A Review: Pulses production, productivity, status and way forward for enhancing farmers income of Bundelkhand region, India

Abstract

Total pulses area in Uttar Pradesh, contributes of pulses through the Bundelkhand region, more than half but the productivity is low because lack of technological approaches for pulse growing area. This review paper assessed the cultivation of pulses production, productivity and area, of Bundelkhand and in India also. The technologies and infrastructure need to be accepted pulses cultivation and accurate policies for the farmers through government. Pulses are next to cereals regarding their nutritional and economic significance to human health. The pulses crop highly water sensitive like chickpea, lentil, mung bean and black gram are dominant in drought prone areas and improve soil fertility by fixing atmospheric nitrogen. Rainfed Agriculture has emerged as an opportunity in raising pulse production which is depend on amount and distribution of rainfall growing area. The cropping system of pulses cultivation year-after-year has observed that incidence of disease, insect-pests and weeds increase in Bundelkhand region. In pigeon pea, chickpea and lentil crops, important biotic agent for affecting production. United Nations declared 2016 ' "International Year of Pulses" was to increase production and consumption of pulses 10% by 2025 and raise public awareness towards health through social media. The many initiatives schemes govern by government of India for increase the pulses growing area and production such as ISOPOM (Integrated Scheme of Oilseeds, Pulses, Oil palm and Maize) (2004-05 to 2009-10), NFSM Pulses **(National Food Security Mission,** 2007-08), for Technology demonstration. The Bundelkhand regions as 5 lakhs farmers of 14 districts of two states of Madhya Pradesh and Uttar Pradesh should be linked with Rani Lakshmi Bai Central Agricultural University (RLBCAU) and benefited from this university to produce pulses.

Keywords: Economics, Fertility, Production, Productivity, Pulses, Schemes.

Introduction

"The Bundelkhand region of Uttar Pradesh in which includes the districts of Jhansi, Jalaun, Lalitpur, Hamirpur, Mahoba, Banda, and Chitrakoot, is a central semi-arid plateau of India that spans across seven districts, 18.3 million people dwell in the region as a whole, 32% of them are considered below the poverty level" (Census, 2011). with a temperature range of 3.0°C to 47.8°C and an undulating landscape, the area has a hot climate. The region experiences average yearly rainfall of 750–850 mm. The area is complicated, rainfed, dangerous, under-invested, vulnerable, socioeconomically diverse, morally distinct **(Samra, 2008).** Independent unit established by ICAR at Kanpur on pulses research in 1984 and now upgrading the Project Directorate (Pulses). Pulses belongs to leguminous family and edible seeds of plants as well as Pulses grow in pods and come in a variety of shapes, sizes and colors. **"International Year of pulses"** with the objectives of increasing production and consumption of pulses by 10% upto 2025 and creating awareness of growing pulses through social media. "Pulses are rich source of protein (20 to 25%) tendency to fixation of atmospheric nitrogen (30-150 kg ha^{-1}) and consistent source of income and employment to small and marginal farmers and thus hold a premier position in the world. Growing of pulses more than 100 countries covering an area of more than 95.72 M ha with more than 92.28 million MT annual productions and the productivity is around 964 kg/ha" **(FAO, Stat. 2021).** "During the year, 2017–18, the total pulses production in India was 18.84 MT from the area of 25.48 M ha with average productivity of 745 kg ha^{-1}" **(Agricultural Statistics at a Glance, 2021)**

Table 1: Summary: All India Pulses (Kharif-2021, Area: Lakh ha)

Crops	Normal Area *	Area Covered		Overall change (%) to2020	
		2021	2020	Actual	%
Arhar (Tur)	45.64	50.499	48.465	2.03	4
Urdbean	37.28	40.048	39.234	0.81	2
Mungbean	33.48	35.409	35.531	-0.12	0
Kulthi	2.20	0.820	0.816	0.00	1
Oth. Kharif Pulses	16.70	15.594	15.296	0.30	2
Total	135.29	142.370	139.343	3.03	2

Normal Area –DES (Ave: 2015-16 to 2019-20)

Table .2: Summary All India Pulses (Rabi-2021-22, Area: Lakh ha)

