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Short communication

Strategies for pulses production for achieving nutritional security in North-East Indian Himalayan Region

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ABSTRACT

Legumes are a significant source of protein, dietary fiber, carbohydrates, vitamins and dietary minerals. 100 g legumes provide 321 – 570 Kcal energy, 21 -28 g protein, 0.8 to 48.0 g fat, 21-63.4 g Carbohydrate and 9.0-22.7 g total dietary fiber. In spite of the several environmental, physical, economical and social constraints of the NEH Region, the average productivity of pulses (848 kg/ha) is higher than the National average (764 kg/ha), indicating the potential of pulses production in this region. North East India soils are acidic in nature, and this region can contribute considerably to pulses production. The present paper presents an overview of the livelihood and nutritional security of food legumes and their prospects and constrains in north east hill regions. An effort has been made to put together all relevant information on new cropping systems (horizontal/vertical) developed for North Eastern Hill Region (Hill and Valley), effect of pulses in improving system productivity and soil properties and their role in crop diversification and intensification at one place.

Keywords: legumes, North-East Indian Himalayan Region, Sustainable agriculture

North East Hill Region (NEHR) of India comprises of 8 states, namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, represents 8.3% geographical area 4% populations of the country (Ngachan *et al.* 2010). Out of the total 26.27 million ha geographical area of NER of India, around 77% is hills and senile plateau, because of hilly topography only 12% net area is under cultivation (Das *et al.* 2016). Forest cover in the region varies from 35·28% to 90.68%of the geographical area (GOI, 2011). The communities in NEHR are predominately agrarian and practice subsistence agriculture and pulses remained an integral component of farming due to their values as nutritious food, feed and forage etc. Legumes are grown as a sole crop, intercrop, catch crop, relay crop, cover crop and green manure crop etc., under horizontal sequential cropping/mono-cropping in different agro-ecological regions. Development of sustainable cropping systems is the key to prosperity of this region and requires inclusion of legume crops either through horizontal intensification or vertical intensification. Crop diversification with inclusion of pulses under shifting cultivated area is required to enhance the legume production in NEH Region, where mixed farming is dominated (Bhadana *et al*. 2013).

In spite of the fact that soil and agro-climatic conditions of the NEHR of India are favourable for pulses cultivation, the region has a deficit of almost 82% of its pulses requirement. North Eastern Himalayan Region is susceptible to soil acidity induced fertility stresses (Patiram, 2007) and the region has more than 80% area under acid soils and hence, the importance of legumes is better understood than in other parts of the country (Das *et al.* 2016). In North East India, nearly 30% of 1.47 million hectares area of the region is categorized as severely eroded with a potential erosion rate of 40-80 t/ha/year (Mandal and Sharda, 2013). Geomorphologic erosion on the surface of the earth has been continuously taking place since time immemorial. Some legumes reduced the soil loss, conserve the soil and water and suppress the weed growth through smothering effects (Konlan *et al.* 2013). It fix the atmospheric nitrogen in soil and improved the soil health (Singh and Singh, 2002). Legume production plays a significant role in nutritional security and used for various purposes including livestock farming. In addition, the farmers of hill terrains areas in the region are mostly belong to resource poor small and marginal farmers with Small and fragmented land holdings. Farm mechanization is less due to high slope gradients across uplands and located sparsely, mostly away from settlements. However, many of these legume crops including Himalayan traditional legumes have high ecological and economic potential and thrive well in harsh environmental conditions with low or no external inputs (Maikhuri *et al*. 1996). The most remunerative and tolerant legume crops to intermittent moisture and soil acidity induced abiotic stresses can be a valuable alternative crop for replacing rice from upland and medium land as well as shifting cultivated areas. Here, productivity of rice in the region is very low (0.5 to 0.9 ha^{-1}) and less economical.

