Enhancing Pulses Production in Bihar: Constraints and Strategies for Sustainable Growth

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ABSTRACT

Food grains are the major agricultural commodity, produced on about 93 percent of cropped area, of which pulses share merely 7.06 per cent and the productivity of pulses ranges between 819 kg/ha in 2000-01 to 897 kg/ha in 2013-14. Bihar ranks 9th in terms of pulses production with a contribution of 0.52 million tons to the national pulse pool. Traditionally pulses have been considered important elements of cropping systems in the Bihar, but with the introduction of irrigation and high profitability of alternative sources of soil nutrients in the form of inorganic fertilizers in 1960s, pulses were replaced or relegated to marginal lands and were substituted by high- yielding varieties of rice and wheat. There has been an incessant decline in pulses area, production and productivity during last three and half decades accounting for about 437.24 thousand hectares, 428.93 thousand tons and 981 kg ha-1 respectively in 2014 - 15 against the corresponding figures of 717.2 thousand hectares, 620.7 thousand tons and 865 kg ha-1 in 2000-01 registering a compound annual decline of -2.5 percent in area and -0.41 percent in production but productivity increased by 2.15 percent per annum. Lentil is only crop which has performed well in Bihar whereas area and production of most of the major pulses have gone down.

In Bihar 2.2 million ha rice fallow land is there which are most suitable for pulses cultivation where medium and long duration paddy is cultivated and after field vacating due to lack of irrigation facility and delay normally the field remains vacant. Post rainy season crop becomes difficult but in some areas relay cropping of small seeded lentil and lathyrus is done by broadcasting the seeds in the standing crop of rice 7-10 days before harvest when there is adequate moisture for germination and converting these mono-cropped areas into double cropped ones by pulses like moong, urd, and lathyrus can increase pulse production and sustain productivity of the rice-based system.. There is need to popularize this system by developing varieties suitable for relay cropping and standardization of this agro-technology. Pulse production in Bihar is adversely affected by a number of biotic and abiotic stresses which can be overcome by assembling the available components of integrated pest management like host plant resistance, cultural practices to disrupt the life cycles of pests, and need-based use of pesticides and to validate them in farmers' participatory on-farm trial and demonstration in farmers field, to deliver management components effectively to stabilize and increase the productivity of pulses. There is also need to strengthen extension efforts to disseminate available pulse technologies through on-farm demonstrations and farmers' participatory research.

Key words: Pulses production, Abiotic constraints, Biotic constraints, Bihar

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INTRODUCTION

Pulses constitute an essential part of the Indian diet for nutritional security and environmental sustainability. They are important food crops due to their high protein content 20 to 25 per cent, carbohydrates 55 to 60 per cent, rich in calcium and iron also. All pulses play a key role in improving of soil fertility through biological nitrogen fixation with the help of rhizobium bacteria found their root nodules playing an important role in enhancing the fertility of soil in term of yield of subsequent crop. Increase in yield of subsequent crop to the tune of about 20-40 per cent has been recorded (Joshi, 1998). While the traditional cropping pattern had always included a pulse crop either as a mixed crop or in rotation and the commercialization of agriculture encouraged the practice of sole-cropping. The net per capita per day availability of pulses has decreased from 61 gms to 32 gms during 1951 to 2010, with decreased production there has been an imbalance in demand and supply resulting in soaring import bills, unpredictable price rises and low net profit compared to competing crops (Joshi and Saxena, 2002). It is estimated that deficit of pulses will be to the tune of 24.9 MT by 2020. The demand-supply gap pulses flagged and shortfall in pulses has been attributed to number of factor, major ones being the increasing population, rising income of the people, geographical shift, abrupt climate change, complex disease–pest syndrome, socio- economic policies and input constrains (Ali and Gupta, 2012). This along with other economic factor like lack of assured market, ineffective government procurement, lack of minimum support price and trade liberalization make pulses cultivation less remunerative as compared to other crops.

Bihar one of the important pulses growing and consuming state in India contributes about 2.35 percent of area which is 7-8 percent of the gross cropped area in the state and 3.06 percent of production. The productivity of pulses range between 819 kg/ha in 2000-01 to 897 kg/ha in 2013-14. It is mostly grown in rain fed condition and resulting in high yield fluctuation every year. In India average yield of pulses in rice fallow system is about 11% higher than national average, whereas in Bihar it is higher than 30% and in Madhya Pradesh by 15% (Joshi *et.al*.,2002). Traditionally pulses have been considered important elements of cropping systems in the Bihar, but with the introduction of irrigation and high profitability of alternative sources of soil nutrients in the form of inorganic fertilizers in 1960s, pulses were replaced or relegated to marginal lands and were substituted by high- yielding varieties of rice and wheat.

Table 1: Area, Production and Yield of total Pulses in India

Year	Area (million hectare)	Production (million tons)	Yield (Kg/ha)
1970-71	22.54	11.82	524
1975-76	24.45	13.04	533
1980-81	22.46	10.63	473
1985-86	24.42	13.36	547
1990-91	24.66	14.26	578
1995-96	22.28	12.31	552
2000-2001	20.35	11.08	544
2005-2006	22.39	13.38	597
2010-2011	26.28	18.24	694
2013-14	25.21	19.78	785

AGRICULTURE PROFILE OF THE STATE

Bihar with a geographical area of about 94.2 thousand square km is divided by river Ganges into two parts, the north Bihar with an area of 53.3 thousand square km and the south Bihar having an area of 40.9 thousand square km. Based on soil characterization, rainfall, temperature and terrain, four main agro-climatic zones in Bihar have been identified. These are: Zone-I, North Alluvial Plain, Zone-II, north East Alluvial Plain, Zone-III all three agro climatic zones have vast untapped potential for increasing the productivity of food grain crops. Across the state soil texture is varies from sandy loam to heavy clay. However the majority type belongs to loam category which is good for crop cultivation. The natural precipitation varies from 990 to 1700 mm mostly received during the month of July to September. Soil PH varies from 6.5 to 8.4. There are three crop seasons- Kharif, Rabi and Zaid. Rice, wheat and pulses are grown in all the districts however the choice of the crop and crop rotation varies across the agro climatic zone. Being located between 25 to 27 degree North latitude the climate of Bihar is of mostly sub-tropical. Nevertheless region close to Tropic of Cancer experiences tropical climate during summer. Bihar gets its maximum rainfall during South-West monsoon season which prevails from June to September.

