PROSPECTUS FOR
AN INTERNATIONAL CENTRE FOR RESEARCH AND
TRAINING WITH POTATOES

This proposal was developed under the United States Government - AID contract PIO/I 527-000-3-00031-A-1 and A-2 to North Carolina State University for a project on the planning and coordination for the creation of an International Center for Research and Training with Potatoes. Scientists from several major institutions with agricultural research and training programs have helped in the development of this proposal.

Submitted by
Richard L. Sawyer
Project Director
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The potato is one of the world's principal food crops. In the Andean region of South America, where it originated, it is the major part of the diet. The cultivation of the potato has been extended to most parts of the world. India now has more area in production of potatoes than the total of Bolivia, Chile, Ecuador and Peru combined. The area in production during the past ten years has practically doubled in India, Iran, Pakistan, Turkey, Burundi, Morocco and Tanganyika, countries which have not normally been thought of as potato producers. Yields per unit area in all of these countries are only about 25 percent that of most European countries or Canada and the United States.

With the potato there exists a tremendous potential for increasing world food supply in the areas where more food is needed. Although the potato is normally thought of as a temperate zone crop, it is grown in many tropical countries. Over half of the people of developing countries (more than 1,000 million) live in a temperate climate where the potato grows very well. A large portion of the population of countries normally considered tropical, such as India, Pakistan, South Africa, Mexico and Brazil, live in areas where the elevation or water have a modifying effect to give a climate sufficiently temperate for good potato production.

The potato is a more efficient producer of food than the cereals. It outranks all other crops in the United States in the production of calories per acre per day (based on high state yields). It outranks all other crops but soybeans, beans, and peas in the production of protein per acre per day. While the potato is generally identified for its carbohydrates, it is also a good source of high quality protein, minerals and vitamins (except for vitamin A).
Through the development of an international center for research and training with potatoes, the limited but developing scientific capabilities of emerging countries would be linked to the assets of Europe and North America. The basic problems in potato improvement, such as heat or cold resistance, disease and insect resistance, quantity and quality of production, are similar for most countries. The development of a problem solving capacity with potatoes is similar for all countries. Present high producing varieties in the world were developed from a small portion of the genetic variability which exists in the Andean region of South America. A center headquartered in this area would catalyze the development and utilization of the genetic wealth for all countries. Through projects linking to the center, a world pool of capabilities for potato improvement would be established.
THE POTATO

The place of origin of the potato was in the Andean region of South America, probably in the general area of Southern Peru and Bolivia. Peru has approximately twice as many wild tuber bearing species as any other country, although some are found as far north as Central America and Mexico. In the 15th century, at the time of the Spanish Conquest in South America, the cultivated potato was introduced into Europe and from there has spread to all areas of the world.

The varieties introduced into Europe were little more than oddities initially. Most of the varieties probably failed to produce tubers since the potato of South America evolved under short day conditions requiring 6 or 7 months to produce a crop. Potato breeders today in the northern latitude improvement programs have difficulty utilizing South American material due to the differences in growing conditions.

Relatively little improvement has taken place in the potato grown in South America in the past four hundred years. However, the potato which was introduced into Europe has been changed considerably as it was developed for northern latitude growing conditions. Because of superior production capabilities, some of the varieties developed in these programs are now being grown commercially back in South America.

In the development of the potato for northern latitude countries, resistances have been developed to most of their major disease problems. The Golden Nematode, for example, is a serious pest in most European countries and in parts of the United States and Canada. It was probably introduced into Europe along with the potato from South America. Resistant
varieties have been developed for European and North American areas where this pest is serious. No resistant varieties have been developed for South America. High yielding potato varieties, which mature in 90 to 120 days, have been developed for the northern latitude countries. Most of the present day varieties of the Andean region of South America still require from 150 to 180 days to mature. The potential exists for the improvement of the potato to the specific climates of other countries of the world similar to what has been done in Europe and North America. The potential exists for further major advancements in the countries of Europe and North America.

Although tremendous genetic diversity exists in the native habitat of the potato, only a small portion which could be made available has been utilized to date in the development of modern day commercial varieties. Research workers in the major potato producing areas of the world have become increasingly aware of limitations within their present breeding programs. There needs to be a thorough assessment of the genetic material that is available for the general improvement of the potato where it is currently grown and to give it a wider adaptability. Much of this assessment work can only be done well in the area in which the genetic variability exists. A predicament now exists where many countries cannot afford to keep their great natural germ plasm resources while the more developed countries cannot afford to let them be lost. Practically every country in which there is a wealth of solanum tuber-bearing genetic material is at the present stage of development where there will be a rapid disappearance of the old native varieties. Unless they become a part of well programmed germ plasm banks very soon, their potential value will be lost forever.
The potato is grown commercially from Alaska and the northern areas of Europe and Asia to the Equator and has a similar geographical distribution in the Southern hemisphere. Table 1 indicates the wide-spread use of the potato and the flexibility for adaptation to different climates of the world. The area in potatoes is declining in most of the developed countries with production remaining about the same due to increased yields. Practically all of the developing countries of Africa, Asia and South America have had major increases in area of production in recent years. Yields per unit area have increased for almost all countries but there is a great difference in levels of yield between the developing and developed countries. Average yields of the developed countries of Europe and North America are several times greater than average yields for the developing countries of South America, Asia and Africa.