India is the largest producer and consumer of pulses in the world accounting for about 29 per cent of the world area and 19 per cent of the world's production (Singh et al., 2015). Even more importantly India is also the largest

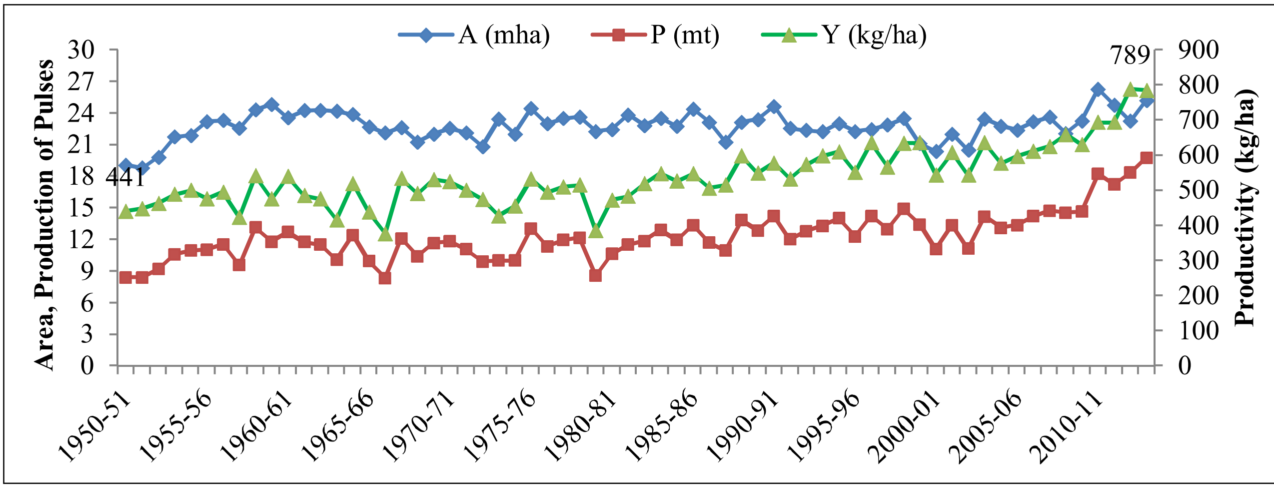

Figure 1. Trends in Area, production and productivity of total pulses in India (www.iipr.res.in)

importer and processor of pulses in the world. Ironically, the country's pulse production has been hovering around 14– 15 MT, coming from a near-stagnated area of 22– 23 M ha, since 1990–91 (Singh et al., 2013). The Pulses area, production and productivity rise in the tune of 32, 135 and 78% during 2013-14 as compared to 1950-51 (Figure 1).

The area under pulses crops increased sharply in the NER from 112,000 ha in 2000–01 to about 217,000 ha in 2013–14 (Das et al, 2016). The productivity of pulses during this period also enhanced from 647 to 848 hg/ha. There is enormous inter-state variation seen in area and production of pulses in NER. The NER can be divided in 2 categories i.e. major and minor pulses producing states. Assam had the highest pulses area of 149,000 hectares and contributed 104,000 tonnes of pulse production during 2013–14, followed by Nagaland and Manipur which accounted 37.80 and 30.38 thousand ha area and contributed 42.5 and 28.65 thousand tonnes production, respectively (Figure 2). There is a wide variation in the productivity of pulses with minimum in Assam (695 kg/ha) and the highest in Mizoram (1476 kg/ha) compared with the national average of 764 kg/ha during 2013–14 (Figure 2). The data on pulses for the past 14 years clearly indicated a sharp rise in area, production and productivity in NER.

The Recommended Dietary Allowances (RDA) for adult male and female is 60 g and 55 g per day. The per capita availability of pulses is @ 42 g per day. Pulses are principal source of vegetable protein in the human diet. The deficiency of protein in human diet often leads to Protein-Energy-Malnutrition (PEM) causing various forms of anemia. Besides, nutritive value of pulses in human diet, food legumes tend to fix atmospheric nitrogen to N-compounds to the tune of 72 to 350 kg per hectare per year and provide soil cover that helps to sustain soil health.

Legumes are a significant source of protein, dietary fiber, carbohydrates, vitamins and dietary minerals. 100 g legumes provide energy 321 – 570 Kcal, protein 21 -28 g, fat 0.8 to 48.0 g, Carbohydrate 21-63.4 g and total dietary fiber 9.0-22.7 g (Table 1). Similarly it is also richer in vitamins and minerals (Table 2-3).