In the south of the natural levee of the Ganga, there is vast stretch of backwaters known as "Tal" lands extending from Buxar to Pirpaity, where most of the rivers and rivulets coming from the south get lost. The flood plains of Ganga, which get reworked and get eroded and deposited at regular intervals, are lighter than "Tal" lands and are known locally as Diara lands. The soils of 'Tal' lands are highly clayey throughout their depths, grey to dark grey in colour, neutral to slightly alkaline in reaction. These soils are moderately rich in nitrogen, available P and K and very hard under normal conditions. The Diara land soils with their undulating landscapes are generally very light to medium heavy textured but all underlain by sandy layers within 80 to 100 cm of their surface and very well drained to moderately well drained, neutral to slightly alkaline in reaction. The cropping pattern in Tal areas has been highly skewed towards production of pulses, that too towards lentil (60%), followed by lathyrus (15%),chickpea (4%), pea (3%). Among other crops wheat (7%), mustard and rai (5%) and potato-onion (2%) are important.

PULSES AND BIHAR

Bihar ranks 9th in terms of production, and contributes about 0.52 million tons to the national pulses pool. It is the third most populous state sharing 2.8 percent of geographical area and 8.6 per cent population of India. Food grains are the major agricultural commodity, produced on about 93 percent of cropped area, of which pulses share merely 7.06 per cent. Adaptability of pulses to diverse climatic and agro-ecosystems is phenomenal making them victim of human apathy. Pulses are often cultivated on marginal lands under rain-fed conditions on residual soils moistures after harvesting of kharif crops. Owing to high instability in productivity there has been an incessant decline in area of pulses area, production and productivity during last three and half decades which accounted for about 437.24 thousand hectares, 428.93 thousand tons and 981 kg ha-1 respectively in 2014 - 15 against the corresponding figures of 717.2 thousand hectares, 620.7 thousand tons and 865 kg ha-1 in 2000-01, registering a compound annual decline of -2.5 percent in area and -0.41 percent in production but productivity increased by 2.15 percent per annum. It is obvious that there has been a radical fall in pulse area with a corresponding decline in pulse production. There has been a compound annual growth in productivity of pulses during 2000-01 and 2014-15, probably due to adoption of improved seeds and steps taken by the

government to accelerate pulse production in recent years. Lentil is only crop which has performed well in Bihar whereas area and production of most of the major pulses have gone down. It is worth noting that there has been a negative correlation between irrigation and acreage of pulses indicating that farmers prefer to allocate irrigated lands to cereals and other crops substituting pulses. Bihar contributes about 3.06 percent in production and 2.35 percent in area. Important pulses like Lentil, Lathyrus, Pigeon pea, Green gram, Chickpea etc are mostly grown in under rainfed conditions on marginal lands with poor level of management practices resulting in low production and productivity which was of 897 Kg/ha in 2013-14.

Table 2: Area, Production and Yield of total Pulses in Bihar

Year	Area ('000 hectare)	Production ('000 tons)	Yield (Kg/ha)
1970-71	1644.8	987.4	600
1975-76	1531.3	822.4	537
1980-81	1367.8	833	609
1985-86	1233.1	887.4	720
1990-91	1175.7	915.8	779
1995-96	921.8	560.7	608
2000-01	717.2	620.7	865
2005-06	596.9	446.8	749
2010-11	605.0	556.0	918
2013-14	500.0	522.0	1044

Table 3: Productivity of major Pulses grown in Bihar

Year	Chick-pea	Pigeon-pea	Lentil	Mung bean	Lathyrus	Urd bean	Peas	Kulthi
1965-66	742	855	-	-	-	-	-	-
1970-71	713	896	643	351	581	487	-	-
1975-76	550	705	582	336	612	377	606	352
1980-81	718	971	641	466	619	470	534	387
1985-86	839	1142	772	485	787	456	665	546
1990-91	941	1243	892	556	790	670	747	537
1995-96	651	929	581	557	657	505	554	455
2000-01	1033	1348	981	581	915	634	965	771
2005-06	902	1291	705	556	853	770	892	858
2010-11	1182	1515	900	669	998	841	1051	980
2013-14	1147	1667	1147	680	-	912	1041	953

CHANGES IN PULSE PRODUCTION IN BIHAR

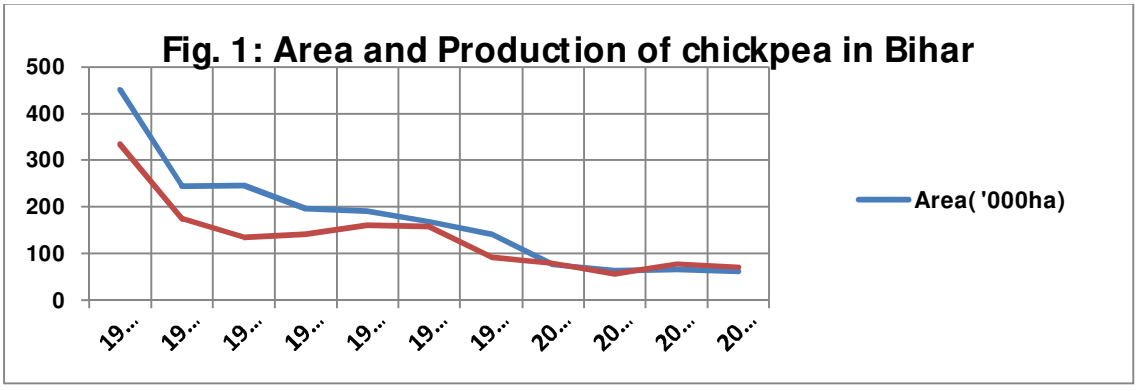
Pulse cultivation was an integral part of cropping system in Bihar with 1644.8 thousand ha area under total pulses and production of 987.4 thousand tones and yield of 600Kg/ha as compared to national yield of 524Kg/ha in 1970-71. In last four decades there has been drastic with reduction