Many factors are undoubtedly responsible for the wide difference in yields between the developing countries of Africa, Asia and South America and the developed countries of North America and Europe. Some of these are size of farm operations, agrarian reform programs and availability of credit or insecticides, fungicides and fertilizer. A large portion of the difference is undoubtedly due to lack of varieties specially developed for the local climate and local disease problems, and the lack of good seed production programs which markedly affect the efficient use of available nutrients and moisture. Many of the developing countries where potato production is increasing are importing seed of varieties which will produce a crop but which are varieties developed for a very different location and climate. There is no other alternative until the capability has been established for problem-solving with potatoes within the specific developing country. In some cases,
combinations of disease resistance are needed which are not yet available in a variety. Recently resistance to the two most important potato diseases of the tropics has been established in the same breeding line. Through such breakthroughs, new breeding tools need to be made available for building better varieties for the various climates of the world. An international center with linkages established to the various areas of competence for potato work in the world could greatly speed the development of resistance knowledge and use.
TABLE 1. Distribution of potato production in the world. The growth pattern in recent years is indicated by the per cent change in land area in production and yields since 1952.

<table>
<thead>
<tr>
<th></th>
<th>Production 1000 metric tons</th>
<th>Land Area 1000 hectares</th>
<th>Yield 100 Kg/hect. Per cent change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>3049</td>
<td>134</td>
<td>-23</td>
</tr>
<tr>
<td>Belgium</td>
<td>1943</td>
<td>62</td>
<td>-26</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>381</td>
<td>33</td>
<td>17</td>
</tr>
<tr>
<td>Czechoslovakia</td>
<td>6037</td>
<td>407</td>
<td>-35</td>
</tr>
<tr>
<td>Denmark</td>
<td>837</td>
<td>37</td>
<td>-67</td>
</tr>
<tr>
<td>France</td>
<td>10,396</td>
<td>516</td>
<td>-54</td>
</tr>
<tr>
<td>Germany(East)</td>
<td>14,043</td>
<td>606</td>
<td>-26</td>
</tr>
<tr>
<td>Germany(Rep.)</td>
<td>21,208</td>
<td>707</td>
<td>-38</td>
</tr>
<tr>
<td>Greece</td>
<td>721</td>
<td>51</td>
<td>46</td>
</tr>
<tr>
<td>Hungary</td>
<td>1507</td>
<td>169</td>
<td>-33</td>
</tr>
<tr>
<td>Ireland</td>
<td>1748</td>
<td>65</td>
<td>-52</td>
</tr>
<tr>
<td>Italy</td>
<td>4010</td>
<td>339</td>
<td>-13</td>
</tr>
<tr>
<td>Netherlands</td>
<td>4840</td>
<td>138</td>
<td>-26</td>
</tr>
<tr>
<td>Norway</td>
<td>807</td>
<td>40</td>
<td>-33</td>
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<tr>
<td>Poland</td>
<td>48,620</td>
<td>2763</td>
<td>7</td>
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<td>Portugal</td>
<td>1296</td>
<td>117</td>
<td>33</td>
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<tr>
<td>Rumania</td>
<td>3086</td>
<td>315</td>
<td>51</td>
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<tr>
<td>Spain</td>
<td>4490</td>
<td>376</td>
<td>5</td>
</tr>
<tr>
<td>Sweden</td>
<td>1300</td>
<td>51</td>
<td>-61</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1125</td>
<td>38</td>
<td>-30</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>7201</td>
<td>287</td>
<td>-42</td>
</tr>
<tr>
<td>Yugoslavia</td>
<td>2810</td>
<td>322</td>
<td>41</td>
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<td>Soviet Union</td>
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North & Central America

<table>
<thead>
<tr>
<th></th>
<th>Production 1000 metric tons</th>
<th>Land Area 1000 hectares</th>
<th>Yield 100 Kg/hect. Per cent change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>1808</td>
<td>124</td>
<td>-13</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>17</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Cuba</td>
<td>98</td>
<td>8</td>
<td>-20</td>
</tr>
<tr>
<td>Guatemala</td>
<td>19</td>
<td>4</td>
<td>33</td>
</tr>
<tr>
<td>Mexico</td>
<td>400</td>
<td>39</td>
<td>30</td>
</tr>
<tr>
<td>United States</td>
<td>13,853</td>
<td>590</td>
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South America

