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

Comment [jS1]: Status of pulses production and productivity

Abstract

The Bundelkhand region contributes more than half of total pulse area of the Uttar Pradesh but the productivity is low because lack of technological approaches for pulse growing area. This study assessed of pulses cultivation area,productionand productivityof Bundelkhand as well as India.The technologies and infrastructure need to be embraced pulse cultivation and suitable policies for the farmers.Pulses are next to cereals in terms of their economic and nutritional importance to human health. The pulses crop highly water efficient like lentil, chickpea, mung bean and black gram are effectively grown in drought-prone areas and improve soil fertility by fixing atmospheric nitrogen. Rainfed agriculture has emerged as an opportunity to raise pulse production.Pulses production is tied up with amount and distribution of rainfall growing area.The cropping system of pulses year-after-year has intensified that incidences of diseases, insect-pests and weeds increase in Bundelkhand region. In pigeon pea, chickpea and lentil crops,important bioticagent for affecting production.The United Nations declared 2016 as **"International Year of pulses"** with the objectives of increasing production and consumption of pulses by 10% by 2025 and creating awareness of benefits of pulses by utilizing social media. The many initiatives schemes governed by government of India toincrease 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. TheBundelkhand 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.

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Comment [jS6]: With inclusion of pulses

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Comment [jS8]: In pigeon pea, chickpea and lentil crops, the biotic factors affects the crop production

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

Introduction

Bundelkhand region of Uttar Pradesh is a central semi-arid plateau of India that spans across seven districts in Uttar Pradesh state comprising Jhansi, Jalaun, Lalitpur, Hamirpur, Mahoba, Banda and Chitrakoot districts covering over 7.1 million hectares area. The region is home to a total population of 18.3 million, 32 per cent of whom live below poverty line **(Census 2011)**. The region is characterized by hot climate with temperature variation ranging from 3.0^{o}C to 47.8^{o} C and undulating topography. The zone receives about 750-850 mm of average annual rainfall. The region is complex, rainfed, risky, under invested, vulnerable, socio-economical heterogeneous, ethically unique, agrarian, and backward **(Samra, 2008).**The ICAR established an independent unit at Kanpur on pulses research in 1984 by upgrading the Project Directorate (Pulses). Pulses are the edible seeds of plants in the legume family. Pulses grow in pods and come in a variety of shapes, sizes and colors.The United Nations declared 2016 as **"International Year of pulses"** with the objectives of increasing production and consumption of pulses by 10% by 2025 and creating awareness of benefits of pulses by utilizing social media.Pulses are rich source of protein (20 to 25%) ability to fix atmospheric nitrogen (30-150 kg ha^{-1}) and a consistent source of income and

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employment to small and marginal farmers and thus hold a premier position in the world. Pulses are grown in 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:AllIndiaPulses (Kharif-2021, Area: Lakh ha)

Crops	NormalArea*	AreaCovered		Changeover (+/-) to2020	
		This Year2021	Last Year2020	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. KharifPulses	16.70	15.594	15.296	0.30	2
Total	135.29	142.370	139.343	3.03	2

NormalArea–DES(Ave:2015-16to2019-20)

Table .2: SummaryAllIndiaPulses(Rabi-2021-22,Area: Lakh ha)

Sl.No	Crops	NormalArea	AreaCovered		Changeover (+/-) 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	Fieldpea	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	OtherRabiPulses	4.443	4.94	6.05	-1.11	-18
TotalRabiPulses		146.145	168.27	166.10	2.17	1

Pulses are rich source of many vitamins and minerals (iron, zinc, calcium, magnesium). The deficiency of various minerals in different parts of the world led to cardiovascular disease and imbalance in majority of the biological pathways. Pulses provide adequate minerals required to fulfill nutritional requirements.Pulses are mostly cultivated under rainfedconditions and do not require intensive irrigation facilities and this is the reason why pulses are grown in areas left after satisfying the demand for cereals and cash crops.

