Role of Legumes in Cropping Systems in the Indo-Gangetic Plains of India

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Legumes have been known for their soil ameliorative effects since time immemorial. They trap atmospheric nitrogen (N) in their root nodules and add substantial amounts of protein-rich biomass to the soil surface and rhizosphere and thus keep the soil productive and healthy. By including legumes in cropping systems, the heavy N needs of modern intensive cereal-based cropping systems such as rice-rice, rice-wheat and maize-wheat can be at least partly met, and the physical and chemical characteristics of the soil are generally improved. Legumes in rotation with cereals not only improve cereal productivity but also economize on N use up to 40 kg N per ha. Chickpea performed better than lentil and pea, and increased yield of succeeding rice crop by 1 ton per ha when compared with wheat, without addition of N fertilizer as well as at 40 kg N per ha. At a higher level of N application (120 kg per ha), the effect was narrowed down and the increase in rice yield was 0.8 tons per ha.

Nutrient Recycling

Partial Recyling

Nutrient recycling in legumes cropping systems could be partial or complete. For partial recycling, short-duration legumes such as mungbean, black gram (urd bean), or cowpea can be either grown as a catch crop during spring or summer, or intercropped with cereals (e.g., maize, sorghum, and pearl millet), oilseeds (e.g., sunflower), and commercial crops (e.g., cotton and sugarcane). This system not only provides a bonus yield of legumes but also

benefits the succeeding or companion crop. Cultivation of cowpea during summer enhanced yield of succeeding rice by 0.33 tons per ha. Intercropping black gram and mungbean with spring-planted sugarcane had synergistic effects on cane yield but soybean and cowpea adversely affected cane production. Incorporation of loppings of leguminous trees such as *Gliricidia* sp. and *Leucaena* sp. in rice fields also helps in partial recycling of plant nutrients. Incorporation of *Leucaena* loppings over a period of three years increased yield of rice by 0.48 tons per ha and that of wheat by 0.73 tons per ha.

Intercropping of Legumes with Sugarcane at Lucknow, India

Cropping system	Yield (t/ha)	
	Sugarcane	Legume
Sugarcane	109.4	-
Sugarcane + black gram	128.8	0.5
Sugarcane + mungbean	113.3	0.4
Sugarcane + cowpea	106.3	0.5
Sugarcane + soybean	102.5	1.2

Complete Recyling

For complete recyling of N, green manuring with *Sesbania* sp., sunn hemp, or cowpea in rice-wheat rotation can be practiced. Green manuring with *Sesbania* over a period of three to four years improved productivity of rice-wheat system by 3 tons per ha on light-textured, sandy loam soils in Ludhiana, Punjab. On medium-textured, sandy loam to loam soils in Kanpur, Uttar Pradesh, the increase in productivity was only 0.6 tons per ha. Green manuring with *Sesbania* also improved the productivity of pearl millet-wheat system in Uttar Pradesh.

Green manuring with *Sesbania* sp. in rice-wheat system increased organic carbon (OC) of soil from 0.29% to 0.45% over a period of six years at Ludhiana. Similarly, on sandy loam in Pantnagar, OC, total N, and available P increased by 0.01%, 15 kg per ha, and 13.8 kg per ha respectively. The OC content and available P also increased under rice-lentil and pigeonpea-wheat sequential cropping. The effect of increased fertility status was also reflected on grain yields of rice and wheat.

Utilization of Rice-Fallows

Vast areas in the eastern Indo-Gangetic Plains (IGP) are monocropped under medium- and long-duration rice. Double cropping is not feasible in these areas due to non-availability of irrigation water and delay in vacating the field after rice. The top soil layer dries up at the time of rice harvest and thus planting of a postrainy season crop is not possible. Under such conditions, these monocropped areas can be used for double cropping by relay planting small-seeded lentil or low toxin (BOAA) containing lathyrus genotypes (e.g., Bio L 212). Lentil or lathyrus seeds are broadcast in the standing rice crop, seven to 10 days before harvest when there is adequate moisture for germination in the top layer of soil. Thus, legumes production can be increased and the productivity of the rice-based system can be sustained. Genotypes of lentil and lathyrus that are specially suited for relay cropping and appropriate production technologies are essential for the expansion of this cropping system.

In some parts of northeastern Bihar and West Bengal where temperatures are moderate during winter, black gram (urd bean) and mungbean can be grown in rice fallows. Thus, the area under legumes can be increased and the residual moisture in rice fallows can be utilized. High-yielding, cold-tolerant, powdery mildew resistant varieties are ideal for this system.

Legumes Production Systems in the IGP

There is great potential for enhancing legumes production both under irrigated and rainfed conditions in the eastern and western regions of the Indian IGP.

The Western IGP

Mungbean as a Catch Crop

Mungbean can be included as a catch crop between wheat and rice by using short-duration (60 to 65 days), high-yielding, and yellow mosaic resistant genotypes such as PDM 54, ML 267, Pusa Vishal, Samrat, and SML 668. However, the success of the system will depend upon the choice of appropriate genotypes of rice and wheat and their timely planting so as to vacate fields with wheat by the end of March or first week of April, assured irrigation, and a community approach to halt the predations of blue bulls and stray cattle. This cropping system can be popularized further by introducing extra-early-maturing (50 to 55 days) varieties of mungbean.

