standard Practices:

Item	Unit	Quantity	Unit costs (\$)	Total costs (\$)
<u>Operating Costs:</u>				
Greenhouse transplants	plant	23,050	0.05	1152.50
Fertilizers:				
N (NH_4NO_3)	kg	90	0.66	59.40
($CaNO_3$)	kg	65	1.43	92.95
P	kg	160	0.51	81.60
K	kg	160	0.26	41.60
Lime	MT	1.2	22.00	26.40
Sprays:				
Treflan herbicide	liter	0.8	7.66	6.13
Orthene insecticide	liter	7.0	16.50	115.50
Bravo fungicide	liter	7.6	6.87	52.21
Machinery (see next page):				
Fuel, oil, repairs	\$			75.99
Subtotal	\$			1704.28
Operating interest	\$		6.00%	102.26
<u>Fixed Costs:</u>				
Machinery (see next page)	\$			111.30
Land charge	\$	1976	6.00%	118.56
<u>Total Cost:</u>	\$			2036.40

Machinery Costs (using 40 HP tractor):

Implement	Time used (hrs/ha)	Operating Costs		Fixed Costs	
		per hour (\$)	total (\$)	per hour (\$)	total (\$)
Plow	2.47	4.44	10.97	7.58	18.73
Disk	1.24	4.28	5.31	11.13	13.80
Harrow	0.74	3.38	2.50	6.96	5.15
Fertilizer spreader	0.49	3.63	1.78	7.81	3.83
Sprayer	2.47	3.98	9.83	10.27	25.37
Transplanter	12.35	3.53	42.60	8.81	108.80
Subtotal (Standard Costs)		75.99		175.68	
Mulch layer	10.00	3.78	37.80	11.13	111.30

Additional Treatments and Their Costs:

Item	Unit	Quantity	Unit costs (\$)	Total costs (\$)
Mulching:				
Black plastic (0.91 m X 1219 m X 1.25 m)	roll	7.69	66.00	507.54
Mulch layer (see Machinery Costs)				158.10

Marketing Costs and Revenues:

Transportation costs	\$0.30/flat
Cooperative costs:	
Membership fee	\$25.00
Commission costs	15% of sales
Commodity sales prices:	
U.S. Fancy & U.S. #1	\$7.00/box
U.S. #2	\$4.80/box

Sources: (1, 5, 7, 11).

Appendix C. Partial Budgets for Transplant Production

Item	Unit	Quantity	Unit costs (\$)	Total costs (\$)
Operating Costs:				
Seed:	oz	4		
<i>Castlette</i> cherry tomato			62.50	250.00
<i>Small Fry</i> cherry tomato			32.81	131.24
<i>Gator Belle</i> bell pepper			32.81	131.24
<i>Keystone Res. Giant #3</i> bell pepper			1.69	6.75
Fertilizer:				
4-9-3 Water soluble	kg	22.72	0.22	5.00
Lime	MT	0.002	22.00	0.04
Sprays:				
Methyl bromide herbicide	kg	4.09	2.86	11.70
Disyston 15G insecticide	kg	0.30	2.47	0.74
Manzate fungicide	kg	0.45	4.40	2.00
Plastic cover (2.7 m X 30.5 m X 4 ml)	each	1	16.00	16.00
Nylon and cheese cover	each	1	55.00	55.00
Machinery (see next page):				
Fuel, oil, repairs	\$			3.27
Subtotal:	\$			
<i>Castlette</i> cherry tomato				343.75
<i>Small Fry</i> cherry tomato				224.99
<i>Gator Belle</i> bell pepper				224.99
<i>Keystone Res. Giant #3</i> bell pepper				100.50
Operating Interest:	\$		6.00%	
<i>Castlette</i> cherry tomato				20.63
<i>Small Fry</i> cherry tomato				13.50
<i>Gator Belle</i> bell pepper				13.50
<i>Keystone Res. Giant #3</i> bell pepper				6.03

Item	Unit	Quantity	Unit costs (\$)	Total costs (\$)
Fixed Costs:				
Machinery (see below)	\$			6.26
Total Costs:				
Castlette cherry tomato				370.64
Small Fry cherry tomato				244.75
Gator Belle bell pepper				244.75
Keystone Res. Giant #3 bell pepper				112.79
Current Costs (all cultivars):				
Greenhouse transplants	plant	10,000	0.05	500.00
Operating Costs	\$		6.00%	30.00
Total	\$			530.00
Savings:				
Castlette cherry tomato				159.36
Small Fry cherry tomato				285.25
Gator Belle bell pepper				285.25
Keystone Res. Giant #3 bell pepper				417.21