Sl. No	Crops	Normal Area	Area Covered		Change over (+/-) 2020-21	
			2021-22	2020-21	Actual	%
1	Gram	95.663	114.95	110.38	4.57	4
2	Lentil	13.903	17.71	16.91	0.80	5
3	Field pea	8.031	10.18	10.38	-0.20	-2
4	Kulthi	2.004	3.71	3.89	-0.17	-4
5	Urdbean	9.074	8.17	8.33	-0.17	-2
6	Mungbean	9.409	5.13	7.03	-1.90	-27
7	Lathyrus	3.618	3.49	3.13	0.36	11
8	Other Rabi Pulses	4.443	4.94	6.05	-1.11	-18
Total Rabi Pulses		146.145	168.27	166.10	2.17	1

Calcium, magnesium, iron, zinc and few of the vitamins and minerals that are abundant in pulses. Cardiovascular illness and an imbalance in the majority of the biological processes were caused by the different minerals that people in different parts of the world lacked. Pulses provide adequate minerals required to fulfill nutritional requirement. Pulses are mainly cultivated under rainfed conditions and do not need robust irrigation facility and so pulses grow in areas which left after satisfying the requirement of cereals and cash crops.

The awareness is rising and the burning topic "soil quality enhancement" has come into the scenario. In this framework include production system can be important modus to take care of soil health as well as human wealth. Pulses are next to cereals in terms of their economic and nutritional importance to human health. In drought prone locations can successfully cultivation of water-sensitive pulses like lentil, chickpea, mung bean, and black gram, which also increase soil richness by fixing atmospheric nitrogen. Pulses contribute to improving soil carbon sequestration and removing harmful metal and organic contaminants from the soil **(Kumar and Yadav, 2018).**

"The production of pulses has a wide potential and improved chances in the UP region of Bundekhand. The poor growth rate is caused by a number of interrelated elements, including soil, climate-related limitations, and extension related issues. Besides, shrinkage in land holding, growing population pressure, increasing food and pulse demand and poor soil health are the key constraints between 1988 and 2009, the percentage of pulses consumed in total protein absorption declined from 10.8 to 7.3% in rural families and from 12.9 to 7.4% in urban households. The country consumes pulses far more frequently than any other protein source, demonstrating the significance of pulses in daily dietary practices. The domestic output of 23 million tonnes in 2016–17 will still fall short of the 29–30 million tonnes predicted demand by 2030. By using precision farming, high-quality inputs, soil test-based INM, timely weed management, mechanized pulse cultivation, generous government policies, and appropriate funding support for implementing states/stakeholders, it is possible to achieve the targeted production and productivity". **(Tiwari and Shivhare, 2017). "**In order to meet the estimated demand for 32 million tonnes of pulses by 2030, document created by the ICAR-Indian Institute of Pulses Research (IIPR), Kanpur, a growth rate of 4.2% must be ensured. The right fertilizer, acceptable cultivars, and plant nutrients all have a big impact on yield and yield components. *Rhizobium* strains that are efficient and selective for symbiotic nitrogen fixing are generally scarce in Indian soils. Leguminous crops need phosphorus as the pioneer plant nutrient for quick and effective root growth, which later helps for improved nodulation by *Rhizobium* bacteria. Sulphur deficiency is becoming more critical day by day in soil which restrict crop yield, produce quality, nutrient use efficiency and economic returns on millions of farms and their deficiency recover by application of sulphur fertilizer. Bio-fertilizers can colonize the rhizosphere and stimulate crop development by boosting the availability and delivery of nutrients and growth stimuli. Nitrogen fixing and phosphate solubilizing bacteria serve a crucial role in providing nitrogen and phosphorus to plants due to long-term use of nitrogen and phosphatic fertilizers". **(Tambekar *et al.*, 2009).** "Some important strains are mentioned as plant growth promoting rhizobacteria (PGPR) and that can be used as biofertilizers ***i.e.*,** *Rhizobium, Pseudomonas, Azospirillum, Azotobacter, Bacillus,* Mycobacterium, Flavobacterium, etc. Use of these biofertilizer through mixing with seed increased the yield of rice by 10-20 %, wheat by 10-40 %, Bengal gram by 10-30 per cent, and potato by 30-35 per cent over control". [28]

