Production Resource Management with Rapid Adoption of a New Crop: Soybeans in Madhya Pradesh

R.P. Singh, R.C. Kashive, V. Bhaskar Rao
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Abstract

Farmers in five districts of Madhya Pradesh added about 400,000 hectares of soybeans to their cropping system between 1970 and 1988 with most being added after 1978. In the same period, farmers increased all other crops by 36,000 hectares. Production resources required for the soybeans were all additional requirements. Land came from increases in land under cultivation and more double cropping. Labor came from more work days per year for family and local hired labor, mechanization and imported migrant labor. Draft power came from mechanization, including tractors. Operating capital came mainly from owned capital (probably from soybean income) and minimizing soybean inputs.

Soybeans have been the catalyst to completely change this agriculture. Under their influence, it is becoming commercialized and specialized with large investments in mechanization and irrigation, all characteristics of a developed agriculture. It is also prosperous.
PRODUCTION RESOURCE MANAGEMENT WITH RAPID ADOPTION OF A NEW CROP: SOYBEANS IN MADHYA PRADESH

R.P. Singh, R.C.Kashive, V. Bhasker Rao, K.G.Kshirsagar, and J.H. Foster

Introduction

Farmers in five districts of central Madhya Pradesh with medium and deep black cotton (vertisol) soils and relatively high rainfall "discovered" soybeans as a new kharif crop in the late 1970's. From about 6,000 hectares in 1977, they rapidly increased the area planted to this new crop until, in 1988, the five study districts were growing more than 400,000 hectares.

Soybeans are a commercial crop grown in the kharif (rainy) season. They are planted just after the monsoon rains begin in June and harvested near the end of September. Often they are followed by a rabi (post rainy season) crop, especially if the land is irrigated. On surveyed farms about a quarter of all soybeans were grown on land that could be irrigated with the remainder grown on rainfed land. They competed successfully for about two-thirds of all irrigated land on these farms with subsistence rice grown on most of the rest in the kharif season.

Soybeans are crushed and their oil used domestically, mostly for human consumption. The oil cake is used for animal feed and is mostly exported from India.

The authors are Economist at ICRISAT, Professor of Ag. Econ, Department of Agricultural Economics, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, Senior Research Associates, and Visiting Economist at ICRISAT, Patancheru P.O., A.P., respectively.
The objective of this report is to document the dramatic changes in farming systems associated with the adoption of soybeans in five districts and to examine how farmers coped with changing demands for production resources (cropland, labor, draft power, and operating capital). We wish to understand the resource management issues involved and how farmers solved the resource supply problems they encountered.

The report first provides background information on the districts and their farmers, the record of soybean adoption, including yields and incentives for adoption, and discussion of farming system changes for which soybeans served as a catalyst. The latter will serve as an introduction to the following sections where farmer response to changing demand and supply situations for each group of production resources is separately discussed. The report ends with a summary after a discussion of the potential for future continued expansion of soybeans in the districts.

Sources of Information

Information for the report comes from three sources: published and updated districtwise land use and crop data, a formal survey conducted in the spring of 1987 in four of the five districts (Betul, Raisen, Sehore and Seoni) and informal conversations with groups of farmers in all five districts (including Hoshangabad) in April, 1991.

For the 1987 survey, two villages in each of the four districts were selected on the basis of high soybean density and low levels of irrigation since the emphasis of the survey was to
be on rainfed cultivation. Sample farmers within each village were selected to represent the farm size distribution in the village. The survey was a cooperative effort by the Department of Agricultural Economics and Farm Management, Jawaharlal Nehru Krishi Viswa Vidyalaya, Jabalpur (JNKVV), and the Economics Group at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Both groups helped develop the questionnaire for the survey. Dr. R.C. Kashive of Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur supervised the farmer interviews and ICRISAT analyzed the data. The survey included two sets of questions. The first set gathered information on the farm family, land use, and crop marketing for the farm as a whole. A total of 323 questionnaires were completed. The second set focussed on soybean production with 266 farmers completing the questionnaire, all of whom had also answered the first set of questions. The number of completed questionnaires is shown in Table 1 by district.

Table 1. Sample Size and Number of Completed Schedules in Selected Districts of Madhya Pradesh, 1986-87.

<table>
<thead>
<tr>
<th>District</th>
<th>No. of completed general questionnaires</th>
<th>No. of completed soybean questionnaires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raisen</td>
<td>90</td>
<td>37</td>
</tr>
<tr>
<td>Seoni</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Betul</td>
<td>81</td>
<td>77</td>
</tr>
<tr>
<td>Sehore</td>
<td>62</td>
<td>62</td>
</tr>
<tr>
<td>Total</td>
<td>323</td>
<td>266</td>
</tr>
</tbody>
</table>
The April, 1991, information was obtained from groups of farmers in each of the five districts in an unstructured "Rapid Rural Appraisal" format. These conversations were held with groups of farmers in eight villages in the five districts. The farmers were selected on the basis of convenience by our contact people for each village while villages were selected on the basis of soybean density and association with our contact people. We generally ended up talking to larger farmers but smaller farmers participated in most groups. In these conversations, the focus was on the new farming system and production resource management issues associated with the adoption of soybeans. Questions and answers concerned the village as a whole rather than individual farmers.

Agricultural Characteristics of Districts and Farmers

Districts

The location of the five subject districts is shown in Figure 1. Although some are in the Narmada river valley and others are upland, they all have medium to deep vertisol soil and rainfall from 1000 to 1400 mm per year. The traditional, pre-soybean, cropping pattern was dominated by single cropped kharif sorghum and rabi wheat although a wide variety of crops were and are grown in both seasons with some variation among districts. In these five districts, gross cropped area (area of crops in each season added together) expanded faster than net cropped area, (amount of land used for crops in at least one season during the year) between the late 1960's and 1988, resulting in an increase in cropping
starting from an intensity close to 100 (very little double cropping), it increased to 120 or over in two districts and to about 110 in the other three.

Table 2. Change in Cropped Area ('000 ha) and Cropping Intensity (%) in Five Districts of Madhya Pradesh during 1966/68 to 1988/89.

<table>
<thead>
<tr>
<th>District</th>
<th>Gross cropped area</th>
<th>Net cropped area</th>
<th>Cropping intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoshangabad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1966/68</td>
<td>421</td>
<td>418</td>
<td>101</td>
</tr>
<tr>
<td>1988/89</td>
<td>575</td>
<td>455</td>
<td>126</td>
</tr>
<tr>
<td>% change</td>
<td>36</td>
<td>9</td>
<td>25</td>
</tr>
<tr>
<td>Betul</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1966/68</td>
<td>408</td>
<td>382</td>
<td>107</td>
</tr>
<tr>
<td>1988/89</td>
<td>480</td>
<td>409</td>
<td>117</td>
</tr>
<tr>
<td>% change</td>
<td>18</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Sehore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1966/68</td>
<td>335</td>
<td>326</td>
<td>103</td>
</tr>
<tr>
<td>1988/89</td>
<td>448</td>
<td>366</td>
<td>122</td>
</tr>
<tr>
<td>% change</td>
<td>34</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>Raisen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1966/68</td>
<td>365</td>
<td>362</td>
<td>101</td>
</tr>
<tr>
<td>1988/89</td>
<td>468</td>
<td>418</td>
<td>112</td>
</tr>
<tr>
<td>% change</td>
<td>28</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>Seoni</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1966/68</td>
<td>379</td>
<td>371</td>
<td>102</td>
</tr>
<tr>
<td>1988/89</td>
<td>407</td>
<td>360</td>
<td>111</td>
</tr>
<tr>
<td>% change</td>
<td>7</td>
<td>-1</td>
<td>9</td>
</tr>
</tbody>
</table>

Increases in intensity are related to increases in irrigation but not in a precise way (Table 3). A modest amount of rainfed land is double cropped while some irrigated land is single cropped. Irrigation levels were low in all five districts in the late 1960's and had increased to 10 to 19 percent of net cropped area.
area by 1989 in four districts. Hoshangabad is a special case because of canal irrigation from the Tawa river. In the four districts, most of the irrigation is from open and tubewells with substantial expansion in the number of wells continuing to occur in 1991.

Table 3. Change in Irrigated Area (000 ha) in Five Districts of Madhya Pradesh during 1966/68 to 1988/89.

<table>
<thead>
<tr>
<th>District/years</th>
<th>Irrigated area ('000 ha)</th>
<th>Percent of net cropped area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoshangabad</td>
<td>7</td>
<td>195</td>
</tr>
<tr>
<td>Betul</td>
<td>21</td>
<td>61</td>
</tr>
<tr>
<td>Sehore</td>
<td>12</td>
<td>69</td>
</tr>
<tr>
<td>Raisen</td>
<td>4</td>
<td>61</td>
</tr>
<tr>
<td>Seoni</td>
<td>24</td>
<td>36</td>
</tr>
</tbody>
</table>

The area of major crops in the districts is shown in Table 4. By the 1986/88 period, soybeans were grown on more land than any other kharif crop. Rice, sorghum and millets were each grown on well over 100,000 hectares. Other kharif crops with substantial area included maize, niger and sesamum, pigeonpea, khesari, and cotton.

The rabi season is dominated by wheat and chickpea in these districts. Linseed and masoor are each planted on about 60,000 hectares while urad and peas are planted on substantial areas. Broadly, these five districts follow similar cropping patterns of
soybeans and coarse grains in the kharif and wheat and chickpea in the rabi seasons. Large interdistrict differences involve rice, millets, sorghum, sesame and cotton in the kharif and linseed, masoor, and urad in the rabi. Districts also differ in the relative importance of seasonal cropping with Betul, and, to a lesser extent, Seoni, dominated by kharif cropping and Raisen by rabi.

Table 4. Area (000 ha) of Major Crops in Five Districts of Madhya Pradesh (Average of 1986-88).