The introduction of legumes into agricultural rotations helps in reducing the use of fertilizers and energy in arable systems and consequently lowering the GHG emissions. Among the many important benefits that legumes deliver to society, their role in contributing to climate change mitigation has been rarely addressed. Legumes can (1) lower the emission of greenhouse gases (GHG) such as carbon

Table 1. Proximate composition of legumes (per 100 gm)

Pulses	Energy (Kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Total dietary fiber (%)
Chickpea	**368**	21.0	5.7	61.0	**22.7**
Pigeonpea	342	21.7	1.49	62.0	15.5
Urdbean	347	24.0	1.6	**63.4**	16.2
Mungbean	345	25.0	1.1	62.6	16.3
Lentil	346	27.2	1.0	60.0	11.5
Fieldpea	345	25.1	0.8	61.8	13.4
Rajmash	345	23.0	1.3	**63.4**	18.2
Cowpea	346	**28.0**	1.3	63.4	18.2
Horse gram	321	23.0	2.3	59.1	15.0
Moth bean	330	24.0	1.5	61.9	-
Peanut	**570**	25.0	**48.0**	21.0	9.0
Soybean	446	16.49	19.9	30.1	9.3

Source: (www.iipr.res.in)

Table 2. Vitamin content in legumes (mg/100g)

Pulses	Thiamin (mg)	Ribo-flavin (mg)	Niacin (mg)	Pantothenic Acid B_5 (mg)	Vitamin B_6 (mg)	Folate (μg)	Vitamin C (mg)	Vitamin E (mg)
Chickpea	0.50	0.20	1.5	1.6	0.50	557	4	0.8
Pigeonpea	0.60	0.18	2.9	1.26	0.28	456	-	-
Urdbean	0.60	0.20	2.3	-	0.20	-	-	-
Mungbean	0.60	0.20	2.3	-	0.20	-	-	-
Lentil	0.80	0.20	2.6	2.12	0.54	479	4.4	0.3
Fieldpea	0.70	0.20	2.9	1.8	0.20	274	1.8	0.3
Rajmash	0.53	0.22	2.08	0.79	0.40	399	4.6	-
Cowpea	**0.94**	0.22	2.36	1.39	0.44	546	-	-
Horse gram	0.40	0.20	1.5	-	-	-	-	-
Moth bean	0.40	0.09	1.5	-	-	-	-	-
Peanut	0.60	0.30	**12.9**	1.8	0.30	246	-	-
Soybean	0.87	0.87	1.62	0.79	0.38	375	6.0	0.85

Source: (www.iipr.res.in)

Table 3. Mineral content (mg/100 g dried weight) in Legumes

Pulses	Iron (mg)	Zinc (mg)	Calcium (mg)	Magne-sium (mg)	Potass-um (mg)	Sodi-um (mg)	Seleni-um (mg)
Chickpea	6.2	3.4	105	115	875	**24.0**	8.2
Pigeonpea	5.2	2.7	130	183	1392	17.0	-
Urdbean	**8.4**	3.5	110	-	-	-	-
Mungbean	6.7	2.7	132	189	1246	15.0	8.2
Lentil	7.5	**4.7**	56.0	122	955	6.0	8.2
Field pea	4.4	3.0	55.0	115	981	15.0	1.6
Rajmash	3.4	1.9	186	188	1316	18.0	**12.9**
Cowpea	7.5	3.7	80.3	250	1450	23.0	-
Horse gram	7.0	-	**287**	-	-	-	-
Moth bean	9.6	-	202	-	-	-	-
Peanut	2.0	3.3	62.0	184	332	-	-
Soybean	15.7	4.9	277	**280**	**1797**	2.0	-

Source: (www.iipr.res.in)

dioxide (CO_2) and nitrous oxide (N_2O) compared with agricultural systems based on mineral N fertilization (Reckling et al., 2014, (2) have an important role in the sequestration of carbon in soils (IPCC, 2007), and (3) reduce the overall fossil energy inputs in the system (Jensen *et al*. 2012).