Mungbean and Black Gram in Spring

Mungbean or black gram can be successfully grown during spring (March-May) after harvest of short-duration post-rainy season crops such as mustard, potato, pea, or sugarcane. Spring cultivation of these legumes is increasing rapidly with the availability of yellow mosaic resistant and high-yielding (0.8 to 1.0 ton per ha) black gram varieties such as Pant U 19, PDU 1, Shekhar, and Narendra Urd 1, which mature in 70 to 75 days. Similarly, release of mungbean varieties such as PDM 11, Pant Mung 2, and MH 81-1-1 has encouraged spring cultivation. About 200,000 ha in the states of Punjab, Haryana, and western Uttar Pradesh are currently occupied by spring black gram and mungbean and the area can be substantially increased.

Chickpea-Cotton Sequential Cropping

Chickpea-cotton system is more remunerative than wheat-cotton system. With the availability of genotypes amenable for late planting, chickpea can be successfully introduced in the uplands of Punjab and western Uttar Pradesh, where cotton is grown as a commercial crop.

Pigeonpea-Wheat Sequential Cropping

Western IGP is a non-traditional area for pigeonpea. But with the introduction of short-duration (140 to 160 days) pigeonpea genotypes such as UPAS 120, AL 15, AL 201, Manak, Pusa 992, Pusa 84, and ICPL 151, pigeonpea-wheat sequential cropping has become popular and the area under this system is increasing progressively. About 150,000 ha under western IGP is under short-duration pigeonpea.

Most of the available short-duration pigeonpea varieties are susceptible to sterility mosaic, fusarium wilt, and phytophthora blight, and have a tendency to prolong maturity with late monsoon rains. Therefore, it is imperative to develop genotypes having a yield potential exceeding 2 tons that will mature by early November (e.g., ICPL 88039 and Pusa 992), to facilitate sowing of winter crops.

Groundnut-Wheat Sequential Cropping

On uplands having light-textured soils, groundnut cultivation is more profitable than pearl millet, maize or sorghum. Wheat in sequence with groundnut is greatly beneficial due to improvement of physical and chemical properties of soils. Government support is needed to popularize this system.

The Eastern IGP

Short-duration Pigeonpea in Sequence with Wheat

As in western IGP, on uplands of eastern Uttar Pradesh, short-duration pigeonpea can be successfully grown. As this region receives more precipitation, pigeonpea planting should be done in ridges in the first fortnight of June with pre-planting irrigation so that by the time monsoon rains start, the seedlings are strong enough to tolerate adverse effects of excess moisture. Short-duration pigeonpea can be popularized with the availability of disease-resistant genotypes having tolerance to excess soil moisture.

Spring and Summer Cultivation of Black Gram and Mungbean

As in western IGP, the eastern region also offers good scope for cultivation of spring black gram and mungbean as well as summer mungbean. Over 200,000 ha of land is presently under mungbean. Both mungbean and black gram are cultivated after harvest of mustard, potato, pea, wheat, and sugarcane. They can also be intercropped with spring-planted sugarcane and sunflower.

Popular Varieties	
Black gram	Pant U 19, Shekhar, Narendra Urd 1, and PDU 1
Mungbean	PDM 11, Narendra Mung 1, Pusa Vishal, and Pant M2

Rice-Chickpea/Lentil Sequential Cropping

Chickpea varities (e.g., KPG 59 and Pusa 372) amenable for late planting in mid-December are cultivated after rice. Under resource constraints, rice-chickpea is more remunerative than rice-wheat. The system has more potential in eastern Uttar Pradesh and Bihar.

In lowland areas with excessive moisture, lentil is a more assured crop than chickpea. Hence, the rice-lentil system is popular in the lowlands of eastern Uttar Pradesh, Bihar and West Bengal. The adoption of the high-yielding, bold-seeded, wilt-resistant vatieties such as DPL 62 and Noori, and small-seeded, rust-resistant varieties such as DPL 15, PL 406, and PL 639 may encourage expansion of lentil.

Post-Rainy Season Pigeonpea

Eastern IGP receives heavy rains and experiences frequent floods during July-August, which cause considerable or complete loss of July-planted pigeonpea. Under such situations, post-rainy season pigeonpea can be grown succesfully. Varieties (e.g., Sharad and Pusa 9) that are resistant to Alternaria blight with yield of 2 tons per ha and suitable for September planting have proved a boon for extension of post-rainy season pigeonpea on uplands of eastern Uttar Pradesh, Bihar and West Bengal. As these varieties are highly thermo-sensitive, their planting period is restricted up to mid-September. Delayed planting causes considerable yield loss. Hence, varieties which can be successfully planted until early October will provide greater opportunities to expand pigeonpea cultivation under sequential cropping with short-duration upland crops such as maize, sorghum, and pearl millet.

Post-Rainy Season Common Bean

Common bean has been recently introduced in the IGP. High-yielding genotypes (e.g., Udai, Amber, HUR 15, and HUR 137) that yield 2.5 to 3.0 tons per ha and suitable for planting in October-November have been adopted. Common bean is a high-value and short-duration (115 to 125 days) crop with few problems of insect pests and diseases. This legume has the potential to cover large areas under irrigated conditions. It can be intercropped with potato.

Adapted from:

Ali, M., P.K. Joshi, S. Pande, M. Asokan, S.M. Virmani, R. Kumar and B.K. Kandpal. 2000. Legumes in the Indo-Gangetic Plains of India. pages 35–70. *In:* Johansen, C., J.M. Duxbury, S.M. Virmani, C.L. L. Gowda, S. Pande and P.K. Joshi (eds). Legumes in Rice and Wheat Cropping Systems of the Indo-Gangetic Plain: Constraints and Opportunities. ICRISAT, Patancheru, India; and Cornell University, New York, USA.

Corresponding author:
Masood Ali