Machinery Costs (using 40 HP tractor):

Implement	Time used (hrs/ha)	Operating Costs		Fixed Costs	
		per hour (\$)	total (\$)	per hour (\$)	total (\$)
Plow	0.30	4.44	1.33	7.58	2.27
Disk	0.20	4.28	0.86	11.13	2.23
Harrow	0.10	3.38	0.34	6.96	0.70
Hand sprayer	2.00	0.37	0.74	0.53	1.06
Total			3.27		6.26

Sources: (1, 2, 7).

Appendix D. Climate Data

Mean monthly temperature and precipitation in the growing season of Blackstone (Nottoway County), Virginia.

Month	Temperature (°C)			Precipitation (cm)		
	1985	1986	Normal	1985	1986	Normal
April	15.0	13.3	13.9	0.34	0.49	3.14
May	21.7	20.0	18.9	3.80	2.26	3.50
June	22.2	23.3	22.8	4.54	1.59	3.64
July	24.4	26.7	25.0	6.24	4.00	5.44
August	23.3	25.0	24.4	4.19	7.89	4.06
September	21.1	19.4	21.1	2.34	0.83	3.63
October	17.2	21.7	16.7	6.32	2.71	2.79

Source: (10).

Appendix E. Soil Characteristics of Test Sites

Six soil types were represented on the sites of the vegetable research. These soil types, unless otherwise indicated, are all deep soils that are gently sloping, well-drained, strongly acidic (pH 4.5-5.5), moderately permeable, moderate in their capacities to hold water, low in organic matter, and low in natural fertility.

Appling sandy loam (clayey, kaolinitic, thermic *Typic Hapludults*). The surface layer of this productive soil type consists of yellowish-brown sandy loam that is approximately 15 cm in depth. The subsoil consists of a yellow-red clay and sandy clay loam material, to a depth of 100 cm. Half of the land with this soil type is in cultivated crops, the remainder being in forests, hay, or pasture. This is the most common soil type in the Nottoway/Lunenburg area.

Caroline sandy loam (clayey, mixed, thermic *Typic Paleudults*). The surface layer is brown to yellowish brown in color, and is approximately 36 cm thick. The subsoil consists of yellowish-brown sandy clay and clay to the depth of 117 cm, below which is 35 cm of a mottled red, brown, and gray clay. Its pH is the most acidic of soils herein described, with natural pH levels not likely to exceed 5.0. This soil type has the potential to be the most productive type in the region, and most of the lands with this soil type are under cultivation.

Cecil sandy loam (clayey, kaolinitic, thermic *Typic Hapludults*). The topsoil of this productive soil type is generally a brown sandy loam that is 18 cm thick. The subsoil is composed of a red clay and clay loam material that goes to a depth of 115 cm. Approximately half of the land with this soil type is in woods, the remainder being in pasture, hay, and crops.

Georgeville loam (clayey, kaolinitic, thermic *Typic Hapludults*). The surface layer of this soil type is a dark brown loam approximately 13 cm thick. The subsoil is mostly red clay, clay loam, and silty clay loam, and its depth is 140 cm. The lands with this soil type are well suited for crops and hay, but most are currently in woods.

Iredell-Mecklenburg loam (fine, mixed, thermic *Ultic Hapludalfs*). This soil type, an association of the Iredell and Mecklenburg loams, has a topsoil consisting of a dark-grayish brown or olive loam that is 23 cm thick. The subsoil is a yellowish-brown clay 50 cm thick. This soil is different from the others in that its acidity is moderate (5.5-6.0), it has moderate levels of natural fertility, and it is less

permeable. Most of the land with this nonproductive soil type is wooded, with the remainder primarily in pasture or hay.

Madison clay loam (clayey, kaolinitic, thermic *Typic Hapludults*). The topsoil consists of a light yellowish-brown sandy loam. The subsoil is a reddish-yellow clay loam. This soil type is more difficult to cultivate than most, but it is well-suited for cultivated crops and hay. Most of the land with this soil type is in woods.

Sources: (3, 6).