Cultivation and cropping may cause significant SOC losses through decomposition of humus (Christopher and Lal, 2007). Shifting from pasture to cropping systems may result in loss of soil C stocks between 25 and 43% (Soussana, 2004). Legume-based systems improve several aspects of soil fertility, such as SOC and humus content, N and P

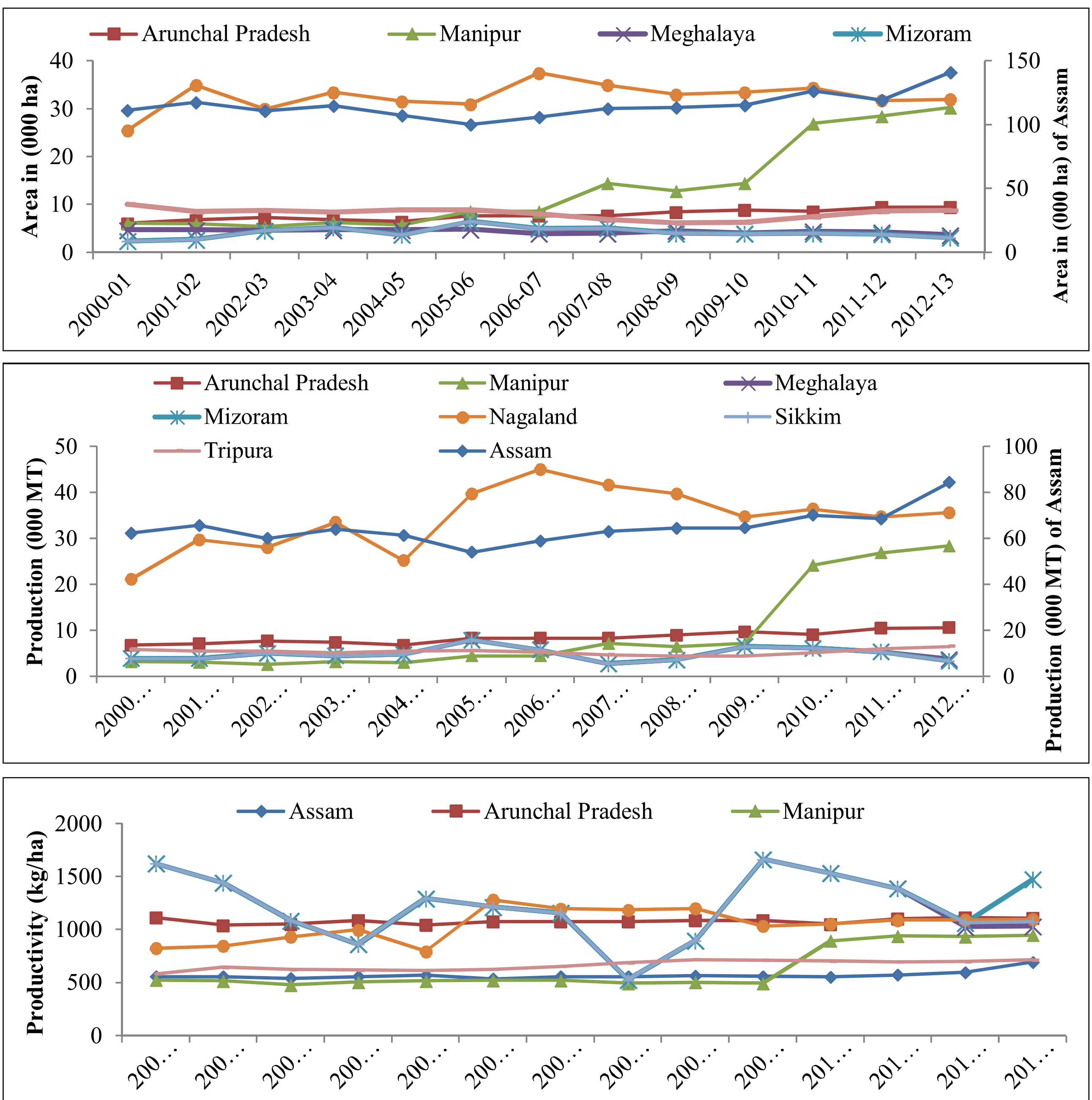

Figure 2. Trends in Area, production and productivity of total pulses in North Eastern states (www.iipr.res.in)

availability (Jensen *et al*. 2012). With respect to SOC, grain legumes can increase it in several ways, by supplying biomass, organic C, and N (Garrigues *et al*. 2012), as well as releasing hydrogen gas as by-product of BNF, which promotes bacterial legume nodules' development in the rhizosphere (La Favre and Focht, 1983). Pulses crop can fix the atmospheric nitrogen in soil and improved the soil health (Singh and Singh, 2002), it reduced the soil loss, conserve the soil and water and suppress the weed growth through smothering effects (Konlan *et al*. 2013).

