

September arhar holds promise for crop diversification in upland ecology of Bihar

Rakesh Kumar^{1*}, Sanjeev Kumar² and Bal Krishna³

¹ICAR Research Complex for Eastern Region, Patna, Bihar 800 014

²Bihar Agricultural University, Sabour, Bihar 813 210

³Lovely Professional University, Jalandhar, Punjab 144 001

North-East Plains (NEPs) experience both temporal and spatial variations in the rainfall intensity, often resulting in temporary waterlogging. This, in turn, leads to partial or complete mortality of pigeonpea seedlings during the rainy season. To address this issue, the adoption of September arhar planting presents as an alternative approach. In post-Green Revolution era, Indo-Gangetic Plains of India, encompassing parts of north-west and north-east plains, witnessed the widespread adoption of rice-wheat system. While this system has contributed to improved food and nutritional security, it has displaced grain legumes from the agricultural landscape. This continued reliance on rice-wheat system has been associated with numerous adverse effects on human health, soil quality, and environmental well-being.

Keywords: Crop diversification, Food and nutritional security, September arhar

OVER past seven decades, a primary focus of agricultural development in India has been to increase agricultural production and ensure food security. Fortunately, Indian farmers, supported by agricultural scientists and policymakers, achieved this goal through initiatives like the 'Green Revolution' and 'Rainbow Revolution'. These efforts not only brought prosperity to millions of Indians but also established India as a self-sufficient agricultural nation. A notable increase in production and productivity was made possible by the introduction of improved crop production technologies. Following the Green Revolution, adoption of rice-wheat system in Indo-Gangetic Plains of India, encompassing parts of north-west/north-east, significantly improved the food and nutritional security in these regions. However, this success came at a cost as grain legumes were displaced from the system. This not only reduced crop diversity but also resulted in a decrease in dietary

diversity, ultimately leading to a lower nutrient-calorie ratio in these regions. Low-income states, heavily reliant on rice, wheat, maize for their caloric needs, witnessed a resurgence of malnutrition, with micronutrient deficiencies, particularly in iron, zinc, vitamin A, being a major contributor to this problem. This further threatens nutritional security in these regions. To address these challenges, it is imperative to diversify the cropping systems by reintroducing food legumes. This diversification will enhance dietary diversity, promote soil health, maintain system productivity, and benefit the agroecosystem. There is

a pressing need to identify cropping systems that are suitable for a range of environments and various levels of farmers' income.

Northeast plains region, encompassing central and eastern Uttar Pradesh, Bihar, West Bengal, and Assam, has historically been a traditional habitat for long-duration pigeonpea cultivation. This crop typically takes 8-9 months from sowing to harvesting and was traditionally grown under rainfed conditions in mixed or intercropping systems, often alongside tall cereals like maize, sorghum, and minor millets. Following the harvest of short-duration cereals and

Table 1. Pigeonpea area ('000 ha) during last five decades in North-East Plains (NEP)

Year	Uttar Pradesh	Bihar	Jharkhand	West Bengal
1970-71	582.4	150.3		25.8
1980-81	522.6	93.7		22.6
1990-91	468.1	66.2		5.8
2000-01*	406.6	43.7	23.5	8.9
2010-11	344.0	36.0	104.0	2.0
2017-18	282.0	18.5	193.7	4.5

*Jharkhand bifurcated from Bihar (AICRPP 2019)



Cropping view of September arhar production system under zero tillage

millet, pigeonpea would remain in the fields for an additional 4-5 months. This traditional cropping system, predominantly practiced in upland areas, not only ensured dietary diversity but also helped in maintaining the soil fertility. However, with the onset of the Green Revolution, sole cropping of semi-dwarf varieties of rice and wheat became prevalent, replacing the traditional mixed cropping system. This shift in agricultural practices posed tough competition to the less lucrative mixed cropping, particularly popular maize-potato intercropping system in Bihar and Uttar Pradesh. Additionally, unpredictable rainfall patterns resulting in unstable yields of arhar (pigeonpea) forced farmers to explore alternative cropping systems. This ongoing transition contributed to a continuous decline in acreage devoted to arhar cultivation. In 2017-18, arhar cultivation area in Uttar Pradesh and West Bengal had decreased by more than 51% and 82%, respectively, compared to levels in 1970-71. In Bihar, the arhar cultivation area had dwindled to 66.2 thousand hectares, a 56% reduction by 1990-91. Even after the partition of Bihar, the area dedicated to arhar cultivation continued to decline, reaching an all-time low of 18.49 thousand hectares in 2017-18. This declining trend was not limited to arhar alone but extended to all pulse crops in the most states of NEP, except for Jharkhand. Adverse effects of rice-wheat system on agricultural productivity have

become increasingly evident. Arhar, being rich in protein and densely packed with essential micronutrients such as iron and zinc, gradually became less accessible in regular diet of low-income individuals who had limited access to animal sources of protein and micronutrients. All these factors have sparked renewed interest in diversifying current narrow cropping systems to enhance overall system productivity, maintain soil health, and combat micro-malnutrition. This entails the incorporation of arhar and other pulses into the cropping system.