<table>
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<tr>
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<th>Production 1000 metric tons</th>
<th>Land Area 1000 hectares</th>
<th>Yield 100 Kg/hect. Per cent change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>1797</td>
<td>163</td>
<td>-12</td>
</tr>
<tr>
<td>Bolivia</td>
<td>670</td>
<td>180</td>
<td>59</td>
</tr>
<tr>
<td>Brazil</td>
<td>1467</td>
<td>217</td>
<td>49</td>
</tr>
<tr>
<td>Chile</td>
<td>717</td>
<td>77</td>
<td>60</td>
</tr>
<tr>
<td>Colombia</td>
<td>800</td>
<td>122</td>
<td>16</td>
</tr>
<tr>
<td>Ecuador</td>
<td>403</td>
<td>48</td>
<td>92</td>
</tr>
<tr>
<td>Peru</td>
<td>1712</td>
<td>272</td>
<td>25</td>
</tr>
<tr>
<td>Uruguay</td>
<td>78</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Venezuela</td>
<td>151</td>
<td>17</td>
<td>54</td>
</tr>
<tr>
<td>Production</td>
<td>Land Area</td>
<td>Yield</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>--------------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000 metric tons</td>
<td>1000 hectares</td>
<td>100 kg/hect.</td>
</tr>
<tr>
<td>Asia</td>
<td></td>
<td></td>
<td>change</td>
</tr>
<tr>
<td>Cyprus</td>
<td>139</td>
<td>9</td>
<td>80</td>
</tr>
<tr>
<td>India</td>
<td>3522</td>
<td>473</td>
<td>108</td>
</tr>
<tr>
<td>Indonesia</td>
<td>42</td>
<td>10</td>
<td>42</td>
</tr>
<tr>
<td>Iran</td>
<td>109</td>
<td>20</td>
<td>400</td>
</tr>
<tr>
<td>Israel</td>
<td>93</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>Japan</td>
<td>3636</td>
<td>183</td>
<td>-13</td>
</tr>
<tr>
<td>North Korea</td>
<td>933</td>
<td>130</td>
<td>30</td>
</tr>
<tr>
<td>Rep. of Korea</td>
<td>566</td>
<td>58</td>
<td>38</td>
</tr>
<tr>
<td>Lebanon</td>
<td>81</td>
<td>7</td>
<td>40</td>
</tr>
<tr>
<td>Pakistan</td>
<td>768</td>
<td>89</td>
<td>424</td>
</tr>
<tr>
<td>Turkey</td>
<td>1760</td>
<td>150</td>
<td>90</td>
</tr>
<tr>
<td>Africa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algeria</td>
<td>204</td>
<td>32</td>
<td>39</td>
</tr>
<tr>
<td>Burundi</td>
<td>94</td>
<td>12</td>
<td>140</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>148</td>
<td>29</td>
<td>45</td>
</tr>
<tr>
<td>Kenya</td>
<td>195</td>
<td>53</td>
<td>6</td>
</tr>
<tr>
<td>Madagascar</td>
<td>100</td>
<td>16</td>
<td>-27</td>
</tr>
<tr>
<td>Morocco</td>
<td>260</td>
<td>26</td>
<td>271</td>
</tr>
<tr>
<td>Rwanda</td>
<td>46</td>
<td>13</td>
<td>62</td>
</tr>
<tr>
<td>South Africa</td>
<td>497</td>
<td>61</td>
<td>7</td>
</tr>
<tr>
<td>Tanganyka</td>
<td>22</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>Tunisia</td>
<td>79</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>U.A.R.</td>
<td>278</td>
<td>17</td>
<td>31</td>
</tr>
<tr>
<td>Australia</td>
<td>653</td>
<td>60</td>
<td>15</td>
</tr>
<tr>
<td>New Zealand</td>
<td>250</td>
<td>11</td>
<td>27</td>
</tr>
</tbody>
</table>

* Data from FAO World Crop Production Statistics 1968.
THE POTATO IN RELATION TO OTHER IMPORTANT FOOD CROPS

The potato has a remarkably wide range of acceptable climates. The geographical distribution of the countries where it is important, as listed in Table 1, indicates the adaptability of the potato. It has a greater flexibility to climate than many major food crops, including corn, rice, peas, sugar beets, sugar cane, and other tuberous foods such as sweet potatoes and casava. The potato is one of the few food crops which produces well at high elevations. In Bolivia, Colombia, Ecuador and Peru, where a large portion of the usable land is at elevations of 10,000 feet or higher, there is no other crop which can compare with the potato in the production of food.

The potato ranks very high in a comparison of the production of calories or proteins by various crops. Table 2 gives such a ranking of several crops based on high state average yields in a country where there is a relatively small gap between available technology and farm production. This data gives an indication of the relative potential productive capacity amongst the listed crops for world food supply.

In the production of calories per unit area of land, the potato ranks second with only sugar cane higher. In the production of protein per unit area, the potato also ranks second with only soybeans higher. However, when these crops are compared for calorie production per unit area per day, the potato ranks first. In protein production per unit area per day the potato ranks after the shorter season crops of soybeans, beans and peas.
TABLE 2.*  Rank of crops according to calorie and protein production  
(based on high state average yields in the United States).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Calories</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production per unit area</td>
<td>Production per unit area per day</td>
</tr>
<tr>
<td>1</td>
<td>Sugar cane</td>
<td>White potatoes</td>
</tr>
<tr>
<td>2</td>
<td>White potatoes</td>
<td>Corn</td>
</tr>
<tr>
<td>3</td>
<td>Sugar beets</td>
<td>Sugar cane</td>
</tr>
<tr>
<td>4</td>
<td>Corn</td>
<td>Rice</td>
</tr>
<tr>
<td>5</td>
<td>Rice</td>
<td>Sugar beets</td>
</tr>
<tr>
<td>6</td>
<td>Sorghum</td>
<td>Sorghum</td>
</tr>
<tr>
<td>7</td>
<td>Sweet potatoes</td>
<td>Barley</td>
</tr>
<tr>
<td>8</td>
<td>Barley</td>
<td>Sweet potatoes</td>
</tr>
<tr>
<td>9</td>
<td>Peanuts</td>
<td>Beans</td>
</tr>
<tr>
<td>10</td>
<td>Winter Wheat</td>
<td>Soybeans</td>
</tr>
</tbody>
</table>