The Missing Link for Sustainable Pulse Production

(a): Ecology of rainfed areas:

Rainfed agriculture has emerged as a viable option for increasing pulse production food production depend on related to the amount and distribution of rainfall. Pulses have been grown in rainfed areas characterized by low soil fertility and moisture stress. **(Sundaram, 2010)** show variability and diversity in terms of varieties and quantity of production in rainfed area **(Inbasekar 2014).** Nitrogen and phosphorus major impact on nodulation and on productivity of legumes **(Singh *et al.* 1998**). Availability of phosphorus is also an issue in legume based cropping system as it is considered most important nutrient limiting pulses production. In general, intercropping may not require additional P as there is little competition for P between component crops, particularly in P deficient soil **(Srinivasan and Ahlawat 1990).** Fertilizer requirement of a cropping system may be increased, unaltered or reduced compared to individual crops in a season or intercropping system depending on crops involved in the system. Therefore, the present study aims at finding out an optimum NPK doses for pigeonpea + sorghum and pearl millet intercropping system Besides this, there is a need to assess the pigeonpea + cereals intercropping system as a means to better resource management with respect to crop growth, productivity, competition and monetary advantage. Combining of cereal and fodder crops, depletion of K relative to N is considerably higher because most Indian soils are thought to be adequate in native K, its application has received little consideration. Mining of native K during heavy cropping and chronic disregard of replenishment by fertilizers resulted in K deficit in many soils; as a result, responses of potassium application became remarkable in many cropping systems. (Goswami *et al.*, 1976).

(b): Lack of irrigation facilities:

"In most parts of the Bundelkhand region, crop yield is low due to a lack of guaranteed irrigation during the crop growing season, poor soils, and frequent droughts. During 2015-16, the percentage of irrigated land to total cultivated area in the UP Bundelkhand region was 49.7% (1.27 Mha), compared to over 80% in UP state, and 37% (1.13 M ha) in MP. Bundelkhand region as compared to 42 percent in MP state. Although, the features the region in such a way that irrigation supplies such as dams, ponds, tanks, lakes, streams, wells, bore wells, and irrigation canals, the region's low and unpredictable rainfall has resulted in a strong reliance on ground water for irrigation. Irrigated area in Bundelkhand region about 42 % of gross sown area in is under irrigation and application of irrigation water through canal accounts for coverage of 24.7% of gross irrigated area. Tube wells are the largest source of irrigation covering about 64 % of the gross irrigated area in the region. The condition has led to misuse and pollute underground water for irrigation purpose in water deficit region" **(Samra 2008, Palsaniya *et al*., 2011).**

(c): Nutrient management in rainfed area:

There is an important mismatch between pulse nutrient demand and supply generally farmers use phosphatic fertilizer result unstable nutrient ratio in the soil which led to deficient of multi-nutrients. Imbalance application of nutrient is one of the major abiotic factors which limit productivity of pulses **(Thiyagarajan *et al.*,2003)** and is frequently deteriorating soil health. The mechanism of biological N fixation in pulse crops to provide N (80-90%) of their requirements, hence a small dose of 15-25 kg N ha^{-1} is required as starter dose to meet demand of most of the pulse crops, In Madhya Pradesh, Maji and Sulaiman (1995) reported that the fertilizer use was very low with chickpea receiving the highest priority and the least to pigeon pea. Although the recommended dose in Madhya Pradesh was 15-25 kg of N and 20-50 kg P_2O_5 ha^{-1} through superphosphate, The trend was just opposite in intercropping system growing of pigeon pea with pearl millet had greater positive N balance in soil in compare with growing of pigeon pea with sorghum at harvest of crop during 2012-13 but in 2013-14 both the intercropping system showed negative N balance due to deficit soil moisture status (rainfed). Under varied fertility levels, maximum positive N balance was analyzed in the intercropping treatment where no fertilizer was applied to pigeon pea and RDF to intercrop during 2012-13. While in 2013-14, variable responses were observed. The above trend in N fertility was possibly due to beneficial effect of pigeon pea through symbiotic N fixation and root exudation as well as supplementation of RDF to intercrops. Addition of nitrogen in soil through different organic forms may not available immediately for crop uptake but balance positive fertility in soil.