in pulses area with only 500 thousand ha area only under pulses in 2013-14 and these area substituted by other crops mainly rice and wheat. This decline in pulses area has been largely attributed to relatively higher profitability of rice and wheat as comparison to legumes (Malik 1994). The spatial distribution and temporal changes of important pulses in Bihar are discussed below:

Chickpea

Chickpea once the most important pulse crop of Bihar is at present most affected by change in cropping preference of farmers. In 1965-66 it covered an area of 450.9 thousand ha with production of 334.4 thousand tones and yield of 742Kg/ha. Thereafter there has been steady decline in chickpea area with nearly 50% reduction in 1970-71 with 244.4 ('000ha), 195.8 ('000ha) in 1980-85, 167.7('000ha) in 1990-95 and 76.2('000ha) in 2000-01. In 2013-14 the area under chickpea was only 61.3 thousand ha. If we look at the yield data we observe that there has been slight rise with 1182 kg/ha in 2010-11 and 1147 kg/ha in 2013-14 but production has drastically fallen due to rapid decline in area. Tal area which was famous for chickpea cultivation has been replaced by other pulses with only isolated patches of chickpea area. As soon as the any area develops irrigation facilities, the chickpea area gets diverted to other more remunerative crops like wheat, mustard, sunflower, sugar cane, potato, etc. This area has also reduced drastically because the existing varieties are not responsive to high input conditions and show excessive vegetative growth and lodging when grown in fertile soil, receive rains or irrigations during crop growth. Drought and heat are the major abiotic stresses affecting chickpea at reproductive and terminal phases of crop growth. Pod borer (*Helicoverpa armigera*) continues to remain a major and challenging insect-pest of chickpea and dry root rot (DRR) and Fusarium wilt are other biotic stresses which deter farmers to grow chickpea.

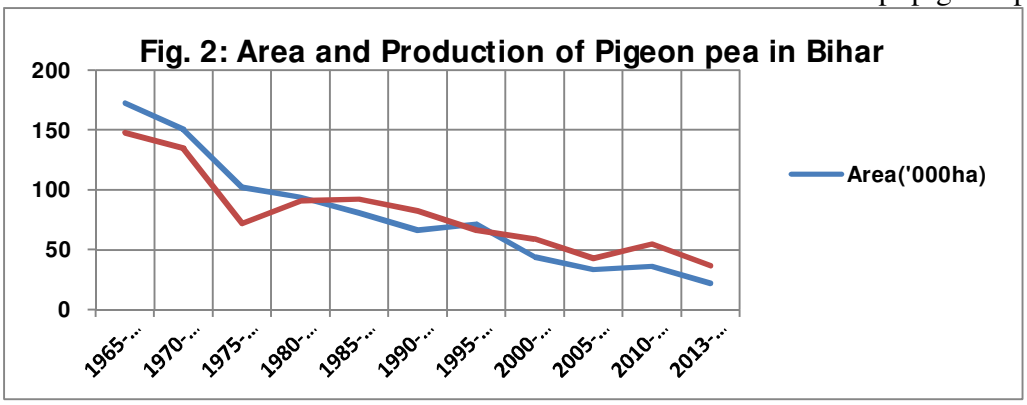
The vast rice fallow area (2.2mha) offer opportunities for expanding chickpea area in Bihar as experiments clearly demonstrates that chickpea is a very suitable pulse crop for rice-fallows, provided suitable varieties and technologies for crop establishment are available. The important traits required in chickpea varieties for rice fallows include early to extra-early maturity and reproductive stage heat tolerance.



Pigeon pea

Pigeon pea is one of the most preferred pulse consumed in Bihar but the area and production has been reduced to 21.9 thousand ha and 36.5 tons respectively in 2013-14 which was in 1965-66 172 thousand ha and production of 147.8 thousand tones. If we look at the decadal data in 1970-

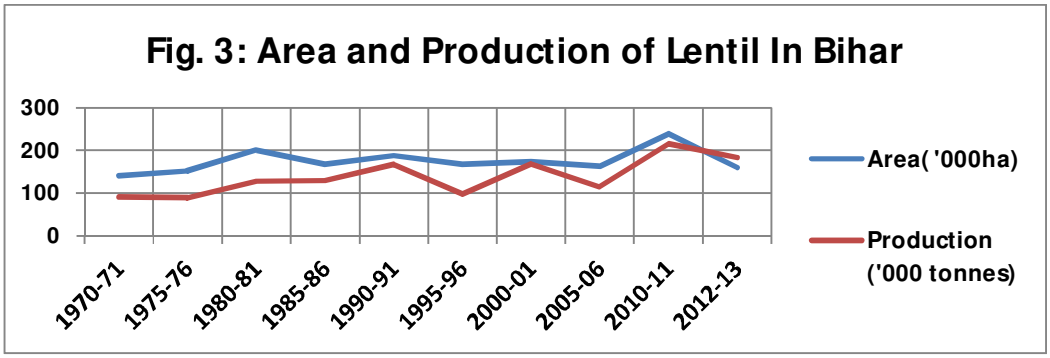
71 , 1980-81, 1990-91and 2000-01 the area and production of pigeon pea was 150.3(‘000ha) and 147.8(‘000t); 93.7(‘000ha)and 91 (‘000 t); 66.2 (‘000ha)and 82.3(‘000t) and 43.7(‘000ha) and 58.9(‘000t) respectively showing a steady decline in area and thereby production. The productivity of pigeon pea has always been more than the national average with highest yield in 2013-14 of 1147Kg/ha, but the matter of concern is very few farmers are opting for pigeonpea cultivation and one the reason is also its being long duration crop with maximum field occupancy. In Bihar traditionally long duration varieties (>200 days) of pigeonpea are grown which are highly photoperiod-sensitive taking about 40 weeks to mature exposesing the crop to terminal drought stress and frosts. Almost every year the crop is damaged by frost leading to lower yields and poor quality seeds. There is need to identify sources of tolerance/ resistance for this constraint and design appropriate breeding strategies to develop suitable varieties. Besides a number of biotic and biotic factors also deter farmers to take up pigeon pea cultivation.