The attention is rising and the burning topic "soil quality enhancement" has come to the scenario. In this context, pulse-inclusive production system can be a strategic modus to take care of soil health as well as human prosperity. Pulses are next to cereals in terms of their economic and nutritional importance to human health. Highly water efficient pulses like lentil, chickpea, mung bean and black

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Comment [jS12]: Link the paragraphs with the previous one gram are effectively grown in drought prone areas and improve soil fertility by fixingatmospheric nitrogen. Pulses are well-known to participate in enhancing soil carbon sequestration and remediating soil from poisonous metal and organic pollutants **(Kumar and Yadav 2018).**

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Thegreatscope and better opportunities for pulses production in Bundekhand region of UP.The growth rate is low due to many interrelated factors arise from soil, climate related constraints and extension-oriented problems. Besides, shrinkage in land holding, growing population pressure, increasing food and pulse demand and poor soil health are the key constraints The per cent share of pulses in total protein uptake has decreased from 10.8 to 7.3% in rural households and 12.9 to 7.4% in urban households between 1988 and 2009. The frequency of pulses consumption in the country is much higher than any other source of protein, which indicates the importance of pulses in their daily food habits.

The domestic production of about 23 million tonnes during 2016-17 shall be still less than the future estimated demand of 29-30 million tonnes in 2030. The targeted production and productivity is possible by way of harnessing this yield gap by growing pulses in new niches, precision farming, quality inputs, soil test-basedINM, timely weed management and mechanized method of pulse cultivation complimented with generous governmental policies and appropriate funding support to implementing states/stake holders **(Tiwari and Shivhare, 2017).**According to the Vision-2030 document prepared by the ICAR-Indian Institute of Pulses Research (IIPR), Kanpur, a growth rate of 4.2% has to be ensured in order to meet the projected demand of 32 million tonnes of pulses by 2030.Plant nutrient, suitable cultivars and correct fertilizer have significant effect on yield and yield component**.** Generally, Indian soils are lacking in effective and specific strains of *Rhizobium* which are responsible for symbiotic nitrogen fixation. Phosphorus is regarded as the pioneer plant nutrient needed by the leguminous crops for rapid and proper root development, which later on becomes helpful for better nodulation by *Rhizobium* bacteria. Sulphur deficiency is becoming more critical with each passing year which is severely restricting crop yield, produce quality, nutrient use efficiency and economic returns on millions of farms. Like any essential nutrient, sulphur also has certain specific function to perform in the plant. thus, sulphur deficiencies can only be corrected by the application of sulphur fertilizer. Application of fertilizer to alkaline soils has been reported to reduce the pH of soil.Bio-fertilizers may colonize the rhizosphere and promotes growth by increasing the availability and supply of nutrients and growth stimulus to crop. Nitrogen fixer and phosphate solubilizing microorganisms play an important role in supplementing nitrogen and phosphorus to the plant, allowing a sustainable use of nitrogen and phosphate 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. Multi-location trials had indicated that inoculation of seed with phospho-bacterial increased the yield of rice by 10-20 per cent, wheat by 10-40 per cent, bengal gram by 10-30 per cent, and potato by 30-35 per cent over control.

Comment [jS14]: Show yield gap by diagrammatic flow

Comment [jS15]: Integrated nutrient management

The Missing Link for Sustainable Pulse Production

(a): Rainfed ecology

Rainfed agriculture has emerged as an opportunity in raising pulse growth. Food production is tied up with amount and distribution of rainfall. Pulses have been cultivated since time immemorial in rainfed conditions which are characterized by poor soil fertility and moisture stress environments **(Sundaram 2010)** show remarkable variability and diversity in terms of varieties and quantity of production **(Inbasekar 2014).**Nitrogen and phosphorus are known to have a great impact on nodulation and thereby, on productivity of legumes **(Singh *et al.* 1998**).Availability of phosphorus is also an issue in legume-based cropping systems 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.Depletion of K relative to N is high in cropping systems involving cereal and fodder crops. Since most Indian soils are considered adequate in native K, its application did not receive much attention. Mining of native K under intensive cropping and continuous neglect of replacement through fertilizers led to K deficiency in many soils; and thus, responses to its application became spectacular in different cropping systems (Goswamiet al. 1976).