Legumes can improve soil fertility or increase yield of the following crop, these benefits largely depend upon the total plant biomass produced, amount of N_2 fixed, amount of N added to the soil through roots, nodules and the leaf fall (Wani *et al.* 1994). Various research findings suggest that the carry-over of N for succeeding crops may be 60–120 kg in berseem (*Trifolium alexandrinum*), 75 kg in Indian clover (*Medicago sativa*), 75 kg in cluster bean (*Cyamopsis tetragonoloba*), 35–60 kg in fodder cowpea (*Vigna sinensis*), 68 kg in chickpea (*Cicer arietinum*), 55 kg in black gram (*Vigna radiata*), 54–58 kg in groundnut (*Arachis hypogaea*), 50–51 kg in soybean (*Glycine max*), 50 kg in Lathyrus and 36–42 kg per ha in pigeon pea (*Cajanus cajan*) (Das and Ghosh, 2012). Legumes with indeterminate growth are more efficient in N2 fixation capacity than determinate types. Fodder legumes in general are more potent in increasing the productivity of succeeding cereals. Through a symbiotic association with legumes, *Rhizobium* bacteria can convert atmospheric N2 into an organic form in the root nodules of crops. The accumulation of N depends on the length of the growing season, local climate and soil conditions. If a legume is grown as a green manure crop, biomass N produced can (in some cases) supply the entire N requirement for the subsequent crop. The proportion of N from N2 fixation in crops ranges from zero – usually where environmental stresses are severe and prevent nodulation – to 98% in crops grown under ideal conditions. The amount of N2 fixed has been recorded as up to 450 kg/ha/crop in the tropics. Legume residues contain P, K and other nutrients that are recycled in relatively available forms for subsequent crops.

Even with the best efforts, pulses production and productivity has been stagnant. Due to the low productivity low input nature, pulses are grown as residual/alternate crops on marginal lands after taking care of food/income needs from high productivity high input crops like paddy and other cereals by most farmers. Also, they grow as rainfed crops with little or no modern yield enhancing inputs. The low priority accorded to pulse crops may be related to their relatively low status in the cropping system. As a crop of secondary importance, in many of these systems, pulse crops do not attract much of the farmer's crop management attention. In addition to this, these crops are adversely affected by a number of biotic and abiotic stresses, which are responsible for a large extent of the instability and low yields. The following strategies to overcome them.

Cropping system is broadly grouped into sequential cropping and intercropping. It may be a regular rotation of different crops in which the crops follow a definite order of appearance on the land or it may consist of only one crop grown year after year on the same area. To enhance the pulses production, it must be included in cropping system either in sequential (horizontal) or intercropping (vertical). The prominent sequential cropping systems involving different pulses have been discussed crop wise.

In recent years, development of early to medium maturing varieties of lentil suitable for planting up to mid of December (HUL-57) with yield potential of 10-12 q/ha has enabled farmers to adopt rice-lentil system instead of rice monocropping system especially in the valley areas, where residual moisture is available (Ansari *et al.* 2015a). Rice-Lentil sequential cropping system was introduced by ICAR Research Complex for NEH Region, Manipur Centre from 2013 especially in Thoubal, Imphal West, Imphal East and Bishnupur and successfully harvested. Rice-Lentil cropping system successfully spread in terraces in hill agriculture in Rice/Maize-Lentil cropping system (Ansari *et al.* 2015b). Introduction of short duration pea varieties is also one of the important factors to enhance pulses productivity. In Manipur, Farmers are mainly growing vegetable/garden pea in rice sequencing. Lathyrus can successfully introduce in relay cropping system. Makhyatmubi is the local cultivar of pea and more popular in Manipur, which is very high potential in production.

Availability of short duration cultivars of pigeonpea (UPAS-120, Manak and Pusa 992) can grow in jhum cultivated area, where pigeonpea can mature in 130-150 days and mustard can be taken as sequence crop. This will provide desired stability and sustainability to productivity of Jhum land system. But there are some issues, which need to be tackled for wider adoptability and profitability from this system. Presently, most of the short duration varieties of pigeonpea available for cultivation are affected by sterility mosaic, fusarium wilt and Phytophthora blight and have tendency to prolong maturity with the late monsoon. Therefore, development and adoption of suitable varieties, which could mature by early November with 2 tonnes yield/ha is required.