Lentil

Lentil is the only pulse crop whose area has remained more or less stagnant over the years with fluctuations. In year 1970-71 the total area under lentil was 140.7(‘000ha) and production of 90.5(‘000t) and now in 2013-14 its area and production is 159.7 (‘000ha) and 183.2(‘000t). But over the years the productivity has always been more than national with 1147 Kg/ha in 2012-13 but much less than potential yield. So it is one of those pulse crop whose area and production can be easily improved with better agro-technology management and policy improvement. Productivity of lentil is also limited by several biotic stresses such as diseases and pests and weeds (Gupta 2014; Kumar et al. 2013). Systematic transfers of available technologies have potential to enhance lentil yield by at least 20-25%.

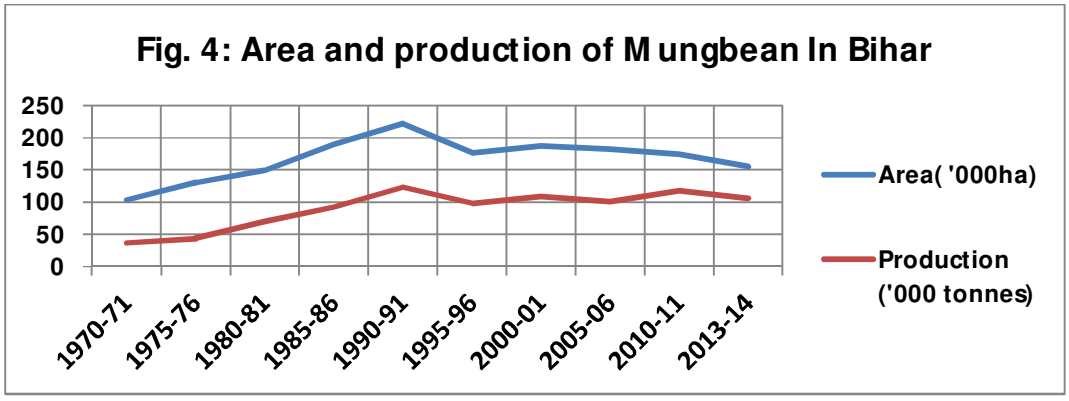
A substantial area of lentil is sown under late sown condition in rice-fallow fields. Early maturing varieties possessing high biomass and tolerance to high temperature at reproductive stage are required. They should also have resistance to diseases like Stemphylium blight, rust and wilt, tolerance to low temperature at vegetative stage and high temperature at reproductive stage, and terminal soil moisture stress with the rice varieties should be early maturing.



Mung Bean

Mung bean is a minor pulse grown in Bihar with nearly 80% of the mung bean sown in summer after harvest of wheat, mustard and potato. In the Indo-Gangetic plains nearly 60% of mung bean is grown in Bihar (largely the northern part), and more than 25% in Uttar Pradesh (mostly in the western part). These two states of India contribute about 17% of total mung bean production in India. Mung bean area in Bihar, has steadily risen from 103.0 ('000 ha) in 1970-71 to 155.1('000 ha) in 2013-14 with productivity of 680 Kg/ha.

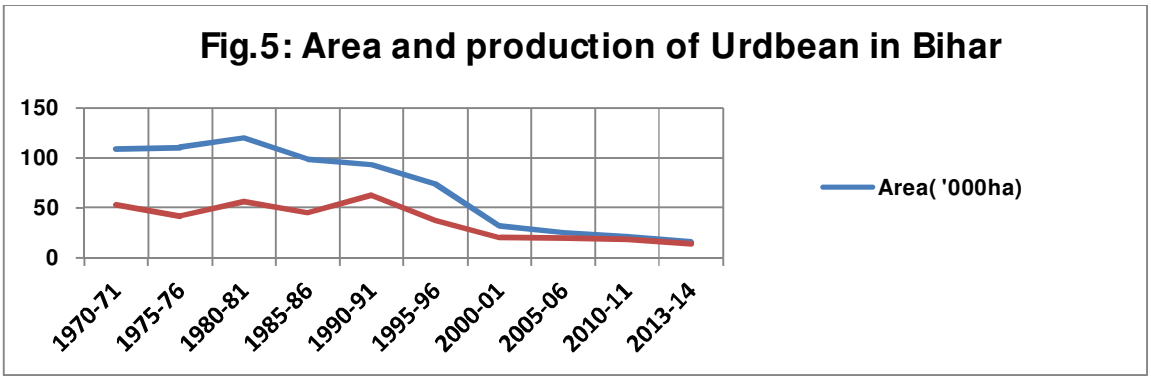
Mung bean offers good potential for bringing additional area and enhancing production and productivity, as varieties with varying maturity groups exist to meet the needs of different cropping systems. Large numbers of viruses, fungal and bacterial diseases are known to damage mungbean crop at different stages of crop growth and during storage so management of abiotic and biotic stresses will lead to increased productivity. Results of the front-line demonstrations indicates scope for enhancing yields at farmers' fields following systematic technology transfer particularly in spring/summer season. As the crop fits well in small window after harvest of rabi crop (such as wheat and rabi maize) mungbean cultivation will help in sustaining productivity of the cereal based cropping systems in Bihar.