<table>
<thead>
<tr>
<th>Season/Crop</th>
<th>Hoshangabad</th>
<th>Betul</th>
<th>Sehore</th>
<th>Raisen</th>
<th>Seoni</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharif</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybeans</td>
<td>112</td>
<td>88</td>
<td>99</td>
<td>50</td>
<td>28</td>
<td>377</td>
</tr>
<tr>
<td>Rice</td>
<td>13</td>
<td>33</td>
<td>5</td>
<td>5</td>
<td>88</td>
<td>144</td>
</tr>
<tr>
<td>Millets</td>
<td>10</td>
<td>63</td>
<td>0</td>
<td>1</td>
<td>48</td>
<td>122</td>
</tr>
<tr>
<td>Niger</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>31</td>
</tr>
<tr>
<td>Sorghum</td>
<td>31</td>
<td>73</td>
<td>38</td>
<td>9</td>
<td>16</td>
<td>167</td>
</tr>
<tr>
<td>Khesari</td>
<td>8</td>
<td>0</td>
<td>4</td>
<td>16</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>Pigeonpea</td>
<td>25</td>
<td>23</td>
<td>14</td>
<td>19</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>Sesamum</td>
<td>27</td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>4</td>
<td>49</td>
</tr>
<tr>
<td>Cotton</td>
<td>32</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>41</td>
</tr>
<tr>
<td>Maize</td>
<td>3</td>
<td>13</td>
<td>5</td>
<td>2</td>
<td>8</td>
<td>31</td>
</tr>
<tr>
<td>Mung</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Groundnut</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Rabi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>151</td>
<td>62</td>
<td>114</td>
<td>163</td>
<td>82</td>
<td>572</td>
</tr>
<tr>
<td>Chickpea</td>
<td>88</td>
<td>25</td>
<td>58</td>
<td>92</td>
<td>25</td>
<td>288</td>
</tr>
<tr>
<td>Linseed</td>
<td>25</td>
<td>2</td>
<td>11</td>
<td>13</td>
<td>17</td>
<td>68</td>
</tr>
<tr>
<td>Masoor</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>39</td>
<td>8</td>
<td>60</td>
</tr>
<tr>
<td>Peas</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>Urad</td>
<td>2</td>
<td>26</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>38</td>
</tr>
</tbody>
</table>

Changes in these cropping patterns since the late 1960's are discussed in the Land Resource section below.
Surveyed Farmers

Sample farmers in four districts are assumed to be representative of soybean growers in this major Madhya Pradesh soybean growing area. Selected characteristics are presented in Tables 5 and 6 by district and by farm size.

Table 5. Characteristics of Sample Farmers (323 farmers) in Four Districts of Madhya Pradesh, 1986-87.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Districts</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raisen</td>
<td>Seoni</td>
</tr>
<tr>
<td>Owned land (ha)</td>
<td>4.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Operated land (ha)</td>
<td>4.5</td>
<td>4.4</td>
</tr>
<tr>
<td>% of operated land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cropped</td>
<td>97</td>
<td>63</td>
</tr>
<tr>
<td>Irrigated</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Livestock (no. per farm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bullocks</td>
<td>2.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Cows &amp; Buffaloes</td>
<td>2.1</td>
<td>2.5</td>
</tr>
<tr>
<td>Other animals</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Farm implements per 100 farmers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumpsets</td>
<td>8</td>
<td>26</td>
</tr>
<tr>
<td>Tractors</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Threshers</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Net cropped area (ha) per:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair of bullock</td>
<td>4.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Threshers</td>
<td>2.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Irrigated hectares per pumpset [b]</td>
<td>3.2</td>
<td>1.6</td>
</tr>
</tbody>
</table>

a. Farms with item ; b. Farms with both pumpsets and irrigated land.

Characteristics by District: Farms averaged a little more than 4.5 operated hectares (area owned plus leased in minus leased out) in size with little difference among the districts. They average
about half a hectare of irrigated land (11%) but this did vary among districts from 0.18 hectare in Raisen to 1.08 in Sehore. Only 73% of operated area was actually cropped in 1986/87. Almost no leasing of land, in or out, was reported by these farmers.

All farms averaged almost 2.4 bullocks per farm with all districts averaging more than one pair per farm. Six percent of the farmers owned no bullocks. For other animals, the type of animals kept was similar in all districts but Sehore farmers had more milch animals than other districts. Betul farmers had more "other animals", mostly sheep and goats.

Farms averaged almost 2.8 hectares of net cropped land per pair of bullocks with only one tractor reported by the entire sample. The average pumpset appears to irrigate 1.6 hectares although some irrigation may involve non-pumped water and/or water pumped by an agency other than the farmer such as government. District differences are substantial. Some farmers may also hire out their pumpsets.

Characteristics by Farm Size: Small farms in the sample averaged 1.3 and large, 7.6 operated hectares (Table 6). Small and medium sized farmers cropped just over 80% of their operated land while larger farmers had only 71% under crops. The remainder was fallow all year but may include grazing land. Irrigated area varied with farm size not only in amount but also in the proportion of operated land irrigated. Small farmers irrigated only 9% while large farmers applied water to 29% of their land. Medium sized farmers were intermediate at 23%.


Table 6. Characteristics of Sample Farmers (323 farmers) by Farm Size Groups in Four Districts of Madhya Pradesh, 1986-87.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Farm size group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less than 2 ha</td>
</tr>
<tr>
<td>No. of farmers [a]</td>
<td>65</td>
</tr>
<tr>
<td>Owned land (ha)</td>
<td>1.52</td>
</tr>
<tr>
<td>Operated land (ha)</td>
<td>1.33</td>
</tr>
<tr>
<td>% of operated land cropped</td>
<td>83</td>
</tr>
<tr>
<td>% of operated land irrigated</td>
<td>9</td>
</tr>
<tr>
<td>Livestock (no. per farm)</td>
<td></td>
</tr>
<tr>
<td>Bullocks</td>
<td>1.6</td>
</tr>
<tr>
<td>Cows and buffaloes</td>
<td>1.9</td>
</tr>
<tr>
<td>Other animals</td>
<td>0.6</td>
</tr>
<tr>
<td>Farm implements per 100 farmers</td>
<td></td>
</tr>
<tr>
<td>Pumps sets</td>
<td>12</td>
</tr>
<tr>
<td>Tractors</td>
<td>0</td>
</tr>
<tr>
<td>Threshers</td>
<td>3</td>
</tr>
<tr>
<td>Net Cropped area (ha) per [b]</td>
<td></td>
</tr>
<tr>
<td>Pair of bullocks</td>
<td>1.4</td>
</tr>
<tr>
<td>Threshers</td>
<td>1.5</td>
</tr>
<tr>
<td>Irrigated hectares per Pumpset [c]</td>
<td>0.9</td>
</tr>
</tbody>
</table>

a. Five farmers had leased-out all their land.
b. On farms having the item.
c. On farms with both pumps sets and irrigated area.

In all cases, the number of livestock owned varied directly with the size of farm. Small farmers averaged less than one pair of bullocks while large farmers have more than three bullocks per farm. Bullocks per hectare, however, show the opposite
relationship. On small farms, an average of 1.4 net cropped hectares must carry the fixed cost of a pair of bullocks while on large farms this fixed cost was carried by 3.5 hectares. The same is true for pumpsets. If we assume all irrigation water was pumped by farmers, the fixed cost of one pumpset must be carried by 0.9 hectare on small farms while it is carried by 1.3 hectares on large farms. The capacity of these production resources was underutilized on small farms making them more costly per unit of production unless their capacity was more fully utilized by leasing them to other farmers. Threshers show low levels of adoption in 1987 with only 21 reported by the 323 farmers.

**Soybean Marketing Practices**

Farmers have experienced little difficulty in selling their soybeans at favorable prices in the four districts surveyed. Most farmers retain an average of about 10% of their crop probably for next year's seed, but 25% sell their entire crop (Table 7). This

<table>
<thead>
<tr>
<th>District</th>
<th>Raisen</th>
<th>Seoni</th>
<th>Betul</th>
<th>Sehore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of Soybean:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sold [a]</td>
<td>85</td>
<td>96</td>
<td>90</td>
<td>89</td>
</tr>
<tr>
<td>Sales in village [b]</td>
<td>64</td>
<td>65</td>
<td>56</td>
<td>4</td>
</tr>
<tr>
<td>Sales to Society [c]</td>
<td>0</td>
<td>75</td>
<td>57</td>
<td>41</td>
</tr>
</tbody>
</table>

Table 7. Soybean Marketing by Sample Farmers (323 farmers) in Four Districts of Madhya Pradesh, 1986-87.  

a. Remainder assumed to be kept for seed.  
b. Remainder sold at the market.  
c. Remainder sold to private dealers.
may indicate a shortage of money for debt payment and other needs or poor home storage facilities but it forces them onto the market for their next year's seed, generally more expensive than saving their own seed. The data show little difference among districts except one village each in Seoni and Sehore reported a higher percentage of farmers selling their entire crop.

In three districts, about two thirds of the soybeans are sold to traders in the village while in Sehore almost none is sold there. The remainder is transported to market by the farmer and sold there. Strangely, the reported village prices are higher than market prices (Table 8). Sales to the Oil Federation (Societies) varied among districts from 0 to 75% with prices received averaging the same as from traders. Prices received were the same for small and medium farmers but somewhat lower for large farmers.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>Average price (Rs./quintal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of sales</td>
<td>Village</td>
<td>359</td>
</tr>
<tr>
<td></td>
<td>Market</td>
<td>327</td>
</tr>
<tr>
<td>Type of buyer</td>
<td>Trader</td>
<td>351</td>
</tr>
<tr>
<td></td>
<td>Society</td>
<td>352</td>
</tr>
<tr>
<td>Size of farm</td>
<td>Small</td>
<td>353</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>354</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>326</td>
</tr>
<tr>
<td>District</td>
<td>Raisen</td>
<td>306</td>
</tr>
<tr>
<td></td>
<td>Seoni</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td>Betul</td>
<td>381</td>
</tr>
<tr>
<td></td>
<td>Sehore</td>
<td>323</td>
</tr>
</tbody>
</table>
a relationship opposite to expectations. Average district prices varied from a low of Rs.306 in Raisen to a high of Rs.381 in Betul.

Variety information was not collected from these farmers but other information on their choice of black vs. yellow seeded variety is instructive about the adoption process. In the initial stages of adoption yellow varieties were more popular because of expected higher yield and higher market acceptability. By 1977, however, yellow had declined to 6% of all soybeans grown in Madhya Pradesh. The reason given was that black varieties were more dependable, had high seed viability and grew well under low levels of management (Bisaliah 1986).

Starting in 1978, however, yellow varieties began to increase in popularity and by 1991 had virtually eliminated the black varieties. Farmers have apparently learned to overcome the disadvantages of the yellow varieties through experience and can now receive their advantages.

<table>
<thead>
<tr>
<th>Cropland Value on Surveyed Farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>The market value of cropland is instructive about the overall productivity of land and the general wealth of farmers although other factors such as the prestige and food security aspects of land ownership are important where subsistence agriculture dominates the thinking of land buyers and sellers.</td>
</tr>
<tr>
<td>The 1987 survey asked farmers the value per acre of each crop field. These values are judged to be reasonably accurate because</td>
</tr>
</tbody>
</table>
of differentiation from field to field on the same farm and similarities from farm to farm in a village. A few estimates completely different from general values in a village have been omitted from this analysis.