* Data from Feds Staff paper October 2, 1970
"Agronomic potential of U.S. Food Crops for production of calories and protein".
The potato, as normally stored and sold, is a relatively bulky product. It is a tuber and not a true seed as is the case with such crops as corn, rice and wheat. Table 3 indicates the relative food value of several crops as normally stored and purchased in the market. Other than problems of bulk, the potato has storage problems not normally encountered with true seeds. During recent years, modern inexpensive storage methods have been developed which will keep potatoes in good condition in most countries without refrigeration for periods up to a year. The use of inexpensive chemical growth regulators to control sprouting is already a standard practice in most major potato-producing areas of developed countries. To more effectively compete as a stored product with true seeded crops, new inexpensive methods of potato processing need to be developed which would allow the food value of the potato to be concentrated and would eliminate many of the perishability problems of the potato tuber in storage.
TABLE 3. Calorie and protein content per pound of several crops as normally purchased in the market.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Calories</th>
<th>Protein (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybeans</td>
<td>1828</td>
<td>155</td>
</tr>
<tr>
<td>Corn</td>
<td>1579</td>
<td>40</td>
</tr>
<tr>
<td>Wheat</td>
<td>1497</td>
<td>43 to 64</td>
</tr>
<tr>
<td>Barley</td>
<td>1579</td>
<td>44</td>
</tr>
<tr>
<td>Rice</td>
<td>1633</td>
<td>34</td>
</tr>
<tr>
<td>Sorghum</td>
<td>1506</td>
<td>50</td>
</tr>
<tr>
<td>Rye</td>
<td>1515</td>
<td>55</td>
</tr>
<tr>
<td>Beans</td>
<td>1542</td>
<td>101</td>
</tr>
<tr>
<td>Peas</td>
<td>1542</td>
<td>109</td>
</tr>
<tr>
<td>Potatoes</td>
<td>279</td>
<td>8</td>
</tr>
<tr>
<td>Sweet potatoes</td>
<td>419</td>
<td>6</td>
</tr>
</tbody>
</table>

* Data from Agricultural Handbook No. 8 ARS. USDA Dec. 1963.
The total nutritive value of potatoes is very often overlooked. In addition to their recognized value as a source of calories, potatoes are a valuable source of vitamins, minerals and protein. Of these, their value as a source of protein is most often overlooked. If an adult male were to consume enough potatoes to supply the 3250 calories he needs, he would meet his daily requirement of 70 grams of protein. Furthermore, the balance of amino acids in potatoes is such that quality of protein would not be a factor. The following Table gives one of the available sets of data which compares the amino acid composition of potato with that of casein:

**TABLE 4.** A comparison of the amino acid composition of potato and casein protein.

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Boiled Potatoes</th>
<th>Casein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoleucine</td>
<td>8.9</td>
<td>6.1</td>
</tr>
<tr>
<td>Leucine</td>
<td>10.9</td>
<td>9.2</td>
</tr>
<tr>
<td>Lysine</td>
<td>11.0</td>
<td>8.2</td>
</tr>
<tr>
<td>Methionine</td>
<td>2.6</td>
<td>2.8</td>
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<td>Phenylalanine</td>
<td>8.6</td>
<td>5.0</td>
</tr>
<tr>
<td>Threonine</td>
<td>7.6</td>
<td>4.9</td>
</tr>
<tr>
<td>Tryptophane</td>
<td>2.4</td>
<td>1.7</td>
</tr>
<tr>
<td>Valine</td>
<td>11.9</td>
<td>7.2</td>
</tr>
</tbody>
</table>
AN INTERNATIONAL POTATO CENTER

Many institutions in the world have potato research programs and capabilities which depend upon the genetic diversity of the potato host and of its pests. For many years scientists involved in potato improvement work have discussed the desirability of a good facility in the area where the potato originated to which they could relate projects. Many programs have been held back due to the absence of a coordinating center and the lack of financial support for this kind of work.

In 1967, at the time a strong national potato program was emerging in Peru, interest was developed to the extent that an international center for potato work was created formally by a Peruvian Presidential Decree. The steady progress which has taken place since the decree is indicated by the following:

1. The Government of Peru is constructing a central headquarters facility for the center which will be completed in 1971.

2. An agreement is in the final stages for signing which gives autonomy to the center and similar operational privileges in Peru that other international crop improvement centers enjoy in the countries in which they are located, and,

3. The U.S. Agency for International Development has provided planning money until June 30, 1971 to develop a funding package and catalyze the center into action.

Objectives

The broad objective would be to enhance the world's capacity to meet goals of increased output and greater efficiency in the production of potatoes. More specifically, the initial objective would be the development of an international program with a major emphasis on germ plasm and its utilization in research and
the training of people working with potatoes. The programs for germ plasm use would involve highly trained scientists in all disciplines who would be involved in the training portion of the programs of the Center. In the development of germ plasm utilization for greater world food production, several institutions from different nations would develop a sharing of competencies and resources and participate in determining and implementing the policies of an international program.