Urd bean

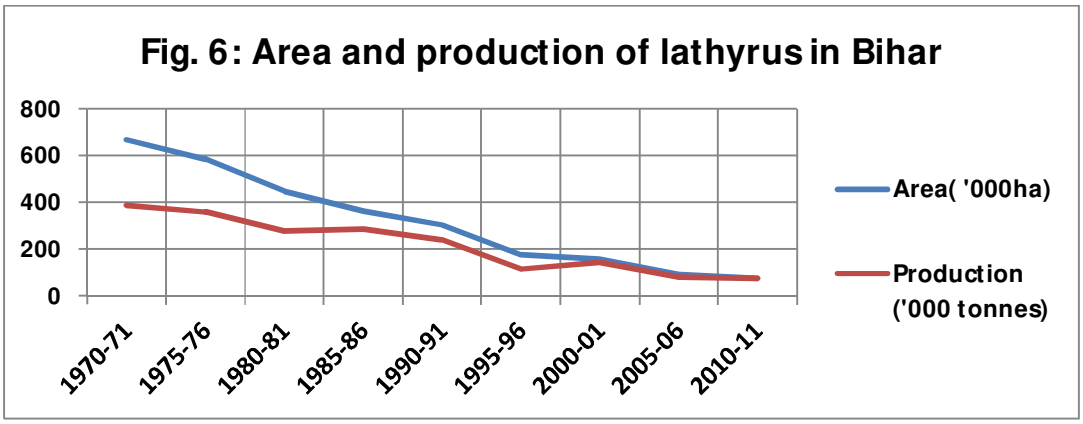
The area under mungbean and urd bean was nearly same in 1970-71 i.e., 103.0 and 108.8 ('000ha) respectively. In 2013-14 this area has come down to only 15.5 ('000ha) showing a severe dip in area over the years. Urdbean is grown mostly during rainy season, however, being a short duration and nitrogen fixing crop, urdbean fits well in multiple cropping systems and can provide desired sustainability to cereal based cropping systems. Much scope exists to bring

additional area under urdbean through inclusion of short duration urdbean varieties between two cereal crops in irrigated areas of Bihar with further scope for increasing area, by introducing short duration and high yielding varieties with better biomass for spring/summer or rabi seasons.



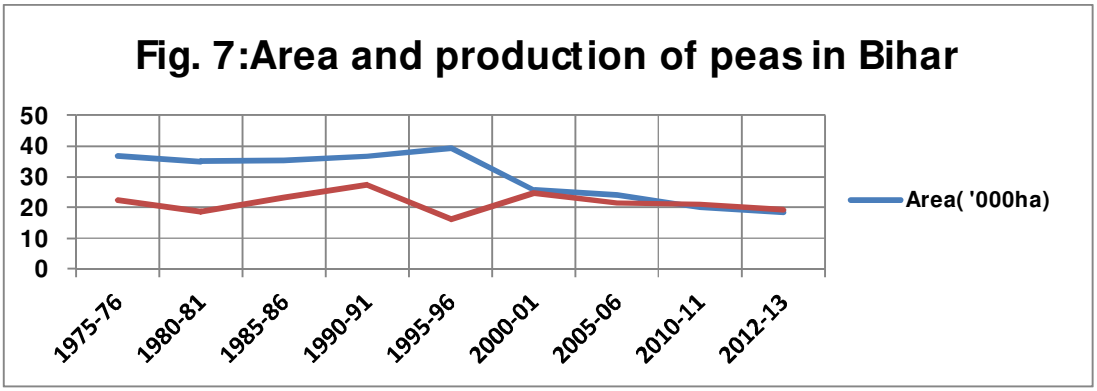
Lathyrus (Khesari)

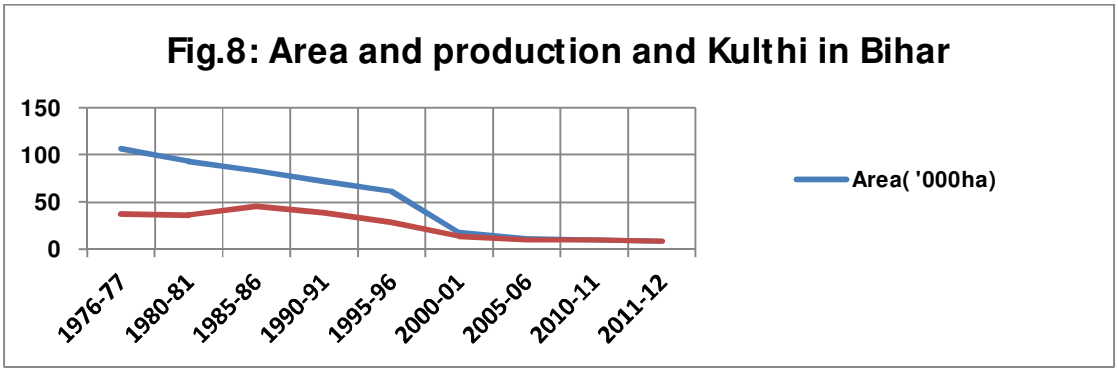
Lathyrus was one of the most important pulse crop grown in Bihar with maximum coverage of an area of 668.3 ('000ha) in 1970-71 and production of 388.1 ('000t), and the scenario remained more or less same with 447.8 and 304.1('000ha) in 1980-81 and 1990-91 respectively. Thereafter, this area under Lathyrus (khesari) declined to 73.8('000ha) although the yield has increased to 998kg/ha in 2011-12. It can be grown in semi arid and arid region and hence serve as only protein source food during drought and famine period. But as the stress level of environment increases the level of ODAP (β-N-oxalyl-l-α-diamino propionic acid) increases which is a neurotoxin amino acid causing neurolathyrism (paralysis) in human beings and animals if consumed on a regular basis for a long period.