Average district values of rainfed and irrigated cropland on these surveyed farms are shown in Table 9. The differences between the two types of land are puzzling because digging and equipping an irrigation well apparently costs about Rs.20,000 per hectare plus interest and fees on any borrowed money. A reasonable expectation is that the opportunity to produce a secure second crop each year with the use of predominantly fixed cost inputs of land, family labour, draft power and especially irrigation once the investment has been made, would substantially enhance net income and thus land value. If such an investment enhances the value of the land by less than Rs.20,000, it is not only a poor investment but the land market is saying that productivity increases fall short of paying for the investment. Since this conclusion is inconsistent with 1991 observations of farmer

<table>
<thead>
<tr>
<th>District</th>
<th>Cropped area (ha)</th>
<th>Average value of land (Rs/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rainfed</td>
<td>Irrigated</td>
</tr>
<tr>
<td>Betul</td>
<td>329</td>
<td>129</td>
</tr>
<tr>
<td>Sehore</td>
<td>491</td>
<td>163</td>
</tr>
<tr>
<td>Raisen</td>
<td>932</td>
<td>32</td>
</tr>
<tr>
<td>Seoni</td>
<td>530</td>
<td>73</td>
</tr>
</tbody>
</table>

Table 9. Average Cropped Area (ha) of Sample Farmers in Four Districts of Madhya Pradesh, 1986-87.
investment decisions, the land market may be reacting to less than optimum use of irrigated land or influenced by slow adjustment to its true productivity. More probably, full information is not in hand.

Differences among districts are also instructive, assuming that none of these villages have land values influenced by nearly urban areas. Natural resource endowments, farming systems, and level of adoption of new production increasing opportunities differ from district to district and influence the final cropping outcome and the value buyers and sellers in the land market give to the land. Explanation of these inter-district differences in value must await a study focused on this issue. Data presented below (Tables 21 & 23), however, show that Sehore farmers have a much higher level of using improved crop practices, such as improved varieties and fertilizer, than farmers in the other districts.

Adoption of Soybeans

A few farmers in some of these districts started to experiment with soybeans in the early 1970's and by 1978, 30,000 hectares were reported in the five districts (Table 10).

After 1978, the area of soybeans expanded rapidly and by 1985, the total area in the five districts was 314,000 hectares a 1047 percent increase in seven years. They further increased to 405,000 hectares in 1988. In 1988, soybeans were grown on 20% of the gross cropped area and on 35 percent of kharif cropped land. Latest available all-India data indicate a continuing increase
from about 1.7 million hectares in 1988 to 2.1 million in 1989.

Table 10. Growth in Soybean Area (000 ha) in Five Districts of Madhya Pradesh, 1977 to 1988.

<table>
<thead>
<tr>
<th>Year</th>
<th>Hoshangabad</th>
<th>Betul</th>
<th>Sehore</th>
<th>Raisen</th>
<th>Seoni</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>2</td>
<td></td>
<td>b</td>
<td>1</td>
<td>b</td>
</tr>
<tr>
<td>1978</td>
<td>6</td>
<td>10</td>
<td>12</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1979</td>
<td>15</td>
<td>19</td>
<td>16</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>1980 [a]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981 [b]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>65</td>
<td>62</td>
<td>29</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>1983</td>
<td>73</td>
<td>58</td>
<td>42</td>
<td>30</td>
<td>6</td>
</tr>
<tr>
<td>1984</td>
<td>102</td>
<td>75</td>
<td>67</td>
<td>40</td>
<td>22</td>
</tr>
<tr>
<td>1985</td>
<td>105</td>
<td>72</td>
<td>75</td>
<td>40</td>
<td>22</td>
</tr>
<tr>
<td>1986</td>
<td>101</td>
<td>78</td>
<td>90</td>
<td>42</td>
<td>25</td>
</tr>
<tr>
<td>1987</td>
<td>117</td>
<td>85</td>
<td>97</td>
<td>53</td>
<td>31</td>
</tr>
<tr>
<td>1988</td>
<td>114</td>
<td>96</td>
<td>57</td>
<td>109</td>
<td>29</td>
</tr>
</tbody>
</table>

a. Data missing from data base.
b. Less than 500 hectares.

Source: Districtwise crop data from Agricultural Situation in India and updated by Agricultural Statistician, Government of Madhya Pradesh, Bhopal.

In addition to district wise adoption information above, data on adoption by individual farmers are instructive about the adoption process (Table 11). In the four districts included in the 1987 survey, a few farmers claimed they were growing soybeans in 1970. Participation rates changed only slowly until 1978 when two percent were growing the crop. After 1978, participation rates increased rapidly and by 1986, 95 percent of survey farmers were growing them.

The participation rate is not the only influence on soybean area. The average area grown on farms growing the crop was also increasing. Farmers tend to start with a small area of a new crop. As they gain confidence in their own ability to grow the crop and
in their judgement that the crop provides a good income opportunity for them, they gradually increase this area until constrained (see discussion of constraints below). Even after that, individual farm area can increase as farmers relax perceived constraints, such as land reservation for subsistence crops or time limitations relaxed by mechanization, when the incentives for doing so are judged to be sufficiently strong.

Table 11. Growth of Soybean Production (based on 266 farms) in Eight Villages of Madhya Pradesh, 1970-86 [a].

<table>
<thead>
<tr>
<th>Year</th>
<th>Soybean area on survey farms (percent of 1986)</th>
<th>Farms growing soybeans per farm (ha)</th>
<th>Percent of all survey farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1977</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1978</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>22</td>
<td>0.8</td>
<td>40</td>
</tr>
<tr>
<td>1983</td>
<td>40</td>
<td>1.0</td>
<td>57</td>
</tr>
<tr>
<td>1984</td>
<td>62</td>
<td>1.1</td>
<td>79</td>
</tr>
<tr>
<td>1985</td>
<td>89</td>
<td>1.4</td>
<td>93</td>
</tr>
<tr>
<td>1986</td>
<td>100 [b]</td>
<td>1.6</td>
<td>95 [c]</td>
</tr>
</tbody>
</table>

a. Prior to 1982, based on answers, to the question, "When did you start growing soybeans?" From 1982 to 1986, based on annual data of hectares grown on each farm.

b. A total of 436 hectares of soybeans were grown by these farmers in 1986.

c. In one village, number of growers declined by 50% from 1985 to 1986 because of unfavourable weather. The above figure is normalized by using the 1985 participation rate.

By 1986, these farmers were growing soybeans on 47 percent of their net cultivated area. In contrast, the average for the districts was 18 percent of the net cultivated area, an indication
that survey sampling was done in villages which were well ahead of their districts in their adoption of soybeans. On a district level, soybean area continued to increase after 1986. This expansion probably came from both an increasing adoption rate in other parts of the districts and a continuing increase in soybean area per farm.

Soybean Yields

Soybean yields in Madhya Pradesh vary from year to year but generally average somewhat below 8 quintals per hectare. Survey farmers were asked to state their highest and lowest yields ever obtained (Table 12). While their experience generally included

<table>
<thead>
<tr>
<th>Percent of farmers</th>
<th>18</th>
<th>21</th>
<th>17</th>
<th>19</th>
<th>13</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Yield of all farmers</td>
<td>13.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range of village averages</td>
<td>10.4 to 18.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

only three to six years, this period included 1986 which was a poor year and some quite good years. While both better and worse years can be anticipated, these data give a good picture of the
range of soybean yields from year to year, from farm to farm, and from village to village. These data include those farmers who may have been reporting production from their fields rather than per hectare.

Maximum yields reported by 253 farmers answering this question averaged 13.8 quintals per hectare with village means ranging from about 10 to almost 19 quintals. Eighteen percent of the farmers reported maximum yields of less than one ton while 12 percent had yields of 2 tons or more. Note that these averages mix irrigated and rainfed crops but since soybeans are grown in the kharif season, irrigation is a major factor only when prolonged dry periods occur in the monsoon. One farmer reported about 60 quintals per hectare and six other farmers in the same village, reported maximum yields ranging from 30 to 59 quintals. They may, however, have answered in terms of their fields instead of per hectare or per acre.

Lowest yields reported by the same farmers averaged 5.7 quintals (Table 13). Village means varied from 4.7 to 7.9 quintals. No farmer reported zero yield and only five percent harvested less than 2.5 quintals in their worst year. About a quarter of the farmers had lowest yields greater than 7.2 quintals and several farmers reported lowest yields that were higher than the highest yields of some other farmers.

This lowest yield information gives perspective to the farmers' definition of crop failure. Farmers in all villages visited in 1991 judged that out of five years, soybean yields will

<table>
<thead>
<tr>
<th>Percent of farmers</th>
<th>5</th>
<th>30</th>
<th>38</th>
<th>27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average yield of all farmers</td>
<td>5.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range of village averages</td>
<td>4.7 to 7.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

be good in two years, fair to poor in two years and a crop failure in one year. Crop failure does not mean "failure to harvest anything". A crop is apparently generally judged a failure if the gross value of the harvest is less than the out-of-pocket costs of growing the crop. This may be a new concept since it is clearly a commercial rather than a subsistence definition and may be one of several examples of changed thinking brought to this agriculture by soybeans.

Incentives to Adopt Soybeans

When farmers make a change of this magnitude and speed, the existence of sufficient incentive to encourage them to do so is clear. These incentives have been documented by several researchers starting in 1972 (Kashive and Williams, 1972, Kashive, 1982, Bisaliah, 1986, Singh, 1988).

Table 14 indicates the nature of this incentive in 1981 at the time the soybean expansion was gathering momentum. Net returns
from either type of soybeans (Rs.800 and Rs.1350 per ha) were reported to be much greater than the main kharif competitor crop, sorghum, with its net return of Rs.100. The return per rupee of cost is also greater for soybeans than for kharif sorghum. Since sorghum was primarily a subsistence crop at the time (grain and fodder), the comparison was more complex than is implied in Table 14 but the commercial incentive was clear and farmers responded to it.

Soybeans may also compete with rabi crops through their impact on rabi soil moisture in rainfed land. The production of soybeans may eliminate the possibility of a following rabi crop on the same land. Soybeans exceeded returns from rabi wheat and chickpea by substantial margins. These rabi crops, however, were primarily subsistence crops. The risk of rabi crop failure after

Table 14. Costs and Returns (Rs/ha) of Selected Crops in Madhya Pradesh, 1981-82.