Appendix F. Extension's Proposal for Research

Page 1 of proposal

FARMING SYSTEMS RESEARCH/EXTENSION SUGGESTED CLIENTS AND TRIALS

Lunenburg County

1. **Cookie Daniels:** Does not own any land. Raised 2 acres of green peppers in 1984 and did an excellent job. Also raises tobacco. Uses family labor in the vegetables as well as in the tobacco. Is willing to cooperate in the project and would do a very good job with a research trial on his farm particularly with peppers or market tomatoes. Has irrigation. No off farm employment.

Suggested Trial: Pepper and/or Market Tomato Trials

1. Variety Testing
2. Spacing

2. **Danny Austin:** Is buying his farm of approximately 200 acres. Raised a wide variety of vegetables in 1984 which totaled about 20 acres. Also raises approximately 12 acres of flue cured tobacco, however, this acreage amounted to about 40 acres 3 years ago. Does have irrigation. Using hired labor. No off farm employment.

Suggested Trial: Pepper Trials

1. Fertilization - Foliar Nitrogen
2. Variety Testing

3. **Bernard Maddux:** Owns about 40 acres of land. Raises hogs and several acres of tobacco. Also raises a little corn to feed the hogs. Does not have irrigation. Has raised a few vegetables in the past for local sales. Major drawback is lack of irrigation. Has sweet potatoes planted for 1985. His wife works off the farm.

Suggested Trial: Cherry Tomatoes

1. Trellised vs. non-trellised
2. Irrigated vs. non-irrigated

Note: Pages 2 and 3 list additional farm families who were suggested for the project to work with.

VEGETABLE TRIALS

- I. Green Peppers
 - A. Spacing
 - 1. Double row planting
 - 2. 8-10 inch in-row spacing vs. 15 inch
 - B. Fertilization
 - 1. One application vs. split applications
 - 2. Nitrogen trials including foliar application of nitrogen
 - C. Variety trials
 - a. *Belle Star*
 - b. *Cadice*
 - c. *Keystone Resistant Giant #3 and #4*
 - d. *Lady Bell*
 - e. *Other new varieties*

 - II. Cherry Tomatoes and Market Tomatoes
 - A. Spacing
 - B. Trellised vs. non-trellised
 - C. Use of trickle irrigation
 - D. Fertilization
 - 1. One application vs. split applications
 - 2. Use of 15-0-14 as compared to 16-0-0
 - 3. Foliar application of nitrogen
 - E. Use of black plastic with trickle irrigation
 - F. Use of black plastic w/o trickle irrigation
 - G. Variety testing
 - H. Recordkeeping
-

Source: (4).

Appendix G. Hatch Act

The Hatch Act of 1887 provided federal funds to the land-grant universities for the purpose of establishing agricultural experiment stations. Readers are directed to the first two sections of the legislation. These sections specifically define both the purpose of the act and the proposed objectives of land-grant research.

The complete version of the original act is presented below. This is followed by a listing of the first two sections of the act as they stand today.

The Hatch Act of 1887

CHAPTER 314. An act to establish agricultural experiment stations in connection with the colleges established in the several States under the provisions of an act approved July second, eighteen hundred and sixty-two, and of the acts supplementary thereto.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in order to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science, there shall be established, under direction of the college or colleges or agricultural department of colleges in each State or Territory established, or which may hereafter be established, in accordance with the provisions of an act approved July second, eighteen hundred and sixty-two, entitled "An act donating public lands to the several States and Territories which may provide colleges for the benefit of agriculture and the mechanic arts," or any of the supplements to said act, a department to be known and designated as an "agricultural experiment station:" *Provided,* That in any State or Territory in which two such colleges have been or may be so established the appropriation hereinafter made to such State or Territory shall be equally divided between such colleges, unless the legislature of such State or Territory shall otherwise direct.

Section 2. That it shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manures, natural or artificial, with experiments

designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective States or Territories.

Section 3. That in order to secure, as far as practicable, uniformity of methods and results in the work of said stations, it shall be the duty of the United States Commissioner of Agriculture to furnish forms, as far as practicable, for the tabulation of results of investigation or experiments; to indicate, from time to time, such lines of inquiry as to him shall seem most important; and, in general, to furnish such advice and assistance as will best promote the purposes of this act. It shall be the duty of each of said stations, annually, on or before the first day of February, to make to the governor of the State or Territory in which it is located a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said stations, to the said Commissioner of Agriculture, and to the Secretary of the Treasury of the United States.