Crop diversification through inclusion of September arhar

Crop diversification plays a crucial role in alleviating economic stress and promoting the growth of farming communities. As mentioned earlier, the initial Green Revolution largely replaced existing cropping systems with the rice-wheat system in many regions. In the pursuit of crop diversification, the inclusion of early arhar (pigeonpea) has gained momentum. However, in the Northeast Plains (NEP), the effort to diversify the rice-wheat system with pigeonpea faces certain challenges primarily linked to unpredictable monsoon patterns. Early arhar, typically sown in May, confronts issues with waterlogging after the onset of monsoons, usually occurring from the last week of June. Excessive soil moisture and phytophthora stem blight (PSB) lead to significant seedling mortality, rendering the endeavour

unproductive. The long duration arhar, planted in July, faces similar constraints. While it is relatively more tolerant of waterlogging and possesses some degree of PSB resistance, substantial seedling mortality can occur if the crop experiences partial submergence for 4-5 days due to continuous rainfall. In such circumstances, even the transplantation of arhar fails to establish the desired plant population.

Production technology of September arhar

Historically, arhar (pigeonpea) was regarded as a low-input crop, and as a result, it did not receive significant attention for development of improved production technology, except in a few nutritional requirement studies. Establishment of All India Coordinated Research Project on Pulses (AICRP) in 1967 marked a turning point, providing a much-needed impetus for research & development in arhar cultivation. This initiative led to the identification of suitable cropping systems, both sole and mixed, involving arhar varieties with varying maturity durations. Over time, production technologies for arhar have been refined and repeatedly validated through experimentation. Here are details of the production technology for arhar, specifically for September planting season:

Planting time: 1st fortnight of September

Seed rate and spacing: 25-30 kg/ha, 45 cm × 10-15 cm

Varieties: Pusa 9, Sharad and IPA203

Fertilizer: 20:40:0 kg NPK/ha. Additionally, 10 kg N/ha (22 kg urea) is applied at optimum moisture levels after 20-25 days of planting.

Sowing on ridges: Necessary measures are essential to prevent early seedling mortality caused by waterlogging due to excessive rainfall during the receding monsoon season.

Seed inoculation: *Rhizobium* culture @ 250 g for 10 kg seed.

Irrigations: Necessary only if there is insufficient soil moisture available throughout entire cropping season.

Weed management: Application of pendimethalin @ 1.25 kg/ha during pre-emergence stage followed by 1 hand weeding at 25-30 DAS.

Disease management: Most destructive diseases, Fusarium wilt (FW) caused by *Fusarium udum*, sterility mosaic (SM) transmitted by mites, *Aceria cajani*, PSB caused by *Phytophthora Drechsler* f. sp. *cajani* and ALB. While FW/SM are widely prevalent, ALB is a major problem in pre-rabi arhar grown during September-April. During last two decades, several resistant varieties have been developed to minimize the incidence of these diseases.

Fusarium wilt

- Growing resistant/tolerant varieties
- Deep ploughing and exposing

field to sunlight during hot summer months

- Field sanitation and removal of all stubbles and plant debris
- Seed treatment with *Trichoderma viride* @ 4-10/kg seed) and mix 2-5 kg of *Trichoderma viride*/ha with 60-75 kg of well decomposed compost, sprinkle it with light water and keep it in shade for 10 days and then mix it in the soil on the last tillage before sowing.
- Seed treatment with carbendazim + thiram (1g + 2g/kg seed)/carbendazim (2g/kg seed)
- Intercropping with sorghum (2:1)
- Cropping rotation with sorghum

Sterility mosaic

- Growing resistant varieties and field sanitation
- Destruction of off-season volunteer plants in vicinity
- Avoid ratoon crop of pigeonpea

Alternaria blight

- Growing resistant varieties
- Foliar spraying of fungicides mancozeb @ 0.25%

Phytophthora blight: Seed treatment with metalaxyl (3 g/kg seed) + ridge sowing + raising

cover crops of cowpea and growing resistant varieties.

Pest-management: Major insect pests attacking September arhar are gram pod borer (*Helicoverpa armigera*) and pod fly (*Melanagromyza obtusa*). Different component of pest management are described in succeeding paragraphs.