<table>
<thead>
<tr>
<th>Season/Crop</th>
<th>Total cost</th>
<th>Gross return</th>
<th>Net return</th>
<th>Net return per rupee of cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharif</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sole soybean (black)</td>
<td>1100</td>
<td>1900</td>
<td>800</td>
<td>1.7</td>
</tr>
<tr>
<td>Sole soybean (yellow)</td>
<td>1450</td>
<td>2800</td>
<td>1350</td>
<td>1.9</td>
</tr>
<tr>
<td>Soybean intercropped</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with sorghum</td>
<td>1300</td>
<td>2450</td>
<td>1150</td>
<td>1.9</td>
</tr>
<tr>
<td>Sorghum</td>
<td>800</td>
<td>900</td>
<td>100</td>
<td>1.1</td>
</tr>
<tr>
<td>Rabi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>850</td>
<td>1100</td>
<td>250</td>
<td>1.3</td>
</tr>
<tr>
<td>Chickpea</td>
<td>850</td>
<td>900</td>
<td>50</td>
<td>1.1</td>
</tr>
<tr>
<td>Groundnut</td>
<td>1300</td>
<td>2100</td>
<td>800</td>
<td>1.6</td>
</tr>
</tbody>
</table>

soybeans virtually eliminated soybean production on land planned for these rabi subsistence crops in the beginning of the soybean era but, as discussed below, by 1991, this constraint was being relaxed by some farmers.

The Impact of Soybean Adoption on Farming Systems

The coming of soybeans to these five districts can be divided into three phases. The 1970's saw a gestation period of tentativeness and experimentation. A few innovative farmers were gaining experience and developing an understanding of management requirements, varietal differences and how to accomplish associated tasks such as harvesting and threshing. At the same time, seed supply, a marketing system, processing facilities and other infrastructural requirements gradually developed, based on a perceived optimistic view of the future of soybeans and government stimulation.

By 1979 when the adoption phase began, soybean opportunities were clear to farmers. Both the knowledge base among farmers and the infrastructure were ready for them to take advantage of this opportunity. In those villages where the phase was ending in 1986, most farmers were growing soybeans and average area per farm had doubled. But little else had changed. The 1987 survey showed continuing low levels of mechanization and other inputs and only modest changes in attitude toward the commercialization of the agriculture. Apparently this was a period of concentration on learning how to grow and sell soybeans and of building confidence
in the soybean future. Farmers were not yet ready to make the
dramatic and fundamental changes which seemed generally to begin
after 1986.

This third and continuing adjustment phase was observed in
1991. It is by no means yet ended but its nature is clear. On
those farms and in those villages which have mostly moved through
phase 3, the agriculture is commercialized, specialized,
mechanized, irrigated and prosperous, all major characteristics of
a developed agriculture. Once the adoption process became
consolidated, farmers began to perceive opportunities both made
possible by and required by soybeans and rapidly produced a
developed agriculture.

Soybeans were a commercial crop from the beginning. In the
1987 survey, only three percent of the farmers reported ever
eating them and in all cases, it was only once. However, a truly
commercial attitude toward the entire farm appears to be a recent
development where almost all management decisions, from crop
selection to input choice and amount, and on to marketing are
based on net income maximization. The farm family may continue to
consume some of the home produced food and fodder but they have
become willing to depend on the bazaar when this has income
advantages for them. For example, 14 of the 323 surveyed farmers
single cropped sole soybeans on all their land in 1986 and
presumably purchased family needs. This new mindset was clearly
articulated by a farmer in 1991 who said, "Now we need to think
like a businessman to survive".
Along with this new understanding of the goal of farming (maximum net income instead of food security for the family) has come from crop specialization. The common crop system on farms near the end of phase 3 is kharif soybeans and irrigated rabi wheat. While crop data presented above show that most farmers have not completed the transition to this extreme specialization in these districts, many have done so. As farmers search for maximum net income, they tend to expand the most profitable crops and drop the production of others. This is a dynamic process, however, and while soybeans and wheat appear to be most profitable at the moment, farmers with this new commercial outlook will continue to search for even more profitable opportunities. Sugarcane, sunflowers, and rabi soybeans were mentioned in our 1991 conversations and we observed a successful experimental (farmer's experiment) field of rabi soybeans. This latter possibility, though, is being discouraged by soybean scientists because of potential expansion of disease and insect problems if the crop were to become common in two seasons of the year.

With the new commercialized mindset, farmers began to use new soybean income to make new farm investments. The 1987 survey found only one tractor and 21 power threshers among 323 sample farmers. By 1991, tractors were common and most wheat and probably soybeans were being threshed by threshers. In one village, the farmers said the pre-soybean to 1991 count was 1 to 60 tractors and from zero to 50 motorcycles. The same can be said for the expansion of irrigation as an investment in additional productivity and net
income. In one village, soybean income facilitated the expansion of irrigation from 20 to 95 percent of total cropland in the village and the development of specialized cropping discussed above (one percent of kharif cropped land was being reserved for groundnuts). Much of this investment facilitated soybean expansion and apparently soybean income paid for it. Farmers are also using soybean income to buy more cropland.

Although some new income was being used for increased consumer durables (motorcycles, electricity, etc.), these farmers are choosing productive investments in their farms before they build new houses. We saw practically no brick or concrete houses in these villages, evidence of a truly commercial mindset. In many parts of developing agriculture, new income means a new house but apparently not in Madhya Pradesh.

Although we collected no data in 1991, this soybean/wheat agriculture is prosperous. Not only is this clear from the above discussion but it is also clear from farmer response. Generally farmers are reluctant to show enthusiasm to an outsider for favorable outcomes but when we asked these farmers if soybeans have been good for them, we always got broad grins and enthusiastic "yeses".

With these insights into the coming of soybeans to Madhya Pradesh, we are now ready to consider farmer solutions to the production resource problems they encountered as they moved from about 6,000 to 400,000 hectares of soybeans in 11 years.
Production Resource Adjustments

The rapid and substantial increase in soybean area in these five districts between 1977 and 1988 involved major adjustments in the use of production resources, land, labor, draft power, and operating capital. The reader is asked to contemplate the level of resources involved in cultivating this many hectares of a new crop. In addition to the 400,000 hectares of land, this effort involved an estimated 40 million person days, 8 million bullock team days. (use of tractors would involve less time) and up to Rs.200 million of operating capital. As is indicated below, the increase in soybeans was accompanied by an increase in the total area of all other crops. Thus these resource levels are additional requirements associated with the coming of soybeans. The ways in which farmers fitted these new resource demands into their on-going farming systems are explored in the following sections.

Land Use Adjustments.

The central land question involves the source of land for this new crop. The impulsive answer would be that it stole land from other crops. Other possibilities would include expansion of cultivated area and expansion of double cropping.

Crop substitution: Changes in the areas of major crops over a 20 year period, including the soybean growth period, are shown in Table 15. In addition to soybeans, major shifts involved expansion of rice, wheat, pulses and chickpea and declines in sorghum, sesamum and other crops. Independently from soybeans, farmers were responding to changing market signals, and changing their crop
mixes during this period. The "Green Revolution" appears to have influenced these farmers directly by increasing the attractiveness of wheat and rice and indirectly by reducing the production of pulses and chickpeas elsewhere and raising their relative prices. The increase in irrigation was, no doubt, a factor for rice and wheat.

Table 15. Changes in the Area (000 ha) of Individual Crops during 1966-68 to 1986-88 in Five Districts of Madhya Pradesh.

<table>
<thead>
<tr>
<th>Crop</th>
<th>3 Year Average Area 1966-68</th>
<th>Percent change in area</th>
<th>Percent change in proportion of gross cropped area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharif crops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybeans</td>
<td>0</td>
<td>377</td>
<td>-6</td>
</tr>
<tr>
<td>Rice</td>
<td>125</td>
<td>143</td>
<td>-14</td>
</tr>
<tr>
<td>Sorghum</td>
<td>225</td>
<td>167</td>
<td>-26</td>
</tr>
<tr>
<td>Pulses [b]</td>
<td>146</td>
<td>251</td>
<td>+72</td>
</tr>
<tr>
<td>Maize</td>
<td>29</td>
<td>31</td>
<td>+7</td>
</tr>
<tr>
<td>Groundnut</td>
<td>36</td>
<td>8</td>
<td>-78</td>
</tr>
<tr>
<td>Sesamum</td>
<td>77</td>
<td>49</td>
<td>-36</td>
</tr>
<tr>
<td>Rabi crops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>488</td>
<td>571</td>
<td>+17</td>
</tr>
<tr>
<td>Chickpea [a]</td>
<td>217</td>
<td>288</td>
<td>+33</td>
</tr>
<tr>
<td>Other crops</td>
<td></td>
<td>581</td>
<td>-22</td>
</tr>
<tr>
<td>Total without soybeans</td>
<td>1924</td>
<td>1960</td>
<td>+2</td>
</tr>
<tr>
<td>Total with soybeans</td>
<td>1924</td>
<td>2337</td>
<td>+21</td>
</tr>
</tbody>
</table>

- Adjusted to include only the current area of Sehore District. Bhopal District was set off from Sehore in 1972.
- Includes pigeonpea, masoor, peas, urad, mung and khesari.
- Since soybeans were not grown in 1966-68, percent change cannot be calculated.
- Includes 122,000 hectares of millets and 68,000 hectares of linseed in 1986-88.
For our soybean analysis, however, we are interested in total area changes of all crops except soybeans. In the 20 year period, the area of these crops actually increased by 36,000 hectares. In the total picture, soybeans did not substitute for other crops. The production resource needs for soybeans, as well as those for the 36,000 hectares, are all additional requirements of this agriculture compared to the late 1960's.

This does not eliminate the possibility of substitution on individual farms, however, as farmers made room for soybeans. One possibility would be for soybeans to substitute for kharif sorghum and then be followed by rabi chickpeas as an addition to double cropping.

Survey farmers were asked if soybeans substituted for or replaced any crops on their farms on rainfed land in either the kharif or rabi season. Eighty percent identified substitution in the kharif season when soybeans are grown and 35% saw substitution of rabi crops (Table 16).