Section 4. That bulletins or reports of progress shall be published at said stations at least once in three months, one copy of which shall be sent to each newspaper in the States or Territories in which they are respectively located, and to such individuals actually engaged in farming as may request the same, and as far as the means of the station will permit. Such bulletins or reports and the annual reports of said stations shall be transmitted in the mails of the United States free of charge for postage, under such regulations as the Postmaster-General may from time to time prescribe.

Section 5. That for the purpose of paying the necessary expenses of conducting investigations and experiments and printing and distributing the results as hereinbefore prescribed, the sum of fifteen thousand dollars per annum is hereby appropriated to each State, to be specially provided for by Congress in the appropriations from year to year, and to each Territory entitled under the provisions of section eight of this act, out of any money in the Treasury proceeding from the sales of public lands, to be paid in equal quarterly payments, on the first day of January, April, July, and October in each year, to the treasurer or other officer duly appointed by the governing boards of said colleges to receive the same, the first payment to be made on the first day of October, eighteen hundred and eighty-seven: *Provided, however,* That out of the first annual appropriation so received by any station an amount not exceeding one-fifth may be expended in the erection, enlargement, or repair of a building or buildings necessary for carrying on the work of such station; and thereafter an amount not exceeding five per centum of such annual appropriation may be so expended.

Section 6. That whenever it shall appear to the Secretary of the Treasury from the annual statement of receipts and expenditures of any of said stations that a portion of the preceding annual appropriation remains unexpended, such amount shall be deducted from the next succeeding annual appropriation to such station, in order that the amount of money appropriated to any station shall not exceed the amount actually and necessarily required for its maintenance and support.

Section 7. That nothing in this act shall be construed to impair or modify the legal relation existing between any of the said colleges and the government of the States or Territories in which they are respectively located.

Section 8. That in States having colleges entitled under this section to the benefits of this act and having also agricultural experiment stations established by law separate from said colleges, such States shall be authorized to apply such benefits to experiments at stations so established by such states; and in case any State shall have established under the provisions of said act of July second aforesaid, an agricultural department or experimental station, in connection with any university, college or institution not distinctively an agricultural college or school, and such State shall have established or shall hereafter establish a separate agricultural college or school, which shall have connected therewith an experimental farm or station, the legislature of such State may apply in whole or in part the appropriation by this act made, to such separate agricultural college, or school, and no legislature shall by contract express or implied disable itself from so doing.

Section 9. That the grants of moneys authorized by this act are made subject to the legislative assent of the several States and Territories to the purposes of said grants: *Provided*, That payment of such instalments of the appropriation herein made as shall become due to any State before the adjournment of the regular session of its legislature meeting next after the passage of this act shall be made upon the assent of the governor thereof duly certified to the Secretary of the Treasury.

Section 10. Nothing in this act shall be held or construed as binding the United States to continue any payments from the Treasury to any or all the States or institutions mentioned in this act, but Congress may at any time amend suspend or repeal any or all the provisions of this act.

Approved, March 2, 1887.

The Hatch Act in 1988

U.S. Code Title 7, Chapter 14

Section 361a. Congressional declaration of purpose; definitions

It is the policy of Congress to continue the agricultural research at State agricultural experiment stations which has been encouraged and supported by the Hatch Act of 1887, the Adams Act of 1906, the Purnell Act of 1925, the Bankhead-Jones Act of 1935, and title I, section 9, of that Act as added by the Act of August 14, 1946, and Acts amendatory and supplementary thereto, and to promote the efficiency of such research by a codification and simplification of such laws. As used in this Act, the terms "State" or "States" are defined to include the several States (including the District of Columbia), Alaska, Hawaii, Puerto Rico, Guam and the Virgin Islands. As used in this Act, the term "State agricultural experiment station" means a department which shall have been established, under direction of the college or university or agricultural departments of the college or university in each State in accordance with an Act approved July 2, 1862, (12 Stat. 503), entitled "An Act donating public lands to the several States and Territories which may provide colleges for the benefit of agriculture and the mechanic arts"; or such other substantially equivalent arrangements as any State shall determine.

Section 361b. Congressional statement of policy; researches, investigations and experiments.

