Management Factors Affecting Legumes Production in the Indo-Gangetic Plains

Grain legumes are important in the Indo-Gangetic Plains (IGP) as food crops for human consumption and animal feed, as components of cropping systems, and as restorers of soil fertility. Legumes are included in the rice-rice or rice-wheat systems that predominate in the IGP. The area under legumes in rice-based cropping systems is substantial.

Some common cropping systems practiced in the region are: *aus* rice-jute-fallow-legume in Bangladesh; pigeonpea-wheat and rice-chickpea in India; rice-wheat-mungbean in Nepal; and mungbean + groundnut-wheat in Pakistan. The choice of legume to be grown depends on various factors such as crop season, rainfall pattern, temperature, soil texture, irrigation water supply, available growing period, and pests and diseases. Although yields of legumes have remained low due to several production constraints, they are still cultivated because they produce reasonable yields with low inputs under harsh climatic and edaphic conditions. When grown before or after rice, legumes encounter some formidable difficulties because the optimum soil physical conditions for these crops differ substantially. Cropping sequences that include rice and legumes, therefore, require special management to improve the total system productivity.

<table>
<thead>
<tr>
<th>Country</th>
<th>Total area under legumes</th>
<th>Legumes area in rice-based systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>785</td>
<td>750</td>
</tr>
<tr>
<td>India</td>
<td>18790</td>
<td>1990</td>
</tr>
<tr>
<td>Nepal</td>
<td>253</td>
<td>197</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1576</td>
<td>262</td>
</tr>
</tbody>
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Area (thousand ha) Under Legumes in the IGP
Grooming the Land

Legumes are cultivated on a wide range of soils, from loamy sand in western IGP to heavy clay in the eastern region. After rice harvest, use of low-energy tillage methods confines cultivation to a shallow depth forming a compacted layer which impedes root growth. While tillage of wet puddled clay soil produces a cloddy surface soil, tillage of dry soil produces small aggregates. Both conditions are unsuitable for good crop stand of legumes. Poor germination in a cloddy seedbed is due to less seed-soil contact and reduced water transmission to seeds while the fine aggregates after wetting and drying form a compact seedbed with high soil strength, which impedes emergence.

Simple management techniques should be adopted for optimum land preparation to facilitate good seed germination, seedling emergence and plant growth. The most common practice for cultivation of mungbean, black gram, cowpea, lathyrus and lentil in rice-fallow is zero tillage. This method reduces the cost of land preparation, facilitates timely sowing and reduces the risk of crop failures caused by early season drought. Although zero tillage is profitable, yet yields are low. Therefore, minimum tillage is required in medium- and heavy-textured soils, in both lowland and upland rice fields in the IGP. Seedbed preparation, especially after rice, should be good in heavy-textured soils. Deep tillage breaks the strong compaction layers preferably along parallel strips at 30 to 50 cm spacing. Legumes are sown on the strips for deep rooting and access to the subsoil water.

Selection of Crops and Genotypes

For good crop establishment in the rice-wheat systems in the IGP, legumes that are capable of penetrating hard soil should be selected. Groundnut has higher root elongation rate than pigeonpea and pea because it has better ability to overcome soil mechanical resistance. In areas receiving rainfall with gradual onset and termination, several legumes perform well: mungbean, black gram and cowpea before rice; and chickpea, lentil, lathyrus, pea, soybean and cowpea after rice.

Seedling emergence and plant vigor depend on seed quality and genotype. Large seeds have more vigorous growth than small seeds. Therefore, selection of appropriate crop and genotype, and use of good quality seed are important criteria for enhancing yield of legumes.
Time of Sowing

Legumes are generally sown when the opportunity exists in the rice-wheat systems and not necessarily at the optimal time. Better management of turn-around time between rice harvest and sowing of the following legume crop can avoid surface soil drying. Sowing date depends on various factors such as duration of rice or wheat crop, cropping sequence and the lag time from harvest of the rice or wheat crop until the field is prepared for legume cultivation. However, some adjustments within the available window can be made to improve timeliness of sowing. Land preparation and sowing practices can be modified so that sowing coincides with appropriate soil moisture condition for good crop establishment.

Sometimes the variety or sowing date of the preceding crop can be changed so that sowing date of the legume crop could be advanced to avoid drought stress during the later growth stages. Short-duration rice or wheat varieties can be used to optimize sowing time of legumes. Sowing date adjustments can also be made by mechanization of various operations to reduce the turn-around time and speed up sowing. In areas with double cropping systems, duration of the two component crops normally covers most of the growing season, leaving little opportunity for adjusting sowing dates to grow legumes. In such areas, short-duration legumes can fit into the narrow summer window of the rice-wheat rotation without sacrificing a rice or wheat crop during the year.

Better Crop Stand for Good Yield

Low crop stand reduces the productivity of legumes. Yields can be improved by increasing the plant density. Under late-sown conditions, plant growth is often restricted. Therefore, a higher plant population is required to compensate the yield loss per plant. However, dense crop stand attracts foliar diseases if appropriate plant protection measures are not adopted.