Among kharif crops losing land to soybeans, sorghum was most often mentioned by farmers. Maize, rice, and pigeonpeas had about equal number of mentions and a few farmers mentioned finger millet and groundnuts. Note that most of these crops could be subsistence crops, especially on smaller farms. Soybean competition with rabi crops is limited to single cropped rainfed lands. About 35% of all farmers mentioned this competition with wheat most commonly losing area to soybeans. Most of the rabi crops mentioned would also be subsistence crops on smaller farms. In fact, only 10% of all wheat
(rainfed and irrigated) in Madhya Pradesh enters the market (CIMMYT, 1991).

Table 16. Substitution of Soybeans for Other Crops on Rainfed Land (based on 266 Soybean Farmers) in Eight Madhya Pradesh Villages, 1986-87.

<table>
<thead>
<tr>
<th>Particular</th>
<th>Kharif season</th>
<th>Rabi season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of farmers identifying substitution</td>
<td>214</td>
<td>92</td>
</tr>
<tr>
<td>Number of mentions of: (a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Paddy</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Pigeonpea</td>
<td>35 (two season crop)</td>
<td></td>
</tr>
<tr>
<td>Finger Millet</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Groundnuts</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Chickpea</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Linseed</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Paddy</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

a. Farmers mentioned as many crops as they wished.

Perceptions gained during visits to villages in the five districts in 1991 reinforce the impression of the substantial power of soybeans to steal land from other crops in the area on both irrigated and rainfed land. On irrigated land, soybean farmers have shifted almost completely to a kharif soybean/rabi wheat rotation. To the extent that irrigated land has increased and that farmers have adopted this rotation, other crops have been reduced. In one village, a farmer spoke up from a group of about 15 farmers and said "Sorghum khatam (finished), maize khatam, paddy khatam, millet khatam, groundnut khatam, mung khatam, everything khatam" (excepting soybeans and wheat).
Expansion of Net Cropped Area: New land for soybeans could come from an increase in the net area being cropped. Table 17 shows that this did occur in these five districts. The total increase amounted to 146,000 hectares with one district showing little change while the other had increases varying from 8 to 15 percent.

Although not of direct interest in this study, an obvious question involves the source of this new cropland. Two answers seem relevant. The 1987 survey indicated that sample farmers were cultivating only 73 percent of their operated land (owned land plus rented in and minus rented out). Over time, farmers may have found ways to increase that percentage thus increasing the actual amount of land they crop.

Table 17: Change in Net Cropped Area (000 ha) during 1966-68 to 1986-88 in Five Districts of Madhya Pradesh.

<table>
<thead>
<tr>
<th>District</th>
<th>Net cropped area</th>
<th>Percent change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoshangabad</td>
<td>418</td>
<td>453</td>
</tr>
<tr>
<td>Betul</td>
<td>382</td>
<td>402</td>
</tr>
<tr>
<td>Sehore</td>
<td>326 [a]</td>
<td>364</td>
</tr>
<tr>
<td>Raisen</td>
<td>362</td>
<td>417</td>
</tr>
<tr>
<td>Seoni</td>
<td>371</td>
<td>369</td>
</tr>
<tr>
<td>Total</td>
<td>1859</td>
<td>2005</td>
</tr>
</tbody>
</table>

---

a. The current Bhopal District was separated from Sehore District in 1972. The figure is an estimate for the current area of Sehore District based on percentage in the districts at the time of division.
Studies have also shown that common land in many villages of India is gradually being encroached upon (Jodha, 1991). If encroachment is occurring in these districts, it would be a source of land added to net cropland. While this source of new cropland apparently supplied 146,000 hectares, the major source of new land for soybeans has not yet been found. Increase in Double Cropping:

Under several circumstances, farmers in these districts have an option to grow two crops per year on the same land (kharif and rabi seasons) thus increasing gross cropped area with no change in net cropland. Traditionally, this has been a single crop area with double cropping on only about 3% of net cropland in 1968-69.

Double cropping has increased substantially since the late 1960's with much of it coming in the 1980's (Table 18). A total of 257,000 ha has been added to gross cropland in 20 years with a consequent increase in cropping intensity to 118.

Table 18. Increase in Double Cropped Area (000 ha) in five Districts of Madhya Pradesh.

<table>
<thead>
<tr>
<th>District</th>
<th>Double cropped area</th>
<th>Increase during 1968/69 to 1986/88</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoshangabad</td>
<td>3</td>
<td>55</td>
</tr>
<tr>
<td>Betul</td>
<td>28</td>
<td>55</td>
</tr>
<tr>
<td>Sehore</td>
<td>11</td>
<td>38</td>
</tr>
<tr>
<td>Raisen</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>Seoni</td>
<td>27</td>
<td>29</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>71</strong></td>
<td><strong>201</strong></td>
</tr>
</tbody>
</table>
Double cropping is found on both irrigated and rainfed land. Since district data do not separate the two types of land, an attempt to do so using 1986 survey data is shown in Table 20. The practice is much more likely to be successful on irrigated land and many farmers double crop all their irrigated land. Through both canal schemes (mainly in Hoshangabad) and well drilling and digging, irrigated land has increased by 343,000 hectares (534%) in 20 years in the five districts (Table 19).

Table 19. Increase in Irrigated Area (000 ha) in Five Districts of Madhya Pradesh.

<table>
<thead>
<tr>
<th>District</th>
<th>Area irrigated</th>
<th>Increase during 1968/69 to 1988/89</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1968-69</td>
<td>1982-83</td>
</tr>
<tr>
<td>Hoshangabad</td>
<td>8</td>
<td>114</td>
</tr>
<tr>
<td>Betul</td>
<td>26</td>
<td>47</td>
</tr>
<tr>
<td>Sehore</td>
<td>15</td>
<td>36</td>
</tr>
<tr>
<td>Raisen</td>
<td>4</td>
<td>32</td>
</tr>
<tr>
<td>Seoni</td>
<td>26</td>
<td>28</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>79</td>
<td>257</td>
</tr>
</tbody>
</table>

Not all irrigated land, however, is double cropped as can be seen by comparing Tables 18 and 19. Information on why farmers fail to double crop some irrigated land is not in hand. It may be because of inadequate or undependable water supply (especially from the canals in Hoshangabad) or because farmers have not yet adjusted their farming systems to their new opportunities.
Table 20. Estimates of Double Cropped Land (000 ha) Based on Sample Farms and District Data in Four Districts of Madhya Pradesh, 1986-87.

<table>
<thead>
<tr>
<th>District</th>
<th>Based on sample farms</th>
<th>Total based on district data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Irrigated Rainfed Total</td>
<td></td>
</tr>
<tr>
<td>Raisen</td>
<td>19 7 26</td>
<td>36</td>
</tr>
<tr>
<td>Seoni</td>
<td>12 55 67</td>
<td>34</td>
</tr>
<tr>
<td>Betul</td>
<td>32 17 49</td>
<td>53</td>
</tr>
<tr>
<td>Sehore</td>
<td>43 38 81</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
<td>106 117 223</td>
<td>176</td>
</tr>
</tbody>
</table>

On the sample farms, 60% of irrigated land was double cropped in 1986-87. Only about one third was double cropped in two districts and about two thirds in the other two. An estimated 106,000 irrigated hectares were double cropped in that year in the four districts, leaving 70,000 irrigated hectares single cropped.

Double cropping on rainfed land is less common with only eight percent double cropped on sample farms. In one district, however, farmers were attempting two crops per year on almost 16% of their rainfed land. The survey did not provide information on trends in this practice but farmers are clearly learning about field conditions and cultivation practices which are likely to result in success. An estimated 117,000 hectares of rainfed land were double cropped in 1986-87 in these four districts.

Table 20, however, indicates that this attempt to divide double cropped land into irrigated and rainfed components has not been particularly successful. Sample farmers were generally not
representative of their districts, at least for these data. Double cropping was substantially over estimated in two districts and somewhat underestimated in the other two, assuming that the district figures are correct. The data show, however, that substantial areas of both irrigated and rainfed land are double cropped in these districts. If the total based on district data and the irrigated total are assumed to be correct, total double cropped rainfed land would be 70,000 hectares.

Sample farmers were asked if they have ever planted rabi crops after soybeans in rainfed conditions. Among all farmers, 22% answered "yes" (Table 21). Sehore farmers show a much greater interest in double cropping with 68% having tried it. Chickpeas

Table 21. Rainfed Rabi Crops after Soybeans based on 266 Sample Farmers in Four Districts of Madhya Pradesh, 1986-87.

<table>
<thead>
<tr>
<th>District</th>
<th>Raisen</th>
<th>Seoni</th>
<th>Betul</th>
<th>Sehore</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>37</td>
<td>70</td>
<td>77</td>
<td>62</td>
<td>266</td>
</tr>
<tr>
<td>Farmers who had tried rainfed rabi crops after soybean (%)</td>
<td>11</td>
<td>3</td>
<td>4</td>
<td>68</td>
<td>20</td>
</tr>
<tr>
<td>Crop used (% of experienced farmers):</td>
<td>Wheat</td>
<td>Chickpea</td>
<td>Pulses</td>
<td>75</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>66</td>
<td>64</td>
</tr>
<tr>
<td>Opinion about rabi yield after soybeans [a]</td>
<td>Experience of farmers (%)</td>
<td>Lower</td>
<td>Higher</td>
<td>No effect</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>76</td>
<td>9</td>
<td>67</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>67</td>
<td>17</td>
<td>17</td>
<td>51</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>26</td>
<td>23</td>
<td>32</td>
<td>53</td>
</tr>
</tbody>
</table>

a. Compared to single cropped rabi yields.
were the most common crop tried after soybeans but wheat was a surprisingly close second. Chickpeas are generally thought to be more tolerant of moisture stress and thus more successful after soybeans or other kharif crops.

The probability of enough moisture for a successful rabi crop after soybeans is generally thought to be one year in three in this area (Pandey, 1986). This can vary from field to field, however, depending on land elevation within its watershed, soil management, time of soybean planting and harvest and other factors. One farmer got a normal rabi crop after soybeans when rains had ended in mid August in 1986 (Foster, et al 1987). Farmers have the opportunity to judge moisture conditions at rabi planting in October. The low percentage of sample farms who have tried rabi crop after soybeans is surprising in view of the probability that they would be successful, and they could know this at planting time, in one year out of three.

It is more surprising based on answers about rabi yields after soybeans. Among those who tried double cropping, 54 percent said double cropped rabi yields were higher than single cropping the same crop and only 32% judged them to be lower. Moisture stress can explain the lower yields while improved nitrogen from legume soybeans could explain higher yields provided moisture is not limiting. The low level of even having tried rabi crops after soybeans may be a transition from old practices to new, partly influenced by the fact that most rabi crops have been subsistence crops and are managed with extreme risk averse conservatism.
Intercropping of soybeans with either a second kharif crop or a dual season crop such as pigeonpea is another cropping alternative. Most farmers reported a preference for sole cropping soybeans but 22% preferred intercropping (Table 22). Sehore farmers have substantially more interest in intercropping than farmers from other districts, the same district relationship as for double-cropping.