Field Pea and Kulthi

Kulthi or Horse gram and field pea are other minor pulses generally grown as mixed with other crops. Kulthi is grown mainly in two different seasons i.e. Rabi and Kharif It is rich in antioxidant properties which are mainly present in the seed coat, helps to cure several diseases like cure kidney stones, diabetes and even fever. Now in 2011-12 Kulthi is grown in 8.6 ('000ha) with production of 8.2 ('000t) and yield of 953Kg/ha. Whereas, field pea covers an area of 36.8 ('000ha) and production of 22.3('000t) in 1975-76 is cultivated only in 18.6('000ha) in 2012-13.





CONSTRAINTS OF PULSES PRODUCTION IN BIHAR

The area under pulses has undergone drastic reduction resulting in low production, although the productivity of major pulses has either increased or remained stagnant but still there is huge gap with potential yield. Pulses are generally grown on marginal lands due to the low productivity-low input nature as rainfed crop, with main focus on high productivity-high input crops like paddy and wheat by most farmers. In a study regarding impact of NFSM on pulse production, marketing it was found that in NFSM and non NFSM district of Bihar about 64% of sample farmers mainly grows pulses for home consumption needs, followed by lack of irrigation and inferior land (14% each) and profitability ranked important only by large farmers (8%). In NFSM and non-NFSM districts pest problem has been mentioned as main limitation (28-30%), other being lower profitability (24%), yield instability (20%) and lack of assured market (16%) were listed as main reasons for shifting away from pulse cultivation (Singh et.al., 2016). As a crop of low priority and status they do not get best of management practices of farmers besides being adversely affected by a number of biotic and abiotic stresses, responsible for a large extent of the instability and low yields. Some of the studies estimated the losses in the range from 15% to 20% of normal production (IIPR 2011). The major abiotic, biotic and socio-economic constraints in Pulse production are enumerated below.

Abiotic Constraints

Drought, water logging, temperature extremes, wind or hail (causing lodging), alkaline and saline soils, acid soils, and deficiencies or toxicities of various mineral nutrients are the common abiotic stresses that limit pulse production in Bihar.

Drought

In chickpea, Pigeon pea, green gram lentil, black gram drought is the main cause of reduction in yield as these are grown in residual receding soil moisture environment or face soil moisture deficit conditions during their reproductive phase and are exposed to terminal drought stress. To overcome such situation better management techniques to conserve soil moisture and maximize crop transpiration over soil evaporation can help to reduce drought effects in pulses. In some situation excess soil moisture in tal and other areas induces excess vegetative growth with more disease incidence as well as lodging in gram and lentil, wheras, Khesari (lathyrus) has good drought resistance and production even when sown on drought-prone upland soils.

Temperature

Terminal drought stress during maturity in chickpea and lentil results in poor pod filling whereas, low temperatures results in frost injury.

Water logging

Khesari (lathyrus) and horse gram can establish well in waterlogged soils, even when relay-sown in rice, and can grow until maturity in waterlogged soils. All other pulses do not tolerate water logging condition.

Micronutrient deficiencies

Deficiency of micronutrients adversely affects production of lentil, chickpea and other pulses, which become more evident once the biotic stress are managed. Experiment have shown that deficiency of micronutrients like sulphur and zinc is common in pulse growing regions and application of sulphur and zinc has been found with a cost benefit ratio of 10-21%.

Nitrogen fixation

In traditional pulses grown area *Rhizobium* spp present in soil results in effective nodulation, but when introduced in new areas the host specific *Rhizobium* also needs to be introduced through inoculation. S. Pande, 1996 observed that in Bihar khesari (lathyrus) nodulates prolifically, in meeting its own nitrogen (N) requirements as well as also fix N_2 to the cropping system. Pulses are very sensitive to alkaline, saline, and acidic soil which limits its prospects of cultivation in irrigated areas where there is such increase incidence.

Biotic Constraints

More than 250 insect species are reported to affect pulses, of which nearly one dozen cause heavy crop losses. Pod borer (*helicovera armigera)* causes the most harm, followed by pod fly, wilt and root rot, important diseases wilt in chickpea, sterility mosaic virus (SMV) in pigeonpea, yellow mosaic virus (YMV) and powdery mildew (PM) are also common and damaging. Another important pest affecting pulses are nematodes, among which root-knot nematodes are important in terms of spread and damage to crop yield, which have been effectively controlled by bio-agents. Some of the common biotic constraints faced by the pulse crops are presented in Table-4.

Table 4. Major problems faced by pulse crops in Bihar (related to insect pests, diseases and nematode problem)