**Location**

The Center is being located in Peru for the following reasons: (1) The efficient collection, classification, and utilization of germ plasm requires that the area chosen include most of the ecological requirements of *Solanum* species as well as the disease, insect and nematode problems for which screening is to be done. (2) A strong national potato research and educational commitment is a prerequisite. (3) A location contiguous to an existing national educational or research institution is strongly recommended. (4) Suitable housing and educational facilities for collaborators should be readily available. (5) International travel facilities must be readily available and easy to arrange. (6) There must be a strongly expressed interest by indigenous scientific and agricultural leaders.

All of the conditions are satisfied only in Peru and it is strongly recommended that the Center be located in Lima, although there are other locations which meet some of the conditions listed.

In Peru, the administrative center would be located in Lima adjacent to the National Agrarian University and the National Agricultural Research Center, which headquarters a vigorous national program. Construction is already under
way for a central headquarters facility for the Center at this location as part of the input by the Peruvian government in indicating its interest in the Center. The germ plasm facility would be located in the central Sierra which is readily accessible by road and which is the ecological hub of the tuber-bearing Solanum species.

This Center would house the administrative unit, laboratories and offices for collaborating scientists, and germ plasm facility. The proposed scientific system would link this center with the human and physical assets of outstanding scientific institutions throughout the world. Such a system would complement emerging national programs in developing areas and increase the efficiency of existing centers of competence.

North Carolina State University would provide initial sponsorship for the development and operation of the Center because of its prime contract for agricultural development in Peru. An agreement has been developed and is approaching the stage for signing between the Government of Peru and North Carolina State University. In this agreement, Peru establishes an autonomous tax-free entity and the operational privileges of the Center, and North Carolina takes the responsibility of sponsoring the Center into action and developing the necessary funding. According to the agreement, once the Center is activated, it will be under the direction of a board of ten directors which will be autonomous and self perpetuating. The agreement prevents any one organization or country from developing a major vested interest.
In the organization of the Center, the experience gained by other international centers for crop improvement has been taken into consideration as much as possible. Following is the third clause in the agreement which gives the Center autonomy and indicates the basic organizational pattern:

"THIRD CLAUSE.- The Center shall operate in Peru, as an association of scientific nature, non-profit, with legal status and economic and administrative autonomy; which will also be tax-exempt.

a) The Center shall be under the direction of a Board of Directors composed of a maximum of ten members; two members of which will represent Peruvian institutions since the headquarters of the International Center are in Peru. These will be the General Director of Agricultural Research of the Ministry of Agriculture and the Director of Research of the Agrarian University of La Molina. The Rockefeller Foundation and the North Carolina State University will also have a member each on the mentioned Board of Directors. The other six members will be elected according to the regulations provided for in item c) below, and shall belong to countries and institutions that form a part of the mentioned Center and that accept as the basic goal of the Center, the development of research and training with potatoes. The Director of the Center will be one of the members of the Board of Directors and initially will be named by the Minister of Agriculture of Peru and the Chancellor of North Carolina State University;

b) Not more than two members of any specific country shall simultaneously render services on the Board, with the exception of the Director;

c) The Board of Directors shall be autonomous and shall adopt its by-laws and regulations to govern the Center.
d) The initial Board of Directors made up of the four indicated members and the Director shall be named by the Minister of Agriculture of the Government of Peru and the Chancellor of North Carolina State University;

e) The headquarters of the International Center will be in the city of Lima, at the Agricultural Experiment Station of La Molina, and shall work in close association with the National Agrarian University.

f) The areas necessary for research in the search of resistances, shall be established initially in the vicinity of the cities of Huancayo and Cuzco;

g) The Center shall have the following rights and privileges; the use or sharing of buildings for laboratories, library, fields for work and research and also, if possible, living quarters for its personnel; acquire adequate pieces of land for its research needs and equipment, machinery and elements necessary to carry out high quality research and training programs as provided for in the sixth clause;

h) The personnel of the Center shall be composed of a group of scientists that shall be primarily selected on an international level, on the basis of their recognized competence in work related to the fields of investigation;

i) Peruvian scientists and scientists from other nations shall receive advanced and intensive training, and shall participate in the research programs of the Center, so that they may later return to their countries of origin sufficiently qualified to orientate national and regional programs for the improvement of potatoes and tuber crops;

j) The training program shall be developed in close collaboration with those Peruvian institutions which specialize in and are dedicated to agricultural research and/or the training of technicians. Foreign institutions which
are qualified by their competence shall also be included in the development of these programs".

Once the Center is operative an early agreement will be established between the institutions involved in the National Peruvian Potato Program and the Center to determine the ground rules for cooperation so that there is complementation and not competition. Care must be taken that there is no robbing of a Peruvian program for staffing the Center and that there is a technical staff international in character with good representation by scientists from Latin America.

Program

The three immediate areas of responsibility for the Center are the collection and maintenance of potato germ plasm, scientific utilization of this material and the training of scientists involved with potato improvement and potato production. Initial priority would be given to the development of a facility which would make the genetic variability which exists with the potato available for use. In the utilization of the genetic wealth, linkages would be established to institutions in Europe and North America where there are excellent facilities, competent scientists, and projects of worldwide importance already under way which could be expanded to an international dimension through the linkage. Although specific projects would depend to some extent on the funding source and the interests of the linking institutions, following is a general discussion of the major areas of work which should receive early attention.
I. Germ plasm collection, maintenance and availability.