Table 22. Preference for Soybeans as Sole, Intercrop, and for Companion Crop (based on 266 Farmers) in Eight Villages of Madhya Pradesh, 1986-87 [a].

<table>
<thead>
<tr>
<th>Preference</th>
<th>Percent of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefer</td>
<td></td>
</tr>
<tr>
<td>Sole crop</td>
<td>78</td>
</tr>
<tr>
<td>Intercrop</td>
<td>22</td>
</tr>
<tr>
<td>Companion Crop [b]</td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>55</td>
</tr>
<tr>
<td>Maize</td>
<td>41</td>
</tr>
<tr>
<td>Pigeonpea</td>
<td>12</td>
</tr>
</tbody>
</table>

a. Includes both rainfed and irrigated cropland.
b. Percent of farmers preferring intercrop. Some farmers named more than one crop.

Among the preferred crops for intercropping, sorghum was the most popular, closely followed by maize with a few farmers preferring a mixture of these two crops. Of the few who prefer the soybean/pigeonpea combination, almost all are in Raisen District where it was preferred by two thirds of the intercropping farmers. Maize was the dominant choice in Sehore.

Summary: Room for the 3-year average of 377,000 hectares of soybeans plus 36,000 added hectares of other crops in these five
districts came from a 146,000 hectare increase in new cropland (increase in net cropped area) and 257,000 hectares of additional double cropping on both irrigated and rainfed land, a total of 403,000 hectares. This does not imply that soybeans were grown exclusively on this land but that these land resources became available at the same time soybeans were being added to the crop system. In practice, since soybeans are kharif crop, reductions occurred in kharif fallow and some sorghum and millet was apparently replaced by soybeans. Other adjustments were made in the total system to produce the 1988-89 crop mix.

Labor Resource Adjustments

Soybeans require labor for seedbed preparation and planting, hand weeding, hand harvesting and threshing. Weeding averages about 25 person days per ha (one hand weeding after interculture with a dora - a small bucker) and harvesting requires about 30 person days. In addition, soybeans have tended to increase crop specialization which results in labor needs becoming concentrated in short blocks of time according to the needs of the specialized crops. The following information comes primarily from the 1991 conversations with farmers since the 1987 survey included no questions on labor use.

The impact of crop specialization and labor demand concentration can be illustrated by an hypothetical but typical comparison. Assume a 5 hectare farmer prior to soybeans and irrigation. He might have planted 2 hectares of several single cropped kharif crops with kharif fallow on three hectares. Then in
In the rabi season, he would use the three hectares for several rabi crops with the two hectares in rabi fallow, except for any pigeonpeas interplanted in the kharif crop. Not only did this system spread labor requirements between kharif and rabi seasons but within each season, the labor demands were stretched out by the varying planting, weeding and harvest dates of the different crops. Family labor, with occasional help from hired village residents for peak labor periods could accomplish all the work.

Now assume this farmer has changed to a soybean-wheat specialized and irrigated double cropped system (as we have seen, an extreme but common adjustment). Not only does he/she now have all five hectares to plant and harvest in each season (and to weed in the kharif) but also labor needs are concentrated into short time periods because all land is growing a single crop in each season and all hectares need attention at about the same time. Of course, the gross cropped area has doubled and cropping intensity has changed from 100 to 200.

Adjustment to these new labor demands has involved a combination of two approaches. Farmers have brought in migrant labor from relatively nearby (upto 100 km) tribal (jungle) areas and have mechanized. Family and local hired labor may also work more days per year. Specific adjustments for each major labor demand period are identified below.

Seedbed Preparation and Planting: The soybean planting task presents a major labor and draft power challenge but these resources are not generally now a constraint on acreage planted.
The labor is supplied primarily by the family often with some local hired labor.

Seedbed preparation is almost entirely done after wheat harvest and before the monsoon rains begin in June. This 1.5 month period is more than adequate for the task, especially when rabi threshing time is reduced with the use of power threshers. While it is possible for bullocks to accomplish the job in this dry, hard soil, the availability of extra power from tractors, now common in many of these areas, has greatly facilitated quality seedbed preparation. One last harrowing after the rains begin and just before seeding is used to destroy weed seedlings. The soybean planting task, itself, is strongly influenced by the weather in the first few weeks of the monsoon. Because of rain or lack of it, the soil in this period is often too wet or too dry to plant. The periods of suitable soil moisture conditions are unpredictable and likely to be short. Since planting should ideally be completed by July 5 and definitely by July 15 in order to complete harvesting and facilitate timely rabi planting, the weather, in the past, could easily limit the area of soybeans planted.

Farmers have solved this constraint by using seed drills, either bullock or tractor drawn. Bullocks can plant about 1.25 hectares per day and tractors about 6 hectares. If planting by bullocks is seriously delayed, farmers now have the option of hiring tractor equipment. Note that the average soybean area per farm among farmers in the 1987 survey was 1.6 hectares. One farmer reported 10 hectares and 11 had 4 or more hectares.
Weeding: Soybeans quite quickly develop a leaf canopy which discourages further weed growth. Farmers do hope to do one interculture and one quick hand weeding with the help of family and local hired labor unless prevented by the weather. Hand weeding can be costly, however, up to Rs.370 per hectare. Some farmers reported trying herbicides but were not enthusiastic. While they did a fair job and were cheaper than hand weeding, they were not effective on all weeds which then matured and provided a new weed seed supply. Farmers also experienced reduced effectiveness due to adulterated herbicide.

Harvesting: The soybean harvest season sees the largest and most time constrained period of labor demand. In addition to the soybeans, other kharif crops must be harvested and threshed and rabi crops planted after their seedbed is prepared. All this must be accomplished in a period tightly bounded by the onset of kharif crop maturity on one side and the approach of minimum levels of soil moisture for rabi planting on the other.

For most farmers, soybean harvest must be accomplished in the seven days between minimal maturity and shattering from over maturity. The more sophisticated farmers can sometimes stretch this period out to a maximum of 15 days by careful selection, at planting time, of a mix of varieties with different maturities and monitored planting dates. The large number of soybean hectares in a village cannot possibly be hand harvested within this short period with local labor. The job is contracted out to nearby tribal people who can spare the time from their own cultivation
and forest collection activities in that season. The wages are outrageous, in the view of farmers - a range of from Rs.25-40 per day for the short period. In one village, we got an estimate of 3000 person days of harvest labor from outside the village. Assuming a seven day harvest period, about 400 laborers are hired by farmers in that one village. At Rs.25/- day, these laborers were paid a total of Rs.75,000 in a seven day period, bringing tribal people into the cash economy with the two harvest seasons per year.

Farmers sometimes lose soybean production because harvest is incomplete at the time when shattering become serious. They told us they feel at the mercy of the laborers during the harvest season because lack of labor can result in a lost crop. Many farmers have developed contact with a particular group of workers and hire the same group year after year which, they said, makes the job of procurement and management of the labor much more secure. One farmer told us that he bought his first tractor in 1990, partly for the purpose of transporting this labor from their villages to his farm. This job of labor procurement and management also occurs for the wheat harvest season although the time constraints are less severe than for soybeans.

The high cost of harvest labor plus its procurement, transport, management and risk of crop loss from incomplete harvest is encouraging farmers to consider the hiring of combine threshers. These threshers are new on the scene and are usually owned and used in the Punjab. Because of slightly different
harvest seasons, they can be driven to Madhya Pradesh and services offered for the current price of wheat at Rs.26/- qtl. about half the wage cost of hand harvesting. In 1991 they were seldom used for soybeans but their use was increasing for wheat in spite of disadvantages. For wheat these include loss of heads on short/bent over stems and about a 5% shattering loss over hand harvest. Most important is the loss of straw (bhusa) left in the field because the combine needs to minimize the amount of material fed into the machine. It cuts the wheat just under its heads. Farmers with livestock must depend on this straw (at the plant base when hand harvesting) as their major source of fodder for the year so these farmers will be reluctant to use the combine on wheat until they shift to tractor cultivation and no longer have bullocks to feed. Even then, they may wish to retain some straw to continue feeding milch cows and other livestock. These disadvantages are less problem with soybeans because the combine must harvest most of the plant and because soybean straw is not a particularly good fodder².

Reasons for low combine use on soybeans were, unfortunately, omitted from our conversations with farmers. Limited throughput

² A problem for wheat farmers using the combine is how to cope with the straw left in the field. It can be incorporated into the soil when tractor power is available but farmers found this causes a yield decline in the following kharif crop of soybeans. The bacteria involved in rotting the straw tend to steal nutrients from the soybeans. The common solution is to burn the standing straw and we saw numerous example of this procedure. It is sad to see this happening on this low organic matter soil when the effects on the soybeans can easily be eliminated by correct use of chemical fertilizers. On the other hand the rotting straw may stimulate the population of white ants (termites) which can damage subsequent standing crops.
per combine in the seven day harvest season may make the trip from the Punjab unattractive and may also discourage local ownership of combines. Uneven topography plus delays and high transaction costs resulting from small areas per farm, including set-up and take-down of the machine at each farm, may also discourage combine owners. Soybeans may be difficult for the machines to completely pick up. These factors will all increase costs of using combines and hand harvesting may currently be cheaper.

Hand harvested soybeans must then be threshed. Traditional threshing and winnowing with the use of livestock trampling, or sometimes tractors and road vehicles is also a high consumer of labor. In the 1987 survey, only 21 power threshers were reported by the 323 interviewed farmers. Casual observation in the spring of 1991, just after wheat harvest, gave the impression that power threshers have now been widely adopted. These threshers produce characteristically shaped piles of straw which were commonly seen in all villages. The speed of power threshers is particularly important for soybeans when double cropping is planned because it reduces threshing time in this high labor demand season. Some migrant labor stays to help with threshing soybeans and to help with rabi seedbed preparation and planting.

Rabi planting: The last area of labor demand to be discussed is the rabi seedbed preparation. Most irrigated land and some rainfed soybean land is planted to a rabi crop under time constraints mentioned above for good yields of rabi crops. The last date for planting is generally about Nov 15 on irrigated land and before
this on rainfed land. In one district with canal irrigation, planting is often delayed (upto January 15) by delays in water arrival in the canals with consequent losses in yield.