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(b):Lack of Irrigation facilities

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Lack of assured irrigation during crop growing season coupled with poor soils and frequent droughts translate into poor crop productivity levels in most parts of Bundelkhand region. During 2015-16, the share of irrigated area to total cropped area in UP Bundelkhand region was 49.7% (1.27 Mha) against about 80 percent in UP state, while it was 37% (1.13 M ha) in MP Bundelkhand region as compared to 42 percent in MP state. Irrigation sources like dams, ponds, tanks, lakes, streams, wells, bore wells and irrigation canals exist in the region. However, low and erratic rainfall in the region has lead to heavy dependence on ground water for irrigation. About 42 % of gross sown area in Bundelkhand region is under irrigation and irrigation through canal accounts for coverage of 24.7% of gross irrigated area. Tube wells are the largest source of irrigation covering about 64 percent of the gross irrigated area in the region. The situation has lead to over exploitation of underground water for irrigation purpose in this water scarce region **(Samra 2008, Palsaniya *et al*., 2011).**

(c):Nutrient management in rainfed area

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There is a significant mismatch between pulse nutrient demand and supply. Farmers rarely use P fertilizer, resulting in an unbalanced nutrient ratio in the soil, which led to the development of multi-nutrient deficits.Nutrient imbalance is one of the major abiotic constraints limiting the productivity of pulses **(Thiyagarajan *et al.*,2003)** and is gradually deteriorating soil health. The in-built mechanism of biological N fixation enables pulse crops to meet 80-90% of their N requirements, hence a small dose of 15-25 kg N ha^{-1} is recommended as starter dose to meet out the requirement of most of the pulse crops. A study on pulse cultivation in Madhya Pradesh by Maji and Sulaiman (1995) has indicated that the fertilizer use was very low with chickpea receiving the highest priority andthe least topigeonpea. Although the recommended dose in Madhya Pradesh was 15-25 kg of N and 20-50 kg P_2O_5 ha^{-1} through superphosphate, Application of RDF to pigeonpea sole with positive P and K balance in soil was possibly due to addition of the recommended dose of P and K to the soil through chemical fertilizers. While, in case of no NPK to pigeon pea sole, the trend was just reverse.In intercropping system, pigeonpea + pearl millet had a greater positive N balance in soil than that of pigeonpea + sorghum at harvest of crop during 2012-13; but in 2013-14 both the intercropping system showed a negative N balance due to deficit soil moisture status (rainfed). Undervaried fertility levels, and maximum positive N balance was analyzed in the intercropping treatment where no fertilizer was applied to pigeonpea 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 the beneficial effect of pigeonpea through symbiotic N fixation and root exudation as well as supplementation of RDF to intercrops. Nitrogen additions through various organic forms may not be immediately available for crop uptake which could be attributed to its positive fertility balance in soil.

(d):Heavy infestation of diseases, insect pest and weeds

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Mono-cropping of pulses year-after-year has intensified the incidences of diseases, insect-pests and weeds in pulse crops in Bundelkhand region. In pigeon pea, chickpea and lentil crops, *Fusarium wilt* is the important biotic and stresses affecting production. In pigeon pea crop, sterility mosaic andPhytopthora blight are the other important diseases in the region. Yellow mosaic disease in mung bean and urdbean crops while powdery mildew and rust diseases in field pea cause significant crop losses in the region. Among insect-pest, gram pod borer (*Helicoverpa armigera*)causes significant crop losses in pigeon pea and chickpea in the region. Mungbean and urdbean crops suffer from spotted pod borer, whitefly, aphids and thrips. A change in incidences and severity of insect pest is frequent in the region, with minor pest like pod fly and thrips emerging as major ones in the recent past. Weeds pose a serious threat in pulse crops due to the slow initial growth (Kumar *et al.* 2013) and they also hinder in intercultural operations and harvesting. Some weeds also act as alternate host of insect-pest and diseases of pulse crops.

B:Technologicalinterventions for enhancing pulse production

(a) Improved varities(New Plant types, Short duration and Disease resistance).

Comment [jS22]: varieties

Intensivebreeding efforts led to development of new varieties with short duration, disease resistance, large seed, photo-thermo insensitivity and amenable for late planting besides higher yield which facilitated crop diversification, intensification and introduction in new niches and cropping systems. In 1988, a dwarf-leafless (leaflets converting into tendrils) variety of fieldpea (Aparna) was developed. This dwarf variety responded well to high plant population, irrigation and nitrogen, and thus significant increase in productivity **(Ali 1988).** Later on, many dwarf and semi-dwarf varieties (Sapna, Uttra, Malviya Matar 15, KPMR 400, KPMR 522, Vikash, Prakash, Pant P 74) were developed. In chickpea, a tall-erect variety (BG 261) with basal branching and bold seeds was developed in 1984. This variety was found ideal for intercropping with mustard cv 'Varuna' in 6:2 row ratio **(Ali 1992).** Now, more emphasis is laid on tall- erect plant types in chickpea, lentil and mungbeans to facilitate mechanical harvesting. In short duration pigeonpea, a few varieties with determinate growth habit (ICPL 87, ICPL 151, ICPL 85010) were developed to facilitate synchronous maturity and timely harvesting but it could not destroy due to heavy infestation of pests.