(d): Infestation of insects, pest, disease and weeds:

Pulses grown year after year in Bundelkhand region through monocropping that cause of infestation of disease, insect-pests and weeds in pulse crops. *Fusarium wilt* is the important biotic stresses affecting production in pigeon pea, chickpea and lentil crops. In pigeon pea crop sterility mosaic and *Phytopthora blight* are the other important diseases in the region. Yellow mosaic disease in mung bean and urdbean crops, powdery mildew and rust diseases in field pea cause significant crop losses in the region. Gram pod borer (*Helicoverpa armigera***)** causes significant crop losses in pigeon pea and chickpea, Mungbean and urdbean crops suffer from spotted pod borer, aphids, whitefly, and thrips. Weeds cause serious threat in pulse crops due to the slow initial growth (Kumar *et al.* 2013) and they also prohibited in intercultural operations and harvesting. Some weeds of pulses also act as alternate host of insect-pest and diseases.

B: Interventions of new technologies for enhancing pulse production:

(a) Improved verities (New Plant types, short duration, Disease resistance).

"Development of novel varieties with short duration, disease resistance, large seed, photo thermal insensitivity, and late planting capability, in addition to increased yield, promoted crop diversification, intensification, and introduction into new niches and cropping systems. a dwarf leafless (leaflets converting into tendrils) variety of field pea (Aparna) was developed In 1988.

This dwarf variety tolerated large plant population, irrigation, and nitrogen well, resulting in a significant boost in yield". **(Ali 1988).** "Many dwarf and semi-dwarf varieties (Sapna, Uttra, Malviya Matar 15, KPMR 400, KPMR 522, Vikash, Prakash, Pant P 74) were developed, a tall-erect variety (BG 261) with basal branching and bold seeds was developed in 1984 In chickpea. This variety was found ideal for intercropping with mustard cv 'Varuna' in 6:2 row ratio" **(Ali, 1992)**. In short duration pigeon pea, a few varieties with determinate growth habit (ICPL 87, ICPL 151, ICPL 85010) were developed to facilitate contemporary maturity and timely harvesting but it could not destroy due to heavy infestation of pests.

Short duration: "Traditional extended duration cultivars frequently endured terminal drought, resulting in crop loss due to greater pest infestation, and encouraged mono-cropping Therefore, need to develop short duration varieties in all pulse crops with identical phenology for different agro-ecological regions. The advent of short duration varieties of pigeon pea during 1975-76 such as 'Pusa Ageti', 'UPAS 120', etc. led to the introduction of pigeon pea in the irrigated area of north-west plains under pigeon pea - wheat double cropping system" **(Ramanujam, 1971)**.

(b): Technique of Sowing: "Traditionally, pulses are sown on flat seed beds after preparation of land. In eastern region (Uttar Pradesh, Bihar, Jharkhand, West Bengal, Orissa and parts of central India, kharif planted pulses often suffer due to water stagnation during rainy season which ultimately reduces productivity. During 1994-95, ridge planting of pigeonpea was conceptualized and evaluated under AICPIP/AICRP which showed very encouraging results in maintenance of optimal plant populations and consequently higher productivity due to proper drainage. Ridges were made at 60-75 cm distance leaving 30 cm wide furrows for drainage of rain water. Two to three rows of short duration legumes such as mungbean/urdbean can be successfully planted on ridges. This system helps in reducing quantity of irrigation water, and also minimizes incidence of Phytophthora blight in pigeon pea". (Ramanujam, 1971).