Appropriate sowing methods should be used to improve germination and establish an optimum plant population of legumes. In rice-wheat systems, seed of legumes can be dibbled at the base of rice stubble. Higher yields can be obtained by tillage and seeding in rows rather than broadcasting. In residual soil moisture conditions, deep sowing reduces the adverse effect of dry topsoil.
In rainy season legumes such as pigeonpea, groundnut, and soybean, crop stand is often vitiated due to water stagnation or poor drainage. In such situations, sowing on raised beds instead of flat beds, or ridges in a ridge-furrow bed system will ensure optimum plant stand. Seedling emergence can be increased and hastened by seed priming, use of bold seeds, and seed pelleting.

**Soil Amelioration**

Mulching, green manuring, stubble incorporation, and relay cropping of short-duration legumes improve soil organic matter content and the structural stability of the soil. Mungbean or black gram can be grown in the rice-wheat rotation to improve soil fertility in the IGP.

Sources of calcium such as gypsum or slaked lime improve the establishment and early root development of legume crop in puddled soils. As puddling results in soil dispersion, the application of gypsum improves the physical conditions of the soil following rice.

In some areas, waterlogging is a serious constraint for legume production. In areas where water is excess during the early part of crop growth, calcium ameliorants can improve the soil structure and drainage, particularly in soils dominated by exchangeable sodium and/or magnesium. Legumes (e.g., soybean, mungbean and black gram) that can better adapt to waterlogging conditions and are better suited to high moisture conditions early in the season, compared to other legumes such as chickpea, pea and lentil should be used.

**Nutrient Management**

Legumes respond to both macro- and micronutrients. Balanced supply of plant nutrients is essential for their high productivity. Legumes improve soil physical conditions and derive a large proportion of their nitrogen (N) requirement through biological nitrogen fixation (BNF). However, a starter dose of 10 to 15 kg N per ha is often recommended. In fields where the rhizobial population is low, late-sown legumes respond to applications of up to 40 kg N per ha. The application of N may not only be directly beneficial to the legume but also benefit the succeeding cereal crops.
The soils of the IGP are generally low to medium in available phosphorus (P) content and therefore application of 17 to 26 kg P per ha increases seed yield of legumes. Sulfur (S) deficiency has been observed in rice-wheat areas due to increased cropping intensity and use of S-free fertilizers (urea and diammonium phosphate). It is more pronounced in legumes than cereals due to comparatively higher S requirement.

Legumes fix atmospheric N in their nodules through *Rhizobium*. But the quantum of N fixed is influenced by several physical, environmental, and biological factors. Lack of native rhizobial population causes poor nodulation. Use of efficient rhizobial inoculants enhances productivity of legumes by 10%-15%. Legume species and cultivars that have high nodulation capacity must be selected.

Increased use of organic manures is essential because of greater incidence of multiple nutrient deficiencies, soil degradation, and decline in productivity. About 25%-50% of the N requirements of wet season rice can be substituted through farmyard manure, crop residues, or green manure. The short window of six to eight weeks between the harvest of wheat and transplanting of rice allows cultivation of a legume (e.g., mungbean, black gram, cowpea, *Sesbania*) for seed, fodder, or green manure. Incorporation of legume biomass into the soil can save 30 to 60 kg N per ha. Mungbean biomass buried after picking pods and before transplanting rice could save as much as 60 kg N per ha.

### Water Management

Legumes require limited irrigation, particularly during drought. Common bean is more responsive to irrigation followed by pea. The success of mungbean as a catch crop during summer in the rice-wheat system is solely dependent upon adequate supply of irrigation. Late-sown chickpea after rice crop also needs irrigation compared to the normal-sown crop, probably due to restricted root growth.

Although pod initiation is the most critical stage in most legumes, the initial soil profile moisture and soil types determine the requirement of irrigation. Similarly, excess soil moisture or waterlogging reduces oxygen in the rhizosphere and thus affects BNF activity and nutrient availability resulting in yield reduction. Therefore, fields should have good drainage, especially in low-lying areas.
**Weed Management**

In early stages of crop growth, legumes are poor competitors to weeds. The nature and magnitude of crop-weed competition is influenced by several factors such as crop species, cropping system, sowing time, plant population, moisture availability, and fertility conditions. Weed competition affects crop yield and BNF. Yield losses due to weeds in the IGP were 44% in pigeonpea, 50% in black gram, and 42% in chickpea.

Short-statured and early-maturing legumes (e.g., black gram, mungbean, cowpea, and soybean) can be intercropped in wide-spaced crops (e.g., pigeonpea) to reduce weed menace. Cowpea, mungbean, and soybean are efficient in smothering weeds. Fast-growing legumes, both as sole crops and intercrops, suppress weeds and improve physical and biological conditions of the soil. Various chemical (herbicides), cultural (hand weeding), and mechanical (interrow cultivation) options are effective and economical for weed management.

*Adapted from:*

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