No farmer reported a problem in getting rabi crops planted on time in terms of labor and draft power availability. This results from the combination of sufficient bullocks or tractors for land preparation, power threshers for soybeans, and use of migrant labor. Farmers generally said they needed and had a month after soybean harvest to get the planting completed.

Summary: It can be summarised that the total effect of soybeans on labor has been to increase total demand and to concentrate it into short periods of time. Farmers have solved this management problem by both hiring outside labor for critical periods and new mechanization, especially seed drills, power threshers, and tractors. The process of adjustment is continuing with increasing interest in combines although costs may currently be higher than for hand harvest. It appears stalled in the case of hand weeding because of farmer dissatisfaction with herbicides and the lack of cultivators which do an adequate job of weed control in this soil. At present, labor supply does not appear to constrain total soybean production and, with the increasing use of machines, is not likely to constrain it in the future. Study of the level of hand harvest wages which will make combines attractive would be useful. Widespread use of combines will tend to eliminate these new wage labor opportunities for tribal people.
Draft Power Resource Adjustments

The impact of soybeans on the draft power resource are generally similar to the impact on labor and have been implied in the labor discussion above. The following summary focuses on how farmers have managed to meet draft power demands.

In early 1987, only one tractor was reported by the 323 surveyed farmers. In one village in 1991, we were told the number of tractors in the village had increased from one to 60 since soybeans had been widely adopted. Other visited villages appeared to have experienced equivalent increases in tractors. These investments in tractors, probably made possible by soybean income, have had major impacts on the draft power situation since tractors are both more powerful and faster than bullocks. On the other hand, at present, more work is probably done by bullocks than tractors in these districts.

Large acreages of soybeans can be planted in a short time. The use of power threshers and combines permit plowing to start soon after rabi harvest when the soil is softer than later in the hot season. This is particularly helpful on farms using bullocks for seedbed preparation. Then the use of the tractor or bullock drawn seed drills for planting speeds this job in comparison to traditional planting in rows. One farmer said his soybean area was limited to 15 acres with four pairs of bullocks and with his new tractor, he expects to expand to 35 or 40 acres. Other farmers, however, said draft power is not constraining because larger farmers have the number of bullocks required to farm their
land or have tractors. Draft power is not constraining soybean area on small farms as long as the farmer has a pair of bullocks.

The second most critical period for draft power is between kharif harvest and rabi planting. When land is to be single cropped (most rainfed land), rabi seedbed preparation on kharif fallow land can be mostly accomplished prior to soybean harvest with only a single cultivation prior to planting. This is the traditional practice. The resource management challenge comes as double-cropping (irrigated and rainfed) expands. In one village visited in 1991, for instance, we were told that irrigation and double cropping had expanded from 20 to 95 percent of village cropland since they started growing soybeans.

Farmers generally reported no problem in getting the work completed. This work has probably been substantially assisted by the use of power threshers for the soybeans and can get upset by late planting of soybeans, resulting in their late maturity.

Where soybeans are grown on irrigated land, the time constraints are somewhat relaxed but yields of rabi wheat are adversely affected if it is planted much later than the usual time because of its young stage of maturity when hot spring temperatures begin.

Draft power has other important jobs throughout the growing seasons such as interculture in soybeans, carrying inputs to the fields and output from the fields and carrying products to market but no farmer identified any problem or constraint in accomplishing these tasks.
Operating Capital Resource Adjustments

Crop production requires the expenditure of cash for several production activities prior to any income received after harvest. For soybeans, this includes the cash costs of seed, chemical fertilizer, pest control, weeding and harvest labor and fuel for tractors and thresher engines or for hiring these machines. Not included are production costs which are not cash operating costs such as family labor, bullock power, fixed costs of tractor ownership and home produced manure.

The 1987 survey included several questions about these cash expenses in the soybean questionnaire answered by 266 farmers. Additional information was obtained in the 1991 village visits.

Seed: About three quarters of the surveyed farmers save soybean seed from the previous crop with the result that it is not a cash cost, only an opportunity cost of not selling this amount of product after the previous harvest. They use 35 to 45 kg of seed per acre, about 6 percent of average yields.

When they wish to try a new variety or supplement their own seed supply they obtain seed from a government seed farm or from other farmers at a cost per kilogram somewhat above normal soybean market prices. About 25% of all survey farmers sold their entire crop. For these farmers, seed for the following crop becomes a cash cost. Table 22 shows varietal preferences of 206 farmers with two varieties being most preferred. Perceived yield potential is the major preference criterion although early maturity is important to many farmers. An interesting difference of opinion on
how the various varieties meet these preferences emerged from farmer answers.

About a third of the surveyed farmers mentioned one or more of three seed problems—quality, availability or price—in response to a general question about soybean problems. In some villages, almost all farmers mentioned seed problems while in others, almost no mention was made. This indicates that seed is not a major cash cost for most soybean farmers because they usually save their own seed.

Table 22. Soybean Variety Preference (based on 206 Farmers) in Four Districts of Madhya Pradesh, 1986-87.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Percent of farmers preferring variety</th>
<th>Percent giving reason for preference:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punjab-1</td>
<td>41</td>
<td>Good yield</td>
</tr>
<tr>
<td>Chhoti</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>Gaurav</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>JS 72-44</td>
<td>37</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good price</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Early maturity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good yield+early maturity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good yield+other</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Fertilizer: A second operating cost is the purchase of fertilizer. Farmers who apply fertilizer to soybeans use a mixed nitrogen and phosphorous fertilizer (D.A.P.) which costs about Rs.175 per 50 kg. Many farmers use none (Table 23.) and most users use less than the recommended level of 125 kg per hectare.
Table 23 indicates manure and fertilizer use by survey farmers and their opinions about response. Few use manure on soybeans and opinions are divided on response to manure by wheat and soybeans. A somewhat higher percent of farmers reported use of fertilizer on soybeans and have the opinion that soybeans respond to fertilizer better than wheat. Use of both is substantially higher in Sehore district than in the other three districts. Survey data indicate little difference among farm size groups in level of manure and fertilizer use.

### Table 23. Use of Manure and Fertilizer on Soybeans (based on 266 Farmers in Four Districts of Madhya Pradesh, 1986-87.)

<table>
<thead>
<tr>
<th>Particular</th>
<th>Raisen</th>
<th>Seoni</th>
<th>Betul</th>
<th>Sehore</th>
<th>All Farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use manure on soybeans</td>
<td>3</td>
<td>4</td>
<td>9</td>
<td>31</td>
<td>12</td>
</tr>
<tr>
<td>Manure gives better response on rainfed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybeans</td>
<td>100</td>
<td>50</td>
<td>17</td>
<td>53</td>
<td>48</td>
</tr>
<tr>
<td>Wheat</td>
<td>0</td>
<td>50</td>
<td>56</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>No opinion</td>
<td>0</td>
<td>0</td>
<td>27</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Use fertilizer on rainfed soybeans</td>
<td>3</td>
<td>5</td>
<td>36</td>
<td>68</td>
<td>28</td>
</tr>
<tr>
<td>Fertilizer gives better response on rainfed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybeans</td>
<td>0</td>
<td>60</td>
<td>48</td>
<td>62</td>
<td>49</td>
</tr>
<tr>
<td>Wheat</td>
<td>100</td>
<td>20</td>
<td>42</td>
<td>26</td>
<td>39</td>
</tr>
<tr>
<td>No opinion</td>
<td>0</td>
<td>20</td>
<td>10</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

Manure involves no cash cost assuming use of self produced manure and family labor to apply it but fertilizer cost is about
Rs.440 per hectare for farmers using the recommended dose. We were given the impression in 1991 that farmers with operating cash constraints use no fertilizer rather than use credit to purchase it although credit is available. The use of credit, of course, increases the ultimate cost of the fertilizer by the interest which accumulates between when credit is taken and repayment after harvest plus the amount of any fees, charges and other costs associated with the loan.

Pest control: Few farmers use any pest control practices on soybeans. While some pest damage is recognized by farmers, most apparently judge that it stays below the economic threshold. In fact, the perceived low level of pest damage is sometimes cited by farmers as a major advantage of soybeans.

Hired labor: Hired labor for weeding and harvesting are the major cash operating costs for soybeans. Harvest labor typically costs about Rs.500 per hectare where wages are Rs.25 per day and more in one 1991 survey village where wages were Rs.40 per day. The cost of weeding labor is more variable both because of variation in the extent of weeding actually done and because it is done with a combination of family and local hired labor.

Machinery: Use of tractors involves cash costs for fuel, lubricants, and repairs or charge for hired tractor services. The same applies to power threshers and hired combines. No information was collected on the amount of cash involved and amounts are highly variable from farm to farm.

Credit: Most farmers manage to grow soybeans without taking a
loan. In the 1987 survey, only 3 out of 266 farmers reported taking a loan for any crop that year. For farmers who do wish to obtain credit, its supply and availability were judged adequate in 1991 in all villages visited. Bank loans with interest rates of around 10 percent per year are available to all non-defaulter farmers but are generally taken by larger farmers. Smaller farmers tend to use money lenders but interest rates are relatively moderate at 3 to 5% per month. While this amounts to 36 to 60 percent per year, it indicates that the supply of this type of credit is more adequate in this part of India than in neighbouring countries where interest rates of 9 to 20% per month were reported to one of the authors in late 1990 and early 1991.

Summary: All these indicate that lack of operating capital is not a constraint on increasing soybean area although it may constrain yield. Farmers either have sufficient capital or minimize input use. For small farmers who save their own seed, do not use fertilizer or pest control, use family labour for weeding and partly for harvesting, and use bullocks for all draft needs, soybeans can be called a low input crop and is valued by farmers for this characteristic. Net benefits from using higher levels of input are apparently available but when transaction and credit costs are added, the net benefits may be low for farmers who need to take a loan to pay these costs. In addition, poor crop years when production levels are lower than are needed to repay the loan, are an ever present possibility and occur about once in five years.
Constraints and Prospects for Expansion of Soybeans

Expansion of soybean area can continue to come from increased average area per farm and from new growers in villages where soybeans have not yet been fully adopted. The latest available district crop data (1988 crop year) show that the soybean area did, in fact, continue to expand in these districts after 1986. In 1991, we also know that farmers continue to be enthusiastic about the opportunity to grow soybeans.

Evidence from the 1987 Survey:

Farmers in the four districts were asked about their plans to expand soybean area in the upcoming 1987 kharif season. About half said they planned expansion (Table 24). Almost all gave the profitability of soybeans as their reason for wanting to expand. Two gave more helpful answers in terms of recognizing an expansion constraint and approaches to overcoming it. One said he would expand by starting to double crop (overcoming a land constraint).