(c): Cropping system: The development of novel agricultural cropping systems in both rainfed and irrigated areas was facilitated by the introduction of short-duration disease resistant pulse crops such as pigeon pea-wheat in the N-W plains and maize-pre-rabi pigeon pea and French bean in the N-E plains., rice–wheat–mungbean, maize-potato or mustard or mungbean or urdbean in northern plains and rice-urdbean in coastal peninsula. The Chitrakoot Dham region of Uttar Pradesh is noted for pulse production, which takes place under rainfed conditions due to a lack of irrigation facilities and typical physiography. Chitrakoot Dham accounts for 18.11% of the state's total land and 25.67% of total production. The productivity of pulses in this region was higher in the state being 8.76 qha^{-1} as against 8.08 qha^{-1} of the state average during 2012-2013. However, the pulse production in the state as well as in the area did not show any appreciable increase for the last fifty years, rather it has been declined. The growth of pulse production in the state was (–) 0.11% per annum, while it was 0.62% per annum in Chitrakoot Dham and (+) 2.71% per annum in Banda district. Total pulse production in 2020-2021 is 25.58 million tonnes from 29.51 million ha area (DAC & FW, 2021), and to meet pulse demand, India is currently importing about 3 million tonnes chickpea, which continues to be the most consumed and accounts for 45%-50% of total pulse production in India. The Bundelkhand region produces 8.4% of the country's total pulse production (1377 tonnes). The region contributes significantly to total area and crop production of crops such as field pea, lentil, and urad bean, accounting for around 43%, 16%, and 11.5% of national production of field pea, urad bean, and lentil, respectively.

(d): Water management: The majority of pulses are grown under rainfed circumstances (84%). and respond well to limited irrigation. Various approaches such as crop growth stage **(Dastane *et al*. 1971, Saxena and Yadav 1975),** IW/CPE ratio **(Yadav 1975; Praharaj and Kumar, 2011)** and cumulative evaporation have been used in scheduling irrigations in different pulses. The 50% flowering stage of field pea was discovered to be the most critical for irrigation. **(Panwar and Malik, 1977)**. Similarly, one irrigation at the early pod filling stage was found to be the most beneficial in lentil and chickpea. **(Panwar and Paliwal, 1975)**.

(e): Rice fallow technology: After harvesting the kharif crop, around 11 Mha of the 44 Mha land under rice remains fallow during the rabi season due to a variety of bio-physical, biotic and abiotic stressors, and socioeconomic restrictions. The most essential limitation for rabi crop cultivation in rice fallows is soil moisture. Lentil, chickpea, and urdbean/mungbean sowing in the eastern and central districts, as well as the peninsular region. Pulses suffer significant losses as a result of various illnesses and insect infestations. Gram pod borer (*Helicoverpa armigera*), a polyphagous insect pest, causes significant yield loss in chickpea and pigeonpea. Similarly, *Fusarium wilt* is the most common disease affecting chickpeas, lentils, peas, and pigeonpeas.. Host plant resistance is the best approach for disease control that has been rigorously tried, and donors as well as elite cultivars are now available for key illnesses. An integrated approach combining cultural, botanicals, and pesticides has been promoted for insect infestations. A unique integrated method to the treatment of wilt and gram pod borer has been devised.

(f): Crop Protection: Pulses suffer greatly as a result of a huge number of insect pests and illnesses. Gramme pod borer (*Helicoverpa armigera*), a polyphagous insect pest, causes significant yield loss in chickpea and pigeonpea. Similarly, Fusarium wilt is the most common disease that affects chickpea, lentil, peas, and pigeonpea. A unique integrated strategy to wilt and gramme pod borer control has been developed.

C: Research finding

The biological nitrogen fixation process is the most efficient way to supply the large amount of nitrogen needed by pulses to produce protein rich high yield for the (Nitrogen fixation and release into soil under different pulses show the table:3) process to occur plant must enter symbiotic beneficial partnership with certain bacteria called rhizobia. Optimum rate of nitrogen fixation in pulse is about 1.0 kg/ha/day within a cropping season. About two third of the nitrogen fixed by a pulse become available to next growing season.

Table 3: N fixation and release in soil

Crop	Nitrogen Fixation (kg/ ha)	Nitrogen release in soil (kg/ ha)
Chickpea	26-63	18.8
Cowpea	53-85	50.3
Lentil	35-100	32.8
Mungbean	50-55	34.5
Field pea	46	59.4
Urdbean	50-60	38.3

Gill *et al.*, (2009)

Table 4: Effect of different treatments on grain and straw Nutrients content in chickpea after harvest stage