The greatest reservoir of potato germ plasm in the world exists in the Andes of Peru, Colombia, Ecuador, Chile and Bolivia. Experience with other crops in other regions has shown that as agricultural development occurs much of this genetic variability is lost unless an effort is made to preserve it. This requires a special effort with potatoes since they are normally asexually propagated. If this wealth of germ plasm is to be preserved it must be done now. Collections of small portions of this germ plasm presently are maintained in the United States, Scotland, and Germany and programs are developing in Argentina, Chile, Colombia, Ecuador and Peru. The North American and European programs are hampered by problems of reproducing some of the introductions due to day length and length of growing season and by protective quarantine measures. However, they serve a very useful role in making these materials readily available to the breeders in those countries. The South American centers are well suited to growing the diversity of genetic material, are accessible to the areas of origin, and are not hampered by quarantine measures within each country. These centers, however, are not apt to be able to expand enough to meet the need, and since this reservoir of germ plasm is as valuable to the rest of the world as it is to these countries, it is sensible for North American and European countries to cooperate in the development of one or more of these South American centers.

In addition to serving in the primary role of collecting, maintaining, identifying, and distributing the *Solanum* germ plasm, this center would be an effective site to facilitate and coordinate the research efforts of foreign scientists whose research requires the experimental conditions present in South America. These might be field conditions at uniform day length, tempe
rature differences during the growing season at the same day length, evaluation of genetic material in the presence of diseases that should not be spread beyond where they naturally occur, and other.

II. Utilization of the genetic material.

A program involved in resistance work, whether it be to a disease, an insect or a physiology problem, requires a thorough knowledge of the problem or the pest, a search for the genetic variability which exists, and the incorporation of what is desired if found into usable breeding lines. Some of the areas of potato improvement where genetic diversity may play an important role are:

A. Increase in the Genetic potential for yield

The genetic base on which potato varieties for northern latitude countries have been developed is very narrow. These varieties are the result of intensive selection on the limited introductions that were initially made into Europe in the 15th century from the very region with which this project is concerned. Limited infusions of new germ plasm have been made sporadically since then, but not until the last decade has any formal effort been made to incorporate a broad base of new germ plasm into North American potato breeding. These programs need to be expanded to more species and to be enlarged where they already exist. The magnitude of the problem mandates that usually an institution cannot undertake the development of more than one species. The Cornell University program with *S. tuberosum* spp. *andigenum* can illustrate the size of these programs and how they serve both the United States and other countries. In 1970, 40,000 seedlings with a broad genetic base will be grown and selections made on the basis of yield, appearance, and disease resistance. Past selections from such materials as this have proven to have potential for hybrid vigor when crossed to *S. tuberosum* varieties and for contribu-
The selected breeding materials are immediately useful to breeders in other countries, European and Asian as well as South American.

B. Disease and Insect resistance and host-parasite relationships.

One of the major thrusts in potato breeding has long been toward incorporating disease resistance into cultivated varieties. The major role of the potato introductions in the past has been in their contribution to this area. Now these achievements are finding utility in the tropical areas where potatoes are grown. In view of the expansion of potatoes into areas of the world where cereals traditionally predominated, in order to provide better balanced and more diversified diets, and in the need to reduce the use of chemical control measures, it is most important that more disease control be genetic. This will require evaluation of the Solanum species for resistance, studies of the genetic behavior of the resistance, its incorporation into useful breeding lines, and a study of the variations in the pathogens which the genetic resistance must withstand. A wide range of viruses, the Golden Nematode, and bacterial wilt are of sufficient world importance to receive priority attention by the Center.

C. Increasing resistance to cold injury.

Potatoes are grown in the tropics at high altitudes or during the cool season. In many regions this makes them subject to frost injury. Within the species of Solanum there is at least one which has been recorded to withstand temperatures of 23° F (-5° C). The transfer of this tolerance of frost to cultivated potatoes has proven to be very difficult and much needs to be done to advance this limit to potato production.
D. Changing the supply pattern.

A common problem in developing countries is an oversupply of potatoes at certain times of the year and shortages at other times. One way of alleviating such problems is to prolong the storage life of potato tubers, either through the use of chemical sprout inhibitors or by using genetic materials with naturally long dormant periods. The great genetic variability in dormancy existing among South American potatoes should make them valuable tools for physiological studies of the nature of dormancy.