Short duration: The traditional long duration varieties often experienced terminal drought resulting in partial or complete failure of crop, encountered more pest infestation and favoured mono-cropping.Therefore, efforts were made to develop short-duration varieties in all pulse crops with matching phenology for different agro-ecological regions. The advent of short duration varieties of pigeonpea during 1975-76 such as 'Pusa Ageti', 'UPAS 120', etc. led to the introduction of pigeonpea in the irrigated area of north-west plains under pigeonpea - wheat double cropping system **(Ramanujam, 1971)**. Later on, many short-duration (130-160 days) varieties such as ICPL 151, Pusa 33, Pusa 855, Manak, Al 15, Al 201 and Pusa 992 were developed **(Ali and Kumar 2009)**. Mid-May to mid-June was found to be the optimum time of planting for the success of pigeon pea-wheat rotation.

(b):Sowing techniques: Traditionally, pulses are sown on flat seed beds after land preparation. In the eastern region (Uttar Pradesh, Bihar, Jharkhand, West Bengal, Orissa and parts of central India, kharif-planted pulses often suffer due to water stagnation during the rainy season which ultimately reduces productivity. During 1994-95, ridge planting of pigeon pea was conceptualized and evaluated under AICPIP/AICRP which showed very encouraging results in the 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 the quantity of irrigation water, and also minimizes the incidence of Phytophthorablight in pigeonpea.

(c)Cropping system: Developmentof short duration and disease resistant varieties of different pulses paved way for design and development of new cropping systems both in rainfed and irrigated areas. Some of the examples are pigeon pea-wheat in N-W plains, maize– pre-rabi pigeonpea/frenchbean in N-E plains, rice–wheat–mungbean,maize-potato/mustard–mungbean/urdbean in northern plains and rice-urdbean in coastal peninsula. Integrated nutrient management: In Uttar Pradesh, the Chitrakoot Dham region is famous for pulse production, where production takes place under rainfed condition due to lack of irrigation facilities and typical physiography. Chitrakoot Dham accounts for 18.11% of the total area and 25.67% of the total

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production of the state. The productivity of pulses in this region was higher in the state being 8.76 q/ha as against 8.08 q/ha 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.

(d)Water management: Pulses are generally grown under rainfed conditions (84%). However, they respond well to limited irrigation. Some of the pulses like rabi Frenchbean and summer mungbean/urdbean in northern plains are cultivated under irrigated conditions. Chickpea has maximum area (35%) under irrigation in the country. 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. In field pea, 50% flowering stage was found most critical for irrigation **(Panwar and Malik, 1977)**. Similarly, in lentil and chickpea, one irrigation at the early pod filling stage was found most effective **(Panwar and Paliwal, 1975)**.

(e): Rice fallow technology: The 44 Mha area under rice, about 11 Mha remains fallow during rabi season due to several bio-physical, biotic and abiotic stresses and socioeconomic constraintsafter harvest of kharif crop. Soil moisture is the most critical constraint for cultivation of rabi crops in rice fallows. Short duration pulses are considered to be the most ideal crops. Efforts have been made to identify suitable crops and varieties for rice fallows. Sowing of lentil, chickpea, and urdbean/mungbean in the eastern and central areas, and in the peninsular region. Pulses experience severe losses as a result of several illnesses and insect infestations.Among insect pests, gram pod borer (*Helicoverpa armigera*) being polyphagous in nature causes considerable yield loss in chickpea and pigeonpea. Similarly, *Fusarium* wilt is the most widely distributed pathogen affecting chickpea, lentil, peas and pigeonpea. Host plant resistance is the best option for disease management which has been rigorously attempted and for major diseases donors as well as elite varieties are now available. For insect pests, integrated approach combing cultural, botanicals and chemicals have been advocated. Specific integrated approach for wilt and gram pod borer management has been developed.