It is further the policy of the Congress to promote the efficient production, marketing, distribution, and utilization of products of the farm as essential to the health and welfare of our peoples and to promote a sound and prosperous agriculture and rural life as indispensable to the maintenance of maximum employment and national prosperity and security. It is also the intent of Congress to assure agriculture a position in research equal to that of industry, which will aid in maintaining an equitable balance between agriculture and other segments of our economy. It shall be the object and duty of the State agricultural experiment stations through the expenditure of the appropriations hereinafter authorized to conduct original and other researches, investigations, and experiments bearing directly on and contributing to the establishment and maintenance of a permanent and effective agricultural industry of the United States, including researches basic to the problems of agriculture in its broadest aspects, and such investigations as have for their purpose the development and improvement of the rural home and rural life and the maximum contribution by agriculture to the welfare of the consumer, as may be deemed advisable, having due regard to the varying conditions and needs of the respective States.

Sources: (8, 9).

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Glossary

Available Water Capacity. The ability of soil to maintain water in the soil profile for uptake by plants. More specifically, it is the difference between the amount of soil water at field moisture capacity and the amount of soil water at the wilting point. Expressed as cm of water per cm of soil.

Capital. Durable goods that are used in production and have themselves been produced, e.g., factories and machinery. Financial capital is also included.

Carcinogenic. Producing, or tending to produce cancer.

Commodity Credit Corporation (CCC). USDA corporation that supports and protects farm incomes and commodity prices, maintains a balanced supply of commodities, and assists in the orderly distribution of agricultural goods.

Cooperative State Research Service (CSRS). USDA agency that administers federal research funds allocated to land-grant institutions.

Current Research Information System (CRIS). USDA computer bank that contains information on the research projects conducted by land-grant institutions.

Expanded Food and Nutrition Education Program (EFNEP). Cooperative Extension program that is directed toward improving the diets of low-income families. Its educational thrusts are in resource management, meal planning, food selection, food storage, food safety, and sanitation.

Experiment Station Committee on Organization and Policy (ESCOP). National committee composed of experiment station directors. Its function is to discuss organization and policy issues as they relate to the operation of State Agricultural Experiment Stations.

Family farm. A farm that is owned and operated by a residing family. Family members are responsible for most of the labor, the managerial decisions, and the financial risks on these farms.

Farmers Home Administration (FmHA). USDA agency that coordinates rural development programs and provides credit to farm families who cannot receive credit elsewhere.

Horticultural farm. A farm that is classified under Standard Industrial Classifications 016 (vegetables and melons), 017 (fruits and tree nuts), or 018 (horticultural specialties [including nursery crops and ornamentals]). Under this scheme, farms are categorized into that classification from which they earn 50% or more of their agricultural sales.

Large-scale farm. A farm with gross sales of \$250,000 or more per year.

Medium-scale farm. A farm with gross sales of \$40,000-\$249,999 per year.

National Research Council (NRC). The principal operating agency of the National Academy of Sciences. The agency is a dynamic assembly of scientists which responds to requests for scientific information by the Federal Government.

Oncogenic. Producing, or tending to produce tumors (cancerous tumors in this dissertation).

Poverty Line. An estimate of the minimum level of income necessary to cover essential living expenses. This is defined by family size, except for one- or two-person families, where it is defined by age. In 1986, the poverty line for a family of four was \$11,200.

Small-scale farm. A farm with gross sales of less than \$40,000 per year.

State Agricultural Experiment Station (SAES). The research department of the land-grant system in every state.

Total funds. Land-grant research funds that include "regular federal appropriations" (including those administered by the CSRS), and "other federal research funds," as reported on USDA Form AD-418. Also included in these funds are "non-federal research funds," as reported on USDA Form AD-419. USAID and PL-480 funds are excluded.

Traditional or Common Farm. A farm that is either small-scaled or medium-scaled, i.e., a farm with gross sales of less than \$250,000 per year.

United States General Accounting Office (USGAO). An agency of the legislative branch of the Federal Government. Its primary function is to examine the way in which public agencies utilize appropriated funds. Its objective is to improve the efficiency of public expenditures.

United States Office of Technology Assessment (USOTA). An agency of the legislative branch of the Federal Government. Its primary function is to provide the U.S. Congress with information that identifies the probable social and physical consequences of policy alternatives concerning the use of technology.

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