Cultivation of Rabi/summer Urdbean and Mungbean in could get momentum only after availability of short duration suitable high yield potential cultivars. Summer urd bean after rice, is more successful in terrace and hill agriculture areas.

Broadbean is very popular and choicest food legume in Manipur. It is cultivated across the Manipur after harvesting of cereals. The local Broadbean is long duration crop. Due to introduction of high yielding short duration cultivars farmers can easily get maximum yield from this sequential cropping system.

Ricebean is more popular in Manipur and extensively grown in terraces, hill agriculture and foot hills (except low land areas). Local cultivars are high potential in yield but they are in long duration nature. Inclusion of high yielding short-medium duration cultivars can of Ricebean will provide enough opportunity to take mustard in sequential cropping.

In intercropping, the crops are arranged in definite rows. Sowing of both crops may be done simultaneously or in staggered manner. Similarly harvesting time may also differ. Intercropping is an improved system of mixed cropping which ensures desired plant stand, ease in cultural operation, spraying of chemicals and harvesting, and higher returns. The major considerations for intercropping are the contrasting maturities, growth rhythm, height and rooting pattern and variable insect pest and disease associated with component crops so that these complement each other rather than compete for the resources and guard against weather adversities. Growing of crops in intercropping systems is found more productive particularly under rainfed conditions. More than 70% area of pulses in India is covered under intercropping systems. Pulses are intercropped with oilseeds, cereals, coarse grains and commercial crops. Pigeonpea is also inter/mixed cropped with short growing grain legumes.

Intercropping of pulses with cereals will more successful in terrace and jhum cultivated areas, where least possibility of water stagnation. Ansari and Rana (2012) reported that the intercropping system recorded significantly higher as compared to sole cropping. It was due to almost similar yield of intercropped as that of its sole stand and additional yield of intercrop as a bonus in intercropping system. Similarly, intercropping system recorded the higher nutrient use efficiency and moisture-use-efficiency and economics as compared to the sole cropping (Ansari *et al*. 2011 and 2012).

Intercropping of pulses with maize is more popular in terrace cultivation and mixed cropping of pulses with rice/ maize is more popular in jhum cultivated areas of Manipur. Maize + rice bean, Maize + soybean, Maize + Urdbean/ Mungbean and are more remunerative in Kharif season. Perennial pigeonpea in intercropping system is generally grown on bunds with cereals, oilseeds and pulses. In Rabi season, mustard + Lentil/Lathyrus/pea, Makhyatmubi + vegetables, Broadbean + vegetables will more remunerative intercropping system.

Excessive tillage of agricultural soils may result in short term increase in fertility, but degrade soils in the medium and long run. Structural degradation, loss of organic matter, erosion and falling biodiversity are all to be expected. Soil erosion resulting from soil tillage has forced us to look for alternatives and to reverse the process of soil degradation. This led to promote conservation tillage, and especially zero-tillage in many parts of the world.

A study on five oilseeds/pulse crops combinations (mustard sole, pea sole, lentil sole, mustard + pea and mustard + lentil (1:1 ratio) were sown utilizing carry-over residual soil moisture and with different tillage methods viz. reduced tillage without maize residues (T1), reduced tillage with maize residues (T2), zero tillage without maize residue (T3) and zero tillage with maize residues (T4). Study revealed that highest mustard equivalent yield (MEY) and water use efficiency (WUE) was recorded with in T2 (1059.6 kg ha^{-1}) followed by T4 (954 kg ha^{-1}). Crops performed better with maize residues incorporation under RT/ZT in terms of dry matter production and yield attributes. Impacts of different tillage methods on important soil physical properties like bulk density was also studied after harvesting of first crop and before growing second crops in rice fallow. The lowest mean bulk density was recorded in the surface soils of ZT treatment (1.35 Mg m-3). 23 to 28% higher WUE was found more under residues management under ZT and RT (Ansari *et al.* 2016).