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(f):Crop Protection Pulses suffer heavily due to a large no. of insect pests and diseases. Among insect pests, gram pod borer *(Helicoverpa armigera)* being polyphagous in nature causes considerable yield loss in chickpea and pigeonpea. Similarly, *Fusarium wilt* is the most widely distributed pathogen affecting chickpea, lentil, peas and pigeonpea. Specific integrated approach for wilt and gram pod borer management has been developed.

C:Research finding:

Table 3. Crops, Nitrogen Fixation and Nitrogen release in soil.

Crop	Nitrogen Fixation ($kgha^{-1}$)	Nitrogenrelease insoil
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

Source: Gill *et al.*, (2009)

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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 soilunder different pulses show the table:1) process to occur plant must enter symbiotic beneficialpartnership withcertainbacteriacalled rhizobia. Optimum rate of nitrogen fixation in pulse is about 1.0kg/ha/daywithin a cropping season.Abouttwo third of the nitrogen fixed by apulse become available to next growing season.

Table,4: Nutrients content of grain and straw in chickpea after harvest of different treatments

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Treatments Fertilizer dose NPK (kg ha^{-1}) and FYM (t ha^{-1})		**Grain (kg ha^{-1})**			**Straw (kg ha^{-1})**		
		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_4-12qha^{-1}	19-16-13-5	2.74	0.87	0.93	1.70	0.43	2.41
T_5 -16qha^{-1}	**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: A miner modification was made in the ready reckoner, FP: Farmers practice i.e. the fertilizer doses the farmers generally applied in the area,GRD: General recommendationof agricultural departmentof thedistrict onthebasis ofsoiltest value.

The higher nutrient content (3.60 N, 0.92 P and 1.06 K kg ha^{-1}) by chickpea grain and (1.82 N, 0.58 P, 2.30 K kg ha^{-1}) by chickpea straw was recorded under T_5 superior than other treatments. The lowest uptake of nutrients under treatment T_1. it is no application of fertilizer by (NPK nutrients). Available nutrients status was also higher in T_4 and T_5 where FYM was applied. When we apply FYM in soil the entire amount of its NPK constituents was not made available at a time in one season; rather, a gradual release took place over a period of years.

Table5: Availablenutrientstatusofsoilbeforesowingand afterharvestofchickpeacrop

Treatments	Physiochemicalproperties						Fertilitystatus(kgha$^{-1)}$					
	pH		EC(dSm^{-1})		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_4-12qha^{-1}	7.3	7.2	0.22	0.17	0.27	0.41	115.35	180	18.8	22.1	255.8	262.2
T_5-16qha^{-1}	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: Aminermodificationwasmadeinthereadyreckoner,FP:Farmerspracticei.e.thefertilizerdoses thefarmersgenerallyappliedinthearea,GRD:Generalrecommendationofagriculturaldepartmentofthedist rictonthebasisofsoiltestvalue,BT-Beforesowing,AH-Aftercropharvest.

Above table indicates that initially the soils were neutral in reaction with average pH 7.3 and low in soluble salts (0.22 dSm^{-1}) which was observed to be neutral with less soluble salt concentration after chickpea crop in rabi season in all the treatments. The organic carbon content which was earlier measured low (0.27%) in the experimental fields before sowing, increased in all the treatments except control in 2014- 15. The organic carbon content was noticed to be remarkably high in STCR treatments especially in T_5. The soils were very low in N (115.35 kg ha^{-1}), medium in P_2O_5 (18.80 kg ha^{-1}) and high in K_2O (255.80 kg ha^{-1}) before chickpea sowing.

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

Treatment	Description		Symbol
T_0	Control No treatment		(L0Z0)
T_1	NPK 0%, Zn 50%	10kg Zn ha-1	(L0Z1)
T_2	NPK 0%, Zn 100%	20kg Zn ha-1	(L0Z2)
T_3	NPK 50%, Zn 0%	20:40:20 Kg NPK ha-1	(L1Z0)
T_4	NPK 50%, Zn 50%	20:40:20 Kg NPK+10kg Znha-1	(L1Z1)
T_5	NPK 50%, Zn100%	20:40:20 Kg NPK+20kg Znha-1	(L1Z2)
T_6	NPK 100%, Zn 0%	40:80:40 Kg NPK ha-1	(L2Z0)
T_7	NPK 100%, Zn50%	40:80:40 Kg NPK+10kg Znha-1	(L2Z1)
T_8	NPK 100%, Zn100%	40:80:40 Kg NPK+20kg Znha-1	(L2Z2)

Table7: Effect of different levels of NPK and Zn on Physico-Chemical propertiesof soil after harvest of pea crop.