Another way to even out differences in supply is to resort to more processing. In terms of world potato consumption, potato processing is increasing at a remarkable pace. Although processing is most important in the developed countries (in the United States nearly half of the potatoes consumed for food are processed) it is also expanding in the developing countries. The value of specific varieties for various forms of processing depends upon enzymatic reactions, specially those involved in carbohydrate transformations. There is evidence that at least some of these enzymes vary even within the limited range of genetic materials commercially cultivated in the United States. It is likely that much broader differences exist among the species available in South America. Such genetic differences could be extremely helpful in elucidating the role of the enzymes in carbohydrate transformations, thus supplying information of interest in a basic biochemical sense as well as for solving potato processing problems. The necessary tests for differences in carbohydrate transformations require little specialized equipment, and could be conducted at the germ plasm center. True seed of selected lines could then be propagated at the linking institutions for more intensive studies.
One of the most promising types of processing for developing countries would seem to be a simplified method of potato dehydration which would require less sophisticated technology than the methods now used. A process has been developed in Peru which is now at the pilot plant stage whereby potatoes are substituted for a substantial amount of the wheat used in making bread. The potatoes are utilized in a relatively raw state without having to go through the process of first being converted to potato flour. In countries where potatoes are important and can be readily grown and where wheat is a major import crop, the development of such utilization possibilities could have a tremendous impact on the economy.

E. Increasing nutritive value to human diets.

Relatively little is known about the variability which exists in the potato for increasing its nutritive value. The excellent quality of potato protein has been established and it is probable that the quantity could be increased.

III. Training and Communication.

The training and communication portion of the activities of the Center would aim at developing interaction between scientists and workers of all countries and institutions involved with potatoes. This network of interaction would include newsletters and publications to keep personnel working with potatoes informed on latest developments, short courses, symposia for the sharing of information and the interchange of ideas and approaches, and the development of a directory of scientists who have sufficient flexibility to be able to make an application of their results and capabilities to more than one country or one area of the world.

A major long range function of the Center would be the training of scientists involved in research and training programs with potatoes. There
is a great need for a team of top ranking scientists working with potatoes who would (1) be available for help in the establishment of programs and projects in developing countries, (2) be available for advice with present projects in which help is requested, and (3) develop and conduct short courses on a wide range of topics important in potato research and the training of personnel working with potatoes. The Center, with its team of scientists, would be a locus for thesis programs with potatoes for Latin American scientists and also those scientists with institutions in North America and Europe which are developing a competence for agricultural work at an international level, and also would serve as an information center on the latest technological advances and research results with potatoes in the world. The Center would develop such a team of scientists and such a program utilizing its own staff and that of institutions linked with the Center.

A main training function of the Center would be the development of a scholarship program enabling outstanding young scientists working with potatoes to receive excellent training in their discipline. The Universidad Nacional Agraria is immediately adjacent to the central headquarters facility being constructed by Peru for the Center on the grounds of the Agricultural Experiment Station at La Molina. The Universidad Nacional Agraria presently has good masters degree programs representing the main disciplines important in potato research such as soils and pathology. A system would be developed whereby scientists receiving training through the scholarship program of the Center might utilize the Universidad Nacional Agraria for formal instruction which could lead to an advanced degree by that University. This University already has a good staff of Ph.D. and Masters degree scientists and teachers.
Over the past several years, Peru has developed a strong national potato program of young well-trained scientists. There is a team approach to solving national problems with potatoes utilizing both University scientists and scientists of the Research branch of the Ministry of Agriculture. This team will be a most valuable asset in the establishment of an inservice training function by the Center. An example in one discipline which gives an indication of the potential which is available in Peru for the training of scientists and thesis work with potatoes is the fact that during the six-month period from January 1, 1970, to June 30, 1970, a scientist of the Universidad Nacional Agraria who recently returned from advanced training in virology has isolated five new and yet un-named viruses of potatoes. This has been substantiated by a senior pathologist working with the North Carolina State University-AID team in the development of a national potato program.

As the program of the Center develops there are a great many services in which it would play an important role in backstopping the development of National Programs. These services are not presently being offered in many developing countries where potatoes are important. Examples of these services would be the development of visual aid material which would be available for national programs in the identification of mineral nutrition deficiencies or disease symptoms for use in seed production programs. Another example would be the development of a thorough up-to-date bibliography on potato literature which is available for the use of scientists and graduate students in initiating and doing their research and thesis work. A very great challenge is the development of information sheets on economically feasible potato practices which could be utilized by the vast numbers of illiterate potato producers which are found in many South American countries and will continue to represent a major portion as Agrarian Reform continues to break up the large farming operations.
Cost of the Center

Although the general organization of the Center is similar to other International Crop Improvement Centers, the program of the Center would allow somewhat different guide lines for a staffing pattern and development of facilities. Since the program will center around the collection, maintenance and availability of germ plasm, there would be no initial need for large major capital investments in physical plant facilities. In the utilization of the genetic material a number of scientists and their present facilities would be drawn into the early work program of the Center through linkage projects.

To begin the work of the Center a core staff of six scientists properly supported with technicians and facilities is necessary in Peru. Although it is impossible to predict with accuracy the future staffing pattern, it is anticipated that as programs of the Center develop, core staff would be added to represent all of the major disciplines involved in potato research and the training of potato workers. Institutions outside of Peru with projects linking to the Center would involve approximately another 30 scientists directly with the initial programs of the Center. Although core staff scientists would have their own research programs, they would play a major role in the coordination of linkage projects in the specific discipline which the core scientist represented.

The government of Peru is presently building a central headquarters facility for the Center as part of its contribution. They will also provide the necessary experimental land on the coast and in the highlands. Work at the project level can be started immediately using laboratories and facilities not being used to capacity in the national program. There are excellent new modest facilities for pathology and nematology work in the national program. There will have to be
long range laboratory facilities developed in Lima and modest highland germ
plasm and experimental facilities which can be programmed over the initial
years. Such facilities are necessary in order to attract and keep top
scientists on the staff of the Center and to maintain the work of linkage
projects at a high level of competence. Much of the linkage money to insti-
tutions outside of Peru will provide use of top facilities already available.