Under the programme "Enhancing lentil production in Eastern and North-Eastern states for nutritional security and sustainable rice-based production system in India" under DAC-ICARDA-ICAR, collaborative project on NFSM-pulses" implemented at Thoubal, Imphal East,

Figure 7. Pea grown under reduced tillage with maize residues and control

Figure 8. Lathyrus grown under reduced tillage with residues and control

Figure 9. Demonstration of Lentil with zero till at Lilong Takyenmakhong and field day organized on lentil cultivation under zero tillage at Sekmai Hijam Khunou

Imphal West and Bishnupur districts during three post-rainy seasons (2013-14 and 2015-16). We have found that, among the tillage effect, the mean maximum grain yield was recorded under reduced tillage (RT) 715.5 kg ha^{-1} followed by zero tillage (ZT) (639.8 kg ha^{-1}) and minimum yield was recorded with CT (504.7 kg^{-1}) (Ansari *et al*. 2015a).

The continuance of jhum in the state is closely linked to ecological, socio-economic, cultural and land tenure systems of tribal communities. Since the community owns the lands the village council or elders divide the jhum land among families for their subsistence on a rotational basis. The dry broadcast or 'punghul' method involves sowing in the month of March/April and harvesting in August/ September. Wet sowing or 'pamphel' is done in the month of May/June and harvested during October/November. Transplanted paddy or 'aringba' is also sown in the month of May/June and harvested in the month of October/ November. In the hilly areas of Manipur, shifting cultivation is widely practiced, with settled terrace farming in foothill or low slope areas, above the adjacent rivers and streams. Depending on the slope, wet broadcast on bunded fields or dry broadcast on unbunded fields is practiced.

The technology demonstrated like Pigeonpea (UPAS-120), Ricebean (Local), Rajma (Chitra)- Potato, Ricebean (Local), Rajma (Chitra)- Potato, Rajma (Chitra)- Pea (Rachna), Ricebean (Local)-Pea (Azad pea), Groundnut (ICGS-76)-Lentil (HUL-57). The farmers produced 1.2 to 1.76 tonnes of pigeonpea/ha, 1.3 to 1.7 tonnes ricebean/ha, 1.4 to 1.9 tonnes Rajma/ha, 1.4 to 1.8 tonnes pea/ha and 0.85 tonne lentil/ha. They have earned net returns varied from. The beneficiaries especially from Jhum cultivated areas received net returns of Rs 56000 to 105000/ha, where, rice mixed farming is dominant with low productivity (0.5 to 0.9 ha^{-1}) and less economical (Ansari *et al*. 2017). When considering economic returns, the legumes can be a valuable alternative crop for replacing rice from Jhum areas. Besides that, pulses crop fixed the atmospheric nitrogen in soil, improved the soil health, and reduced the soil loss, conserve the soil and water and suppress the weed growth through smothering effects. Pulses production in hill agriculture plays a significant role in nutritional security and used for various purposes and as well as for second cycle produce in livestock farming.

Figure 10. Diversified the rice mixed farming with legumes and pulses at Haochong Village, Tamenglong District, Manipur

There is tremendous opportunity to enhance pulses production especially in Jhum areas, where farmers are growing crops in mixed cropping on rotational basis. There are some potential pulses for jhum areas are pigeonpea, ricebean, soybean, mungbean/urdbean, broadbean, Makhyatmubi, winged bean, cowpea, lima bean and tree bean either as sole cropping or intercropping or agro forestry system.

Transfer of technology programmes (farmers trainings, front line demonstrations, sensitization programmes etc.) have to be organized to familiarize the farmers with the improved production technology of pulse crops and hammer home the point that yield will increase substantially if these crops are grown as per the recommended package of practices. Such programmes are very important to bridge the gap between actual and potential yield of legume crops.

Vast of the area in the region is hilly. Farm mechanization is non-existent. As compared to other parts of the country, low cost farm machineries and implements for the hilly terrains should be available for the farmers.

In nutshell, to increase area and production of pulse crops we need crop specific and region specific approaches, which should be adopted in the overall framework of systems approach. There is need to integrate the production technology, dissemination, utilization and support systems for transfer of improved technology to get the maximum production of legumes for the sustainable livelihood and food security in the region. There is urgent need of linkage between the public and private agencies to ensure the availability of latest technology, knowledge and empowerment of the stakeholders. Successful legume cultivation depends on the available resources and their proper utilization by the farming community to achieve maximum production and income from the landholding.

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