Treatment combination	BD (Mg m-3)	PD (Mg m-3)	Porespace (%)	pH 1:2 (w/v)	EC (dSm-1)	N (kg ha-1)	P2O5 (kg ha-1)	K2O (kg ha-1)	Zn (ppm)	Organic carbon (%)
T0=(L0Z0)	1.26	2.57	47.33	7.73	0.16	275.33	21.50	106.20	0.52	0.65
T1=(L0Z1)	1.23	2.47	46.67	7.55	0.16	295.33	23.03	124.50	0.54	0.70
T2=(L0Z2)	1.24	2.68	47.33	7.54	0.15	299.33	26.00	133.80	0.58	0.73
T3=(L1Z0)	1.21	2.59	48.00	7.46	0.15	295.67	24.83	152.13	0.62	0.72
T4=(L1Z1)	1.22	2.51	48.67	7.37	0.14	299.33	27.33	161.97	0.65	0.74
T5=(L1Z2)	1.23	2.63	49.67	7.34	0.12	305.67	26.17	170.67	0.71	0.75
T6=(L2Z0)	1.22	2.48	48.33	7.31	0.12	302.33	28.00	187.40	0.75	0.73
T7=(L2Z1)	1.20	2.58	50.00	7.30	0.11	311.67	28.87	214.27	0.80	0.76
T8=(L2Z2)	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 will be laid 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^{-1}*(Pisum sativum L.)* Cv. Rachna. Pea grows in 9th 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 uni furrows opened by about 5 cm.

The results in above Table:7 indicate some of the important parameter on physical and chemical properties on Pea crop. NPK and Zn fertilizers conjunction on bulk density, particle density and pore space to be non-significant. The bulk density (Mgm^{-3}), particle density (Mgm^{-3}) and pore space (%) of postharvest soil was recorded 1.21, 2.50 and 49.67 with the treatment T_8 respectively. The slight decreased in bulk density, particle density and pore space may be due to tillage operation and increase in plant growth. indicate some of the important parameter on physical properties on 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^{-1}), available phosphorus (kg ha^{--1}), available potassium (kg ha^{-1}) and Zn (ppm) was found significant. pH, EC (dSm^{-1}), organic carban (%), available nitrogen (kg ha^{-1}), available phosphorus (kg ha^{-1}), available potassium (kg ha^{-1}) and available Zinc (ppm) was recorded 7.05,0.11, 0.76,315.33, 28.90, 225.27 and 0.91 respectively in the treatment T_8 that was significantly higher as compared to other treatment 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 SOCand 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/cc0	Total porosity	SOC (%)	Total N (%)	Olsen-(Pmg/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

Comment [jS29]: Try to review different researchers' results for enhancing pulse production in a single table rather than giving each result table as it is review paper

A considerable residual impact of pulses on improvement in soil fertility could be brought by inclusion of pulses in crop sequence. It is also observed that pulses have higher microbial load except *Azotobacter* as compared to cereals or fallow. Pulses also contribute to an increase diversity of soil flora and fauna leading a greater stability to the total life of soilby providing additional Nitrogen.

(D):Government Initiatives for Enhancing Pulses Production in India and in Bundelkhand.

- Timely availability of critical inputs like seed, bio-fertilizers including micro and macro nutrients at fieldlevel.
- Promotion of short duration crops like urd & mung to make different production system profitable and improved soil health may be explored.Location specific strategybased 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 andcommunity reservoirs in a focus manner with end to end solution to extend the coverage and improving Water Use Efficiency (WUE).
- Seedavailability 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.
- IntegratedNutrient 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)
- Technology demonstration

Conclusion

The advance released technologies have the potential of doubling production at national level without increasing area under pulses if farmers adopt the recommended technological intervention for pulses production systemand mange useunbalanced nutrient ratio in the soil, which are the development of multi-nutrient supply. Nutrient imbalance is one of the major abiotic constraints limiting productivity of pulses and is gradually deteriorating soil health.The yield enhancing technologies and nutrient managementapproaches wider adoption among the farming community in their respective farming systems and increase production and productivity of pulse crops in the Bundelkhand region.

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Comment [jS30]: Maintain same pattern