Table 24. Plans for Soybean Expansion in the Next Crop Season (based on 238 Sample Farmers) in Four Districts of Madhya Pradesh, Spring, 1987.

<table>
<thead>
<tr>
<th>Planning expansion</th>
<th>Percent of farmers</th>
<th>Percent giving reason [a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Good price or profitable</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Expects to start double cropping</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>New irrigation water available</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>No more land available</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>No more water available</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

a. 18 farmers gave no reason.
while the other had found new water for irrigation (overcoming a water constraint). The question asked only about expansion plans and reasons why or why not expansion was planned. Other farmers who answered only in terms of soybean profitability may also have been overcoming land or water constraints to achieve their planned expansion.

This possibility is reinforced by answers of the 52% of farmers who planned no expansion. They all faced a land or water constraint. The implication is that they wanted to expand but could not.

Analysis of cropping patterns on 101 farms naming a land constraint as the reason for no further soybean expansion shows that 20 had some kharif fallow followed by rabi subsistence food and fodder crops (wheat and chickpea). These farmers said they had no more land for soybeans even though they had fallow kharif land. They had not yet completed the transition to commercial thinking and were minimising risk of rabi subsistence crop failure by maximising moisture stored in the soil through kharif fallow.

The remaining 81 farmers grew kharif crops on all their cropland. Only 21, however, grew soybeans on all their land (and some of these intercropped with sorghum). The remaining 60 allocated some kharif land to kharif grain crops - rice, sorghum or millet. Farmers were using some land for subsistence food and fodder production and saying they had no more land for soybean production even though they understood that soybeans were more profitable.
The 21 farmers using all their kharif land for soybeans, a completely commercial crop, may represent the adjustment of the future. Most farmers, however, were not yet ready to make this complete break with their subsistence past. Growing confidence in the market to supply food and reduced fodder needs through tractorization may speed this transition. Greater experience with double cropping may also help.

These farmers were thinking of soybean area expansion by crop substitution and expansion of double cropping. Expansion may also be possible by increasing the percent of operated land which is cropped, only 73% in 1986-87. Except for encroachment onto common land, land adjustments which facilitated soybean expansion in the past appear to represent opportunities for continuing expansion. Maintenance of soil fertility may constrain double cropping on the less fertile land.

In conclusion, farmers in 1987 in these four districts were anxious to expand their area of soybeans because of their profitability. Almost half were planning to do so but the remainder were not because they had no more land (or water) they wanted to use for soybeans. Only 21 of the 101 citing a land or water expansion constraint, however, faced and absolute constraint with all their land already growing soybean. The remaining 77 could expand their soybean area but chose not to, generally for subsistence food and fodder reasons. With incentive for expanded soybean area, gradual expansion on most farms can be anticipated.
as farmers learn how to overcome the resource constraints they now recognize.

1991 Perspective About the Future:

Our 1991 observations provide for a more general understanding of both changes since 1986 and trends which help predict the future.

First, district crop data and our observations indicate that within each district, some areas have moved more completely into soybeans and associated crop specialisation than other areas. The gradual decline of sorghum and minor (other) crops in the districts as a whole compared with the virtual elimination of these crops in several visited villages provides evidence for this conclusion. Soybeans can be expected to continue to expand into areas in each district where they are not yet fully adopted. This process can be expected to continue until all areas reach resource constraints on continued expansion as they are perceived by farmers.

Second, the use of tractors is rapidly expanding in these districts. This contributes indirectly to soybean expansion by relaxing rabi fodder demands for feeding bullocks and associated livestock. At the same time, irrigation has been expanding which enables farmers to expand double cropping with both kharif soybeans and rabi subsistence crops. Both changes reduce the need farmers see to limit soybean area in order to reserve kharif fallow land for low risk production of rabi subsistence food and fodder crops.
Third, evidence was found to support the conclusion that soybeans are becoming the crop of choice in direct competition with both kharif and rabi subsistence crops. This was directly stated in two villages and implied in a district focused discussion. A group of about 15 farmers was asked what constrained soybean expansion in their district. They easily agreed that it was the need for subsistence crops (minus sorghum, however, when it was said that "Even the tribals want wheat these days"). When asked about changes in soybean area in the district, the same farmers all agreed it was expanding. District data show this to be true up to 1988 at the rate of 8,000 to 10,000 hectares per year.

On single-cropped rainfed land (82 percent of all cropland in these districts), farmers are choosing to change from rabi subsistence crops to kharif soybeans. The number of farmers who have completed this change and grow only soybeans is currently small but is apparently increasing. Among the 323 surveyed farmers, 14 grew only soybeans and an additional seven grew soybeans but with an intercrop in 1986. Both groups reported total rabi fallow.

The ultimate limit on kharif soybean area is to grow them on all net cropped land in the kharif season, thus eliminating kharif fallow as well as other kharif crops. Table 25 indicates the potential for expansion by elimination of kharif fallow which was estimated to be 531,000 hectares in 1986-87 in the four districts of the 1986 survey. This compares with that year's soybean area of 241,000 hectares.
While current trends show movement toward this limit, it is not expected ever to be reached. Other opportunities and constraints such as the supply and demand situation for both soybeans and competing crops, will continue to impact the expansion. The data do show, however, that land supply is not much of a current constraint on soybean expansion in this study area.

Table 25. Estimated Area of Kharif and Rabi Fallow (000 ha) in Four Districts of Madhya Pradesh [a], 1986-87.

<table>
<thead>
<tr>
<th>District</th>
<th>Percent of net cropped area fallow on sample farms</th>
<th>Estimated fallow area in district</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kharif</td>
<td>Rabi</td>
</tr>
<tr>
<td>Betul</td>
<td>b</td>
<td>79</td>
</tr>
<tr>
<td>Sehore</td>
<td>21</td>
<td>49</td>
</tr>
<tr>
<td>Raisen</td>
<td>88</td>
<td>9</td>
</tr>
<tr>
<td>Seoni</td>
<td>24</td>
<td>57</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>34</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>

a. Estimates based on cropping patterns of 323 sample farms.
b. Almost none.

A final potential for expansion is the possible adoption of rabi soybeans on irrigated land. Trials were completed in the 1990 and 1991 rabi seasons in one district with promising results. Although it is discouraged by soybean scientists who fear rapid disease and insect development with 2-season production, farmers could find rabi soybeans economically attractive as a competitor to irrigated wheat. This would increase, possibly substantially, total hectares of soybeans grown.
The above trends all involve the power of soybeans to expand onto additional land, sometimes with reduction in the area of existing crops. An opposite potential influence on soybean area may come from new commercial crops that have the power to steal land from soybeans. Once commercial attitudes have been completely assimilated by farmers under the influence of the soybean experience, they can be expected to seek new crops or uses for their production resources which will be even more profitable than soybeans. Both sugarcane and sunflowers were mentioned by farmers in our 1991 conversations.

In addition to area expansion, production can increase by increasing average yields. Yields in Madhya Pradesh and in India have been variable but generally level since the late 1970's and in 1988 stood at 794 kg/ha (FAO, 1988). Asian yields averaged 1254 kg/ha in the same year, more than 50 percent higher, and developing market economies averaged 1695 kg/ha, double the Indian yield. A one quintal increase from 8 to 9 per hectare would add 40,000 tons to production valued at Rs.200 million (20 crores) in these 5 districts.

In the 1987 survey, 82 percent of the farmers reported highest (not average) yields above 1000 kg/ha and 12 percent reported more than 1950 kg/ha. Dr. B.L. Jain (1987) suggests that an average yield of 20 quintals is an achievable goal. As discussed above, the average yield and many of these highest yields were generally obtained under low input conditions.
These comparisons suggest substantial scope for average yield increases in Madhya Pradesh. Generally, breeders and farmers could be expected to move in these directions over time with a crop which has become so important. The generally flat yield experience of the last ten or so years, however, raises doubts about these expectations.

The potential for significant average yield increases appears to exist but farmers are not acting to realize this potential. Both biological and economic research could clarify this mystery and suggest policy options to stimulate farmers to take effective action to raise yields. New varieties with improved tolerance to waterlogged soil conditions might help. A discussion of yield increasing constraints can be found in B.L. Jain, 1987.

Summary: As long as the price of soybeans remains attractive to farmers, relative to other crops, their area is expected to continue expanding for the foreseeable future in these five districts. Some area may, however, be lost to even more profitable commercial crops. Without new policy initiatives, yields are likely to remain low and flat although individual farmers are demonstrating the way to higher yields.

Summary and Conclusions

Soybeans have been the catalyst for fundamental ongoing change in the agriculture of the five study districts with substantial benefits. Major benefits come from more complete use of existing land and labor resources, additional production without additional
social cost and often without additional private cost. Investment in irrigation and mechanization, both required for soybean expansion and made possible by soybean income, have further enhanced the productivity of these resources.

Expansion is not generally constrained by the supply of production resources. While soybeans involved additional supplies of these resources, compared to the pre-soybean agriculture, farmers have managed to find them and the approaches used can continue to provide expansion possibilities into the foreseeable future.

Expansion of soybean area, rapid between 1978 and 1988, is expected to continue at a somewhat subdued rate, as they spread throughout the districts and gradually reach intensity levels now found in only some sections of each district. Even in sections with maximum current intensity, there is potential for continuing area expansion as farmers relax constraints they now perceive. Average yields are low compared to Asian and other yields and to on-farm research results. Expectations of average yield increases of 50 to 100 percent or more seem reasonable with many farmers already achieving such yields. But average yields have remained variable and flat for 10 years and policy changes which will start an upward trend are unclear.

Under the influence of soybeans, this agriculture is taking on the characteristics of a developed agriculture. Farms where soybeans have been fully adopted, by current definition, have become commercialized with specialized crops and investments in
mechanization and irrigation. They have become prosperous in comparison to farms with lower adoption rates.

Except for the yield problem, soybeans are creating an unsung mini-Green Revolution in Madhya Pradesh. As long as soybean prices stay attractive, expansion of area and production is expected to continue. The tremendous social and likely private benefits of yield increases remain to be achieved.

In 1966, an influential book by Arthur Mosher titled, Getting Agricultural Moving was published. The central theme of the book identified the role of development experts as creating opportunities for farmers to get more of what they want from their farms and letting the farmers do the rest. The Madhya Pradesh soybean experience appears to be an excellent example of Mosher's approach in practice.
References


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