Treatments dose of fertilizer NPK (kg/ ha) and FYM (t /ha)		Grain (kg/ha)			Straw (kg/ha)		
		N	**P**	**K**	**N**	**P**	**K**
T_1-Control	0-0-0	1.67	0.43	0.54	1.19	0.14	1.38
T_2 - FP	10-20-15	2.10	0.54	0.65	1.37	0.27	1.79
T_3- GRD	20-40-30	2.54	0.74	0.80	1.52	0.36	1.98
T_4-12q/ha	19-16-13-5	2.74	0.87	0.93	1.70	0.43	2.41
T_5 -16 q/ha	**40-29-45**	**3.60**	**0.92**	**1.06**	**1.82**	**0.58**	**2.30**
LSD (P=0.05)		0.155	0.021	0.074	0.040	0.016	0.102

Singh *et al.*,2018

Note: FP: Farmers practise, *i.e*. the fertiliser doses commonly used by farmers in the area, GRD: General recommendation of the district's agricultural department based on soil test value.

Higher nutritional content in grain and straw of Chickpea T_5 (3.60 N, 0.92 P, and 1.06 K kg/ ha) and (1.82 N, 0.58 P, 2.30 K kg/ ha) respectively than other treatments(T_1,T_2,T_3,T_4.. The lowest uptake of nutrients under treatment control T_1. Nutrients available status was also higher in T_4 and T_5 where application of FYM. When we applied FYM to soil, the complete amount of its NPK ingredients were not made available at once in one season but rather gradually over a number of years.

Table 5 : Soil nutrient availability before and after harvest of the chickpea crop

Treatments	Physico-chemical properties						Fertility status (kg/ ha)					
	pH		EC(dS/m)		OC (%)		N		P2O5		K2O	
	BS	AH	BS	AH	BS	AH	BS	AH	BS	AH	BS	AH
T_1- Control	7.3	7.4	0.22	0.26	0.27	0.20	115.35	95	18.8	21.0	255.8	224.3
T_2 - FP	7.3	6.9	0.22	0.29	0.27	0.30	115.35	143	18.8	18.2	255.8	258.4
T_3 - GRD	7.3	7.1	0.22	0.20	0.27	0.34	115.35	157	18.8	19.6	255.8	247.8
T_4-12 q /ha	7.3	7.2	0.22	0.17	0.27	0.41	115.35	180	18.8	22.1	255.8	262.2
T_5-16 q /ha	7.3	6.9	0.22	0.20	0.27	0.50	115.35	200	18.8	24.7	255.8	265.5
LSD(P=0.05)	-	0.01	-	0.002	-	0.01	-	3.50	-	0.75	-	6.59

Singh *et al.*,2018

Note: FP: Farmers practice *i.e*. the fertiliser doses commonly used by farmers in the area, GRD: General recommendation of the district's agricultural department based on soil test value. BS-Before sowing, AH-After crop harvest.

The above table shows that the soils were originally neutral in reaction with an average pH of 7.3 and a low concentration of soluble salts (0.22 dS/m) which was observed to be neutral with less soluble salt concentration after chickpea crop in rabi season in all treatments..The organic carbon content, which had previously been measured at a low level (0.27%) in the experimental fields before to sowing, increased in all treatments except the control in 2014-15. The organic carbon content was high in STCR treatments inT_5. Before chickpea sowing, the soils were very low in N (115.35 kg/ha), medium in P_2O_5 (18.80 kg/ ha) and high in K_2O (255.80 kg/ ha).

Table 6: The treatments consisted of nine combinations of NPK and Zn source of fertilizer.

Treatments	Description		Symbol
T_0	Control No treatment		L_0Z_0
T_1	NPK 0%, Zn 50%	10kg Zn /ha	L_0Z_1
T_2	NPK 0%, Zn 100%	20kg Zn /ha	L_0Z_2
T_3	NPK 50%, Zn 0%	20-40-20 Kg NPK/ ha	L_1Z_0
T_4	NPK 50%, Zn 50%	20-40-20 Kg NPK+10kg Zn / ha	L_1Z_1
T_5	NPK 50%, Zn 100%	20-40-20 Kg NPK+20kg Zn/ ha	L_1Z_2
T_6	NPK 100%, Zn 0%	40-80-40 Kg NPK/ ha	L_2Z_0
T_7	NPK 100%, Zn 50%	40-80-40 Kg NPK+10kg Zn /ha	L_2Z_1
T_8	NPK 100%, Zn 100%	40-80-40 Kg NPK+20kg Zn/ ha	L_2Z_2

Table 7: Effect of NPK and Zn levels on soil physicochemical parameters of pea crop after harvest.

