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Pulses in Uttarakhand: Has Their Potential Been Tapped Enough to Attain Food and Nutritional Security?

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ABSTRACT

Background: Malnutrition is a global health crisis and Uttarakhand state is no exception. Besides the implementation of various government schemes for eradication of undernutrition is at very slow pace calls for analyzing the present situation and future prospects of food crops. In this regard, Uttarakhand a hilly state with many agricultural constraints needs special attention. Pulses known for rich protein and micronutrient content can serve as an excellent source for mitigating protein deficiency and attaining food and nutrition security. Various pulses in different cropping pattern are being grown in the state. The current study aims at exploring the dynamics, diversification and decomposition of pulses in Uttarakhand and their role in providing food and nutritional security.

Methods: Secondary data related to area under pulses, production and yield were taken from official website of Agriculture department, Government of Uttarakhand. The data gaps were filled through linear interpolation. Production of total pulses was linearly extrapolated to estimate pulses production for 2035-36. Growth and instability, diversification and decomposition of pulses were analyzed. The Food and Nutritional security statistics were taken from directorate of Economics and Statistics, Government of Uttarakhand and explored in relation to pulses.

Result: It was found that the state is faring well in production of pulses as an increase in absolute area, production, yield and proportion of pulses in gross sown area was observed. High pulse diversification was seen. However, a decline in all major pulse-based cropping systems was seen. Moreover, in the state, where 31% of the population lacks adequate protein intake, there is a pressing need to enhance the availability, accessibility *and* absorption of protein-rich pulses, particularly for vegetarians. Additionally, it is essential to reevaluate the state's food and nutrition security status in alignment with the updated guidelines from ICMR-NIN in 2020.

Key words: Crop diversification, Food and nutrition insecurity, Growth and instability, Pulses.

INTRODUCTION

Pulses are the edible seeds that grow within the pods of legume family and are one of the key components of balanced diet. The history of growing and consuming pulses can be traced back through the ages. In India, pulses are being cultivated for millennia. According to Kumar and Dutt (2019), nearly 5.63 to 10.90 percentage share of food grains production in India is attributed to pulses.

Pulses are essential for maintaining human, animal and environmental health. Pulses being rich source of protein are important for growth and wellbeing, especially for vegetarians. Besides, they are store house of vitamins, minerals and fiber making them ideal for imparting therapeutic nutrition as well. The residue of pulses is used as animal fodder improving animal health. Pulses also provide environmental benefits. Pulses improve soil quality as they fix nitrogen in the soil, lower soil erosion and decrease the use of synthetic fertilizers. They have low carbon footprint compared to animal protein sources and are highly water efficient. Thus, pulses are vital for environment sustenance in addition to providing food and nutritional security.

Currently malnutrition has become a global health crisis. From 828 million hungry people in 2021 to more than one billion obese people in the world, the picture of malnutrition is reigning around the world. Food insecurity is rising at an alarming rate owing to climate change, COVID-19 pandemic, war/conflicts and poverty. In 2021, nearly 924 million were facing food insecurity at various levels with 45 million children under 5 suffering from wasting and 149 million from stunting. According to a joint report released by FAO, IFAD, UNICEF, WFP and WHO

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(2022) there are almost 3.1 billion people could not afford healthy diet in 2021. It was reported that 45% children die due to hunger and related causes.

India faces a similar predicament with regard to malnutrition. As per the NFHS-5 (2022) report, 35.5% of children under the age of 5 suffer from stunted growth, 19.3% experience wasting *and* 32.1% are underweight. The report also highlights that 18.7% of women and 16.2% of men have Body Mass Index (BMI) values below the normal range. Additionally, a concerning 67% of children below 5 years old and 57% of women in their reproductive years are affected by anemia.

Adequate and nutritious food can play a crucial role in mitigating these health challenges. The dysfunctional food demand–supply chain needs to be tackled in order to address the issue of food and nutritional insecurity. Policy programmes have historically been instrumental in filling the demand-supply gaps. For instance, as compared to the target, National Food Security Mission (NFSM) achieved the bumper production of pulses to the tune of 24.51 million tonnes during 2017-18 as per the report of (Kumar *et al.*, 2020).