Crop	Insect Pests	Diseases	Nematodes
Chickpea	Pod borer (*Helicoverpa armigera*)	Fusarium wilt *(Fusarium* spp)	Root-knot (*Meloidogyne* spp)
	Semilooper (*Autographa nigrisignn*)	Botrytis gray mold (*Botrytis cinerea*),	-
	Bruchids (*Callsobruchus* spp)	Wet root rot	-
	Cutworm (*Agrotis ypsilon*)	Stemphylium blight (*Stemphylium* spp).	-
Lentil	Ap h i d *(Aphis craccivora)*	Rust (*Uromyces viciae-fabae*)	Root -knot *(Meloidogyne* spp)
	Pod borer (*Etiella zinckenella*)	Stemphylium blight (*Stemphylium* spp).	-
	Bruchids (*Callosobruchus chinensis, C. maculatus*	Fusarium wilt *(Fusarium* spp)	-
Pigeon pea	Pod borer (*Hclicoverpa armigera)*	Fusarium wilt *(Fusarium* spp)	Cyst *(Heterodera cajani*)
	Podfly (*Melanagromyza obtusa)*	Phytophthora blight (*Phytophthora drechsleri* f. sp *cajani*	Lesion *(Pratylenchus* spp)
	Legume pod borer (*Maruca vitrata*)	Sterility mosaic	Root-knot (*Meloidogyne* spp)
	Blister beetle *(Mylabris pustulata*)	Alternaria blight (*Alternaria alternata*)	-
Pea	Leaf miner (*Phytomyza atricornis)*	Powdery mildew *(Erysiphe pisi)*	Root -knot *(Meloidogyne* spp)
	Stem fly (*Ophiomyia phaseoli*)	Rust (*Uromyces viciae)*	Cyst (*Heterodera goettingiana)*
Mung bean and Urd bean	Bihar Hairy Caterpillar *(Spilosoma obliqua)*	Yellow mosaic	Root -knot *(Meloidogyne* spp)
	Aphid (*Aphis craccivora)*	Cercospora leaf spots (*Pseudocercospora cruenta)*	Cyst *(Heterodera* spp)
	Thrips (*Megalurothrips distalis*)	Powdery mildew (*Erysiphe polygoni)*	-
	Whitef l y (*Bemisia tabaci)*	-	-

Recently many successful trials have been conducted to control pod borer through using nuclear polyhedrosis virus (HaNPCV) and *bacillus thruringiensis Berliner (Bt) var. kurstaki*, which has been found to be more efficacious in bringing about higher and quick mortality.

Physiological Limitations

Pulses in general have a high rate of flower drop. In pigeon pea, over 80% of the flowers produced in a plant are shed by decreasing flower drop, yield can be increased considerably Recent increase in yield levels in pigeonpea is due to release of long duration (annual) varieties, which maximize utilization of assimilates in filling the available sink of a large number of flowers (Rego and Wani 2002).

Biofertiliser

Most pulses growing areas have low to medium population of native *rhizobium* and seed inoculation with biofertiliser (*rhizobium*) can increase pulses productivity by 10-12%. Lack of quality culture is also one of the major constraints in use of biofertilisers. *Vesicular-arbuscular mycorrhizae* (VAM) promises for improving supply of phosphate and micronutrients like zinc pulse crops. Phosphate solubilising bacteria (PSB) in rainfed pulses production systems in soils with poor phosphorus availability can help in production improvement. Combined use of culture, like dual inoculation of rhizobium and VAM results in higher yield as compared with rhizobium alone.

Irrigation

Pulses are mostly cultivated on marginal lands as rainfed crops and experimental results at IIPR have shown improvement in productivity due to one irrigation at a critical stage. There was 50% increase in grain yield in sole crop and more than double in intercropped pigeonpea with two irrigations given at the vegetative and flowering stages at ICRISAT (Sharma and Jodha 1982).

Post-Harvest Technology

Post-harvest losses account for 9.5% of total pulses production of which storage accounts for the maximum loss of 7.5% and processing, threshing and transport results in 1%, 0.5% and 0.5% losses, respectively. Pulses are more susceptible to damage by storage insects (5%) as compared to wheat (2.5%), paddy (2%) and maize (3.5%) (Deshpande and Singh, 2001). There is need to popularize storage structures like metal storage bins. Processing efficiency of dal mills has recently increased to 70-75% as compared to 65-66% in traditional dal mills. To decrease post harvest loss and increase rural employment mini dal mills should be popularised by formation of pulse producer groups and processer associations.

Socio-economic Constraints

Awareness and access to new technology:

Farmers' awareness on improved varieties and seed availability of improved varieties are the key factors in the spread of improved varieties. The television will be the most popular media for increasing awareness; trials and farmers' fairs/field days will also be helpful. The identified technology needs to be subsidized for wider adoption.

Lack of Quality and improved seed

In any crop, generally an increase in the production and productivity is brought about by the wider availability and adoption of improved varieties of seeds but there is a shortage of Certified/Truthful seed at farmers' level. Since the beginning of coordinated pulses improvement programme in 1967, 400 improved varieties of different pulse crops have been released in India but only 124 varieties are in the production chain. There is a huge gap in demand and supply of quality seed and seed replacement ratio is very low (2-5%), while the required seed replacement ratio is 10% as both public and private agencies have not been able to meet the requirement of quality seed and the seed replacement ratio is very low.

Cash and Credit:

Cash is a key element for enabling smallholder farmers to shift from low input-low output to high-input-high-output agriculture. But access to credit by these farmers is low because of their low asset base, low risk bearing ability and high risk environments. This can be effectively tackled by the insurance-linked credit to pulse crops without any collateral security. The scale of finance should be sufficient enough to cover all the costs of the recommended practices (Reddy 2009). .

Farm mechanization:

In Andhra Pradesh increased mechanization of farm operations is one of the reasons for success of expansion of area under chickpea which needs to be replicated in Bihar. It can further be enhanced by developing varieties suitable for harvesting by combine harvesters. In peak season farm mechanization activities such as harvesting and threshing needs to be encouraged through the distribution of subsidized farm machinery to cope with labor shortage and higher wage rates.

Marketing:

Markets for legumes are thin and fragmented due to scattered production and consumption across states. Farmers sell their marketed surplus immediately after harvest, while some large traders/wholesalers trade between major markets and hoard pulses to take advantage of speculative gains in the off-season, for pulses like khesari, demand is localised and markets are underdeveloped Due to this, farmers do not benefit from the higher market prices of pulses. Investments in market infrastructure, warehouses, market information systems both in public and private sectors through Public-Private Partnership (PPP) models and economic viability gap funding models need to be encouraged.