Treatment combination	BD (Mg /m)	PD (Mg/ m)	Pore space (%)	pH 1:2 (soil:water)	EC (dS/m)	N (kg/ ha)	P_2O5 (kg /ha)	K_2O (kg /ha)	Zn (mg/kg)	OC (%)
$T_0=(L_0Z_0)$	1.26	2.57	47.33	7.73	0.16	275.33	21.50	106.20	0.52	0.65
$T_1=(L_0Z_1)$	1.23	2.47	46.67	7.55	0.16	295.33	23.03	124.50	0.54	0.70
$T_2=(L_0Z_2)$	1.24	2.68	47.33	7.54	0.15	299.33	26.00	133.80	0.58	0.73
$T_3=(L1Z_0)$	1.21	2.59	48.00	7.46	0.15	295.67	24.83	152.13	0.62	0.72
$T_4=(L_1Z_1)$	1.22	2.51	48.67	7.37	0.14	299.33	27.33	161.97	0.65	0.74
$T_5=(L1Z_2)$	1.23	2.63	49.67	7.34	0.12	305.67	26.17	170.67	0.71	0.75
$T_6=(L_2Z_0)$	1.22	2.48	48.33	7.31	0.12	302.33	28.00	187.40	0.75	0.73
$T_7=(L_2Z_1)$	1.20	2.58	50.00	7.30	0.11	311.67	28.87	214.27	0.80	0.76
$T_8=(L2Z_2)$	1.21	2.50	49.67	7.05	0.11	315.33	28.90	225.27	0.91	0.76
Sem+	1.22	2.55	48.40	7.40	0.13	299.99	26.07	164.02	0.67	0.72
CD at 5%	NS	NS	NS	0.29	0.02	5.80	0.689	0.873	0.02	0.02

Chetan *et al.*,2018

Experiment was carried out in 2x2 factorial randomized block design with three levels of N P K and Zn plot size was 2x2 m^2 for crop seed rate is 80-100 kg/ ha *(Pisum sativum* L.*)* of variety Rachna. Pea grown in 9^{th} November 2017 and the source of Nitrogen, Phosphorus, Potassium and Zinc were Urea, SSP, MOP, and $ZnSO_4$ respectively. Basal dose of fertilizer was applied in respective plots according to treatment allocation unifurrows opened by about 5 cm.

Non-significant effect of NPK and Zn fertilizer on physico- chemical properties on Pea crop results shown in above Table:7 The bulk density, particle density and pore space (%) of postharvest soil was observed 1.21, 2.50 and 49.67 with the treatment T_8 respectively. The modest drop in bulk density, particle density, and pore space attributed to tillage and increased plant growth. Observation of some of the critical parameters affecting the physical qualities of the pea crop NPK and Zn fertilizers in conjunction on BD, PD, and pore space was found non-significant and pH, EC (dSm^{-1}), Organic carbon (%), available nitrogen (kg/ha), available phosphorus (kg/ ha), available potassium (kg/ ha) and Zn (mg/kg) was found significant. pH, EC (dS/m), organic carban (%), available nitrogen (kg/ ha), available phosphorus (kg/ ha), available potassium (kg ha^{-1}) and available Zinc (mg/kg) was observed 7.05,0.11, 0.76,315.33, 28.90, 225.27 and 0.91 respectively in the treatment T_8 that was significantly superior than other treatments combination.