Some of the advantages of a Peru location for the Center include construc-
tion costs for laboratory - greenhouse facilities and the modest cost of sup-
porting staff for the scientists of the Center. The climate in Lima has an
annual average precipitation of less than an inch. The annual temperature
fluctuates between approximately 60 and 85° F (15 and 28° C). For a large
amount of the breeding and genetic work, low cost screen house facilities are
sufficient. There is no need for expensive heating and cooling facilities in
laboratory or greenhouse construction. A building of a size to adequately
house the laboratory needs of the Center for the initial years, was completed
in 1968 for the pathology-nematology programs at a cost of $75,000.00.

Good supporting personnel for the Center scientists can be obtained from
the flow of trained people graduating from the National Agrarian University.
Starting salaries for technicians with five year college degrees are presently
under $300.00 a month and Center professionals can be backstopped very adequately
at a relatively low cost.

The Center would probably develop an agreement with the new National Agrarian
library for any inputs into library facilities. This National facility is nearby
the central headquarters building presently under construction for the Center.
The National Library was over-built with expansion in mind and will not be
utilized to capacity for quite a few years. It is anticipated that an agree-
ment could be developed which would be advantageous to both the Center and
the National Library.

A tentative initial and future staffing pattern is given in the follow-
ing Table. Future core staff may come from several sources. Visiting pro-
fessors may be utilized through the financing of individual country programs.
There have been responses from several European countries indicating a strong
interest in such linkages for some of the institutions. Some of the funding
for additional core staff would hopefully come from individual country pro-
grams which recognized a direct value to their needs through such participa-
tion.
TABLE 5.- Estimated Staff Requirements.

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<th>Initial</th>
<th>Future</th>
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<td>Asst. Director</td>
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(a) Peru based personnel - full time with the Center.
(b) To be obtained through linkage projects with institutions outside of Peru.
A tentative budget has been developed for the Center which would involve approximately 36 scientists in the priority projects discussed in this prospectus. To finance the program of six core scientists and thirty linking scientists would require a million dollars annually. Of this, approximately one half would be for the program of the core staff and the supporting costs in Peru for the thirty scientists with linking projects. Core support figures were developed using as a basis the present cost of foreign technical assistance programs in Peru where they applied. Senior scientists representing the disciplines with which the Center will be most concerned, and who had a working knowledge of Peru, developed cost figures for projects in their specific disciplines which included laboratory and field equipment and facilities and technician support.

Funding

A great deal of contact work has been done to determine the interest of countries who might be interested in supporting the Center, countries which might see a value to participating in the program of the Center, and organizations which are presently involved in the funding of international crop improvement programs. There has been unanimous agreement that a potato center would be a valuable asset in helping to solve the problems of world food production. There has been unanimous agreement that no one organization has the present flexibility of funding to provide such long-term funding and that several of the potential funding organizations should join forces in such a venture.
The U.S. Agency for International Development has provided planning money for a one-year period for the specific purpose of developing a funding package, establishing the legal entity, and catalyzing the Center into activity. It also expects to be a major contributor to the program of the Center. The Rockefeller Foundation, which has had a major interest in potato improvement for many years, has been very helpful in bringing the project to its present status and has indicated that there would be project support available. Other specific funding organizations which have been contacted and have shown interest in the development are the Ford Foundation, the United Nations Development Program, the World Bank, and the Inter-American Development Bank.

Governmental representatives and scientists from the countries of Germany, Great Britain and the Netherlands have indicated the possibility and desire for participation. It has been indicated that no specific action could be taken until the Center is a legal autonomous entity with programs activated in the name of the Center. The same is true for such countries as Bolivia, Chile, Colombia, Ecuador and Peru. Letters have been received from administrators and program leaders highly endorsing such a development and indicating the possibility for financial participation once the Center was active and program guidelines were established.

The Potato Association of America has formerly endorsed the development of the Center. The potato scientists of Europe have indicated a similar backing and requested a formal presentation of the status of the development of the Center at their last Triennial Conference in 1969. At the second International Tuber-root Crop Symposium in Hawaii in August 1970, an explanation of the development of the Center received enthusiastic response from
representatives from Asian and African countries where the importance of potato production is increasing rapidly. There is every indication that activation of the Center by a few of the interested and potential funding organizations will catalyze project support from a large number of funding sources.
Left, Central headquarters facility under construction for the International Potato Center and right, the Administration building of the National Research Service at La Molina.

Soils Department at the La Molina Experiment Station of the National Research Service.

Pathology wing of the Nematode-Pathology building at the La Molina Experiment Station of the National Research Service.
National Agrarian Library at the National Agrarian University at La Molina.

Student Union building at the National Agrarian University at La Molina.

Left, laboratories and right, office buildings at the National Agrarian University at La Molina.
International Nematode School conducted in September 1970 at the La Molina Experiment Station. Scientists from eight countries attended this school conducted by Nematologists from Cornell and North Carolina State University, and the La Molina Experiment Station.