PROSPECTS OF INCREASING AREA AND PRODUCTION OF PULSES IN BIHAR

Bihar had been a traditional pulse growing state but the focus with time shifted to more remerative and assured cropping system of cereal-cereal. With policy apathy it has reached to low which can be reversed with more focus on pulses. New initiatives can change this trend with following steps:

Short-duration pigeon pea in sequence with wheat

Introduction of short duration pigeon pea in uplands of Bihar can be successfully grown. As this region receives heavy rainfall it is important that sowing should be done in the first fortnight of June with pre-planting irrigation so that by the time monsoon rains start the seedlings are strong enough to combat adverse effects of excess moisture. Development of varieties tolerant to excess soil moisture, would help in popularization of short-duration pigeon pea.

Spring/summer cultivation of black gram and mung bean

Bihar has good scope of cultivation of kharif/spring black gram and mung bean as well as summer mung bean. With nearly 155.1 thousand hectare area under mung bean there is great scope of widening this area. They are very suitable for intercropping with spring-planted sugarcane and sunflower. Under resource constraints, rice-chickpea is found to be more beneficial than rice-wheat and northern Bihar show most potential for this system. In excessive moisture area i.e., in lowland lentil is a more assured crop than chickpea. So the rice-lentil system is also very popular in the lowlands of Bihar.

Utilization of rice fallows

In Bihar 2.2 million ha rice fallow land is there which are most suitable for pulses cultivation. In large area medium and long duration paddy is cultivated and after field vacating due to lack of irrigation facility and delay normally the field remains vacant. Post rainy season crop becomes difficult but in some areas relay cropping of small seeded lentil and lathyrus is done by broadcasting the seeds in the standing crop of rice 7-10 days before harvest when there is adequate moisture for germination and converting these mono-cropped areas into double cropped ones increasing pulse production and sustaining productivity of the rice-based system. Expansion of this system will increase the pulse areas and bringing rice fallow under pulse production. There is need to popularize this system by developing varieties suitable for relay cropping and standardization of this agro-technology.

In Bihar main rice fallow areas lies in district like Kishanganj, Sahebganj, Gaya, Aurangabad, Katihar and Bhagalpur. After the harvest of *kharif* rice, climatic conditions of rice fallow lands in these areas are suitable for growing pulses. The residual moisture left in the soil at the time of rice harvest is sufficient to raise short-season crops so by use of short-duration and high-yielding varieties of rice which will allow vacating fields in September-October these rice fallows can be converted into productive lands. Pulses like lentil, mungbean, urdbean, lathyrus, peas etc. in rice fallows can increase the productivity as well as sustainability of rice-wheat production system. In low land areas with excessive soil moisture, lentil is more suitable and assured than chickpea so it can be made more popular in the lowlands of Bihar. Groundnut can also be introduced in rice fallows in *Char* area of Bihar.

Area expansion

Besides rice-fallow there is further scope of increasing pulse area by cropping system manipulation, like mungbean and urdbean as catch crop in summer/spring under cereal-based cropping systems of Bihar, intercropping of short-duration pulses like mungbean, urdbean, cowpea in sugarcane etc. Mungbean with ratooned Sugarcane during spring/summer (irrigated), Chickpea or lentil with autumn planted sugarcane and advocating new cropping systems like rice–lentil.

Integrated Pest Management

Integrated pest management (IPM) gives wider scope for cost-effective control of multiple pests and diseases. It is basically pest management technique which uses one or more management options to reduce pest population below the economic injury level, while ensuring productivity and profitability of the entire farming system. Pulse crop is attacked by more than one disease and pest at a time. A variety of chemical, biological and cultural methods are utilized to reduce pest and disease damage. Properly planned cropping systems involving crop rotation or intercropping of non-host and host crops, different agronomic practices like summer ploughing preceding kharif pulses are cost effective components of IPM. However, farmers are hesitant to use knowledge intensive, systems approach IPM as it needs community approach and takes time to yield results.

Cultivation of post rainy pigeon pea and common bean

Varieties like *Sharad* and *Pusa 9* are suitable for September planting, are found best for extension of post-rainy pigeon pea on uplands of, northern Bihar which receives very heavy rainfall in July causing damage to Jul planted Pigeon Pea. As the Sept sown varieties are thermo-sensitive any delay after mid- Sept. causes heavy loss in yield.

Introduction of black gram and mung bean as winter crops

In some part of northeastern Bihar where the winter temperature are moderate black gram and green gram can be introduced in rice fallow areas utilizing residual moisture and bringing additional area under pulses increasing system productivity too. Another important practice widely applied is that of “growing of short duration legumes” such as moong bean, cluster bean, cowpea and horse gram in widely spaced crops and incorporation of their biomass after harvesting (green manuring), which increases the yield of subsequent crops. Rotation of legumes with non-legumes is another practice to derive benefit from the nitrogen fixed by the *rhizobium*-legume interaction and to meet at least 50% of the nitrogen requirement of most of the cropping systems.

CONCLUSION

Rice-wheat and rice-based systems are the predominant cropping systems in Bihar, as a result natural resources soil and water, are threatened due to their over-exploitation and after affects of climate change is putting an extra stress on such systems. Pulses can play an important role in reversing this process of degradation of soil and water resources, and improving the production potential of the total cropping system. Pulses are an effective source of reversing the process and can contribute significantly to achieving the twin objectives of increasing productivity as well as improving the sustainability of the rice and wheat based cropping system in the IGP (Ahlawat *et al.* 1998; Lauren *et al.* 1998; Yadav *et al.* 1998).There is need to assemble the available components of integrated pest management like host plant resistance, cultural practices to disrupt the life cycles of pests, and need-based use of pesticides and to validate them in farmers' participatory on-farm trial and demonstration in farmers field, to deliver the pest management components effectively to stabilize and increase the productivity of pulses. There is particular need to strengthen extension efforts to disseminate available legume technologies through on-

farm demonstrations and farmers' participatory research. Every year Government of India announces higher MSP than cereals but effective procurement mechanism from farmers is lacking. Efforts are also needed to develop appropriate models for crop insurance to encourage Pulse production in Bihar.

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