Table 8: Effect of inclusion of pulses in Rice based cropping system on soil organic carbon fraction on an inceptisols of Indo- Gangetic plain zone (Kanpur)

Treatments	Very labile C frac$_1$(%)		Labile C frac$_1$(%)		Less labile C frac$_1$(%)		Less labile C frac$_1$(%)	
Cropping system	0-20 cm	20-40cm	0-20 cm	20-40cm	0-20 cm	20-40 cm	0-20 cm	20-40cm
R-W-F	0.11	0.12	0.09	0.17	0.23	0.15	0.14	0.08
R-C-F	0.17	0.14	0.10	0.14	0.21	0.13	0.15	0.07
R-W-M-V	0.18	0.18	0.11	0.09	0.27	0.07	0.15	0.08
R-C-F-R-W-F(2yr)	**0.18**	**0.15**	**0.13**	**0.12**	**0.17**	**0.12**	**0.14**	**0.08**
LSD (P=0.05)	0.021	0.019	0.02	NS	0.04	0.01	NS	NS

(Source: Ghos *et,al*., 2012).

Note: R-W-F, Rice-Wheat-fallow, R-C-F,Rice-Chickpea-fallow,R-W-F,Rice Wheat –Mungbean, R-C-F,R-W-F, Rice- chickpea fallow-Rice Wheat-Fallow

Among nutrient management treatments organic fertilizer treatmenthad greater amount SOC. Carbon fraction 3, active pool and passive pool and CMI is considered the best soil management practice in the present study. Among different cropping system rice-wheat – mungbean and rice- wheat- rice-chickpea, having higher biomass, maintained greater SOC and CMI under INM practices, and are considered the ideal system in term of maintenance of soil health and long-term perspective of system productivity

Table 9: Change in soil properties (0-1cm) under Rice Wheat and pigeonpea- Wheat after three crop cycle

Cropping system	Bulk density (g/cc)	Total porosity(%)	SOC (%)	Total N (%)	Olsen-P (mg/Kg)
Initial value	1.48	43.5	0.46	0.026	7.3
Rice- Wheat	1.0	42.7	0.44	0.030	7.9
Pigeonpea-wheat	**1.42**	**4.4**	**0.49**	**0.034**	**7.2**

Gill *et al.*, 2009

Inclusion of pulses in crop sequence could have a significant residual impact on soil fertility improvement. It has also been discovered that pulses, with the exception of Azotobacter, have a larger microbial burden than cereals or fallow. Pulses also contribute to an increase in the diversity of soil flora and fauna, resulting in enhanced soil stability by giving more nitrogen.

(D): Government Initiatives to Increase Pulse Production in India and Bundelkhand.

- Timely availability of critical inputs like seed, bio-fertilizers including micro and macro nutrients at field level.
- Promotion of short duration crops like urd & mung to make different production system profitable and improved soil health may be explored. Location specific strategy based on feedback of farmers as well as technology, validation, feasibility etc.
- Strengthen and proper implementation of PMKSY (Pradhan Mantri Krishi Sinchayee Yojna) , Rain water harvesting through farm ponds and community reservoirs in a focus manner with end to end solution to extend the coverage and improving Water Use Efficiency (WUE).
- Seed availability with the various agencies (Seed-hubs of ICAR/KVKs/Seed Societies/Agencies etc.) for monitoring quality and utilization in real time.
- One of the most important action may be taken in consideration as seed production subsidy should be given to society after ensuring that seed used as a seed purpose only.
- Integrated Nutrient Management and water management through micro-irrigation need to be focused, by making SHC (Soil Health Card) recommendation compulsory.
- Need more effective development/creation of social media platform *i.e.* mobile based and proper extension of advanced forewarning and forecasting system from District/KKVs through Gramin Krishi Mausam Seva (GKMS) to Block/Village/Extension functionaries/Kisan Mitra /Krishak Didi to circulate the information. **National Pulses** Development Project (NPDP) (1985-90)
- ISOPOM (Integrated Scheme of Oilseeds, Pulses, Oil palm and Maize) (2004-05 to 2009-10)
- NFSM-Pulses **(National Food Security Mission)** (2007-08)
- NFSM + Special initiatives (2010-11 to 2013-14)
- Demonstration of Technologies

Conclusion

The new technology have ability to double national production without extending the area under pulses crop. if farmers adopt the recommended technologies for pulses production system and management of imbalanced nutrient ratio in the soil than the multi-nutrient supply. Nutrient imbalance is one of the major abiotic constraints that limit the productivity of pulses and is gradually deteriorating soil health. Farmers should adopted yield enhancing technologies and nutrient management approaches in their different farming systems and increase production and productivity of pulse crops in the Bundelkhand region.

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