Cultural practices

- Sowing outside the normal timeframe, whether early or late, can exacerbate pest-related damage.
- Recommended sowing times and rigorously implement pest control measures.
- Planting at close spacing or achieving high plant density per unit area tends to attract more pests.
- Ratoon and residual straw from arhar cultivation become significant sources of pests. It is advisable to eliminate these during the summer months.
- Dealing with pests such as blister beetles, grey weevils, brown bugs, leaf tiers, and hairy caterpillars can be somewhat effective through methods like handpicking, jarring, or bagging.
- Conducting deep plowing of fields during summer season proves beneficial as it reduces the likelihood of pest proliferation.

Biological control measures, like use of NPV, have demonstrated high effectiveness in managing pod borers in arhar. A combination of NPV at a rate of 350 LE, along with adjuvants and Novaluron 10%, or alternate sprays of NPV 350 LE/ Novaluron 10%, is effective in controlling pod borer larvae.

Chemical control

Pest infesting floral bud, pod/seed: Lepidopteran insects (*Helicoverpa armigera*, *Exelastis atomosa*, *Catochrysop sonejus*, *Lampedes boeticus*, *Catocherysops Strabo* and *Maruca testulis*) first infest floral buds and then pod. Dipterans (*M. obtusa*), coleopterian (*Callaosobruchus* sp. and *Apion* sp.) and hymenopteran (*Tanaostignoides*



Most productive and profitable cropping system for upland agro-ecosystem of Bihar under climate change scenario

sp.) borer commence their activity with beginning of pod borer formation. To control these pests effectively, following measures are suggested:

Foliar spraying

- Spray of NSKE has been found effective against borer complex. To prepare it, 1.0 kg powdered NSKE should be tied loosely in a muslin cloth, soaked in 20 litres of water overnight. Muslin cloth may be pressed, and extract collected. About 200g of ordinary soap is added to this solution, thoroughly dissolved.
- Spray of Acephate 45% + Cypermethrin 5% WDG (2 g/litre of water)/Novaluron 5.25% + Indoxacarb 4.5% SC (1.6 ml/litre of water) is effectively controlling Lepidopteran pests.
- Spray of Chlorantraniliprole 18.5% SC (0.5 ml/litre of water) or Novaluron 5.25% + Indoxacarb 4.5% SC (1.6 ml/litre of water) has been found effective to control Dipterans borers (pod borers).

Dusting: Dusting with methyl parathion 2%, malathion 5% or carbaryl @ 25-30 kg/ha is effective.

Economic threshold level (ETL):

Most essential part of measures to control pests is timing of control. First spraying should be done when ETL reaches. ETL of different pests are as follows- Pod borer: 1.0 larva/plant; Other Lepidopteran borers: 2-3 larvae/plant; Pod fly: 5% egg lying on pods.

Integrated pest management (IPM): Recent emphasis is on identification of control measures that have a combination of different components, including simple cultural practices i.e., summer deep ploughing, adjusting planting date, shaking of plant, manual collection/eradication of insect, chemical preparation, NMSE and use of biological pesticides, i.e., NPV, Bt. Products.

Post-harvest care: *Bruchids* (*Callosobruchus* spp.) are serious pests of pulses during field and storage. An easy, simple, safe way to protect small quantities of grains is by smearing seed with 1% edible oil i.e. mustard/coconut oil/by mixing 2% fine inert dust like kaolin/lime powder with grain. For bulk storage, grains should be stored in airtight structures i.e., Kuthala/Bujhari and with Al phosphide @ 1 tablet/100 kg of seed. Spraying of 1% fenvalerate on ground surface and walls is also

quite effective to check residual or ongoing infestation.

SUMMARY

Crop diversification serves as a pivotal strategy for alleviating economic stress within farming community. Persistent reliance on rice-wheat production system has led to various adverse impacts on human health, soil quality, and environmental well-being. However, introduction, adoption, and acceptance of new crop varieties and innovative production technologies hold potential to transform this situation. There is an imperative need to pinpoint cropping systems that can cater to diverse environments while bolstering farmers' income. Notably, the cost of cultivating cereal-based systems surpasses that of September-planted arhar-based system in terms of net returns. Thus, promoting and embracing the September arhar-based production system emerges as a viable agronomic choice, offering substantial economic gains, ecological sustainability, and long-term viability.

*Corresponding author email: rakeshbhu08@gmail.com



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Krishi Anusandhan Bhawan – I, Pusa, New Delhi 110012

Tel: 011-25843657; email: bmicar@icar.org.in, businessuniticar@gmail.com

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