Pulses being climate resilient and nutrient rich can play a vital role in dealing the issues of nutritional insecurity, especially protein deficiency and hidden hunger. Although today India is the largest producer of pulses in the world, pulses were not given as much importance as major cereals during green revolution, sidelining the pulses to the non-irrigated areas. From 1950-2008, the productivity of pulses and area under pulses grew by only 45 and 25%, respectively. Till 2016, the domestic production of pulses was less than 20 MT and thus, depending on imports to meet the demand. However, now comparatively an increase in the production with decline in import and an increase in export are being witnessed. Increasing trends have been observed in export of agricultural commodities except for pulse crops because of prohibition of export of pulses. Moreover, import of pulses has also shown an increasing trend as reported by Qasim (2021). However, it has been estimated in the report of World Food Programme (2022) that in 2032-33 the demand for total pulses would be around 35.23 MT and the total supply would be around 33.95 MT and a deficit of 5-6 MT in domestic supply would continue (WHO, 2022). This calls for improving the production across the country.

The present paper deals with the role of pulses in achieving food and nutritional security in special context to Uttarakhand state of India. Uttarakhand is a young state carved from Uttar Pradesh in 2000. It is located in the northern part of India with largely hilly terrain. Of the total 13 districts, 10 are completely hilly districts with undulated topography. Eighty six percent of total geographical area is under hills and 14% is under plains. The economy of the state majorly depends on agriculture but unfortunately owing to its topography only 14% of the geographical area is currently under cultivation. Out of the total net irrigated area, 85.83% is in plains and 14.17% is in hills as per State Horticulture Mission (2023). The agriculture sector in the state continues to remain heavily dependent on rainfall. Moreover, the sloppy lands in hilly terrain are highly prone to erosion and have low nutrient status with no irrigation facilities, thus making agriculture a tedious task.

Considering the wide agro-climatic conditions and topography of the state, the paper was undertaken with the aim of exploring the dynamics, diversification and production decomposition of pulses in Uttarakhand and its association in mitigating food and nutritional insecurity.

MATERIALS AND METHODS

Data

The area, production and yield data of pulses grown in Uttarakhand was taken from ‘Agricultural Statistics of Uttarakhand’ given on the official website of Agriculture Department, Government of Uttarakhand (2022). The Gross Sown Area (GSA) was sourced from Indiastat (2023). Data gaps were filled through interpolation. Production of total pulses was linearly extrapolated to estimate pulses production for 2035-36. The data from Directorate of Economics and Statistics, Planning Department of Uttarakhand (2023b) was taken to understand the food and nutritional security status in relation to the pulses.

Growth and instability analysis

Compound annual growth rate (CGR) was used for estimating growth. The compound annual growth function was specified as semi-log equation as suggested by Rehman (2011):

$$\ln Y = a + bt + e \qquad \text{...Eq (1)}$$

Y = Area (ha)/production (tonnes)/yield (qtl/ha).
a = Intercept.
t = Year.
b = 1+ r (The slope coefficient ‘b’ measures the instantaneous growth rate).
r = Compound growth rate.

The compound growth rate is calculated by multiplying by 100 using the following equation:

$$CGR = [\text{antilog } b - 1] * 100$$

Eq. (1) is estimated using Ordinary Least Square (OLS) method. The t-test was applied to test the significance of ‘b’.

For measuring instability Cuddy Della Valle Index (CDVI) as described by Cuddy and Valle (1978) was used. It is given by:

$$CDVI (\%) = CV \sqrt{1 - R^2} \qquad \text{...Eq (2)}$$

Where,
CV = Per cent.
R^2 = Coefficient of determination of a time trend regression adjusted for its degrees of freedom.
CDVI <15 shows low instability.

CDVI varying between 15 and 30 shows medium instability and CDVI>30 shows high instability.

The growth and instability analysis was done for the period 2005 to 2020.

Pulses diversification

Diversification of pulses was estimated using Simpson's Diversification Index (SDI) as described by Adjimoti and Kwadzo (2018). The proportion of pulse i is given by

$$S_i = \frac{a_i}{A}$$

Where,

a_i = Area under pulse I and A is the total area under pulses. The SDI is widely used and is given by

$$SDI = 1 - S_i^2$$

SDI varies between 0 and 1 with values nearing 0 indicate specialization and those nearing 1 indicate diversification.

Also, proportion given by the following formula was found out to estimate pulses area proportion:

$$\text{Proportion} = \frac{\text{Area under pulses}}{\text{Gross sown area}}$$

Decomposition analysis

The decomposition analysis (Kakali, 2006; Siju, 2001) was done using the equation below:

$$\Delta P = A_b\Delta Y + Y_b\Delta A + \Delta A\Delta Y$$

which translates to,

Change in Production = Yield effect + Area effect + Interaction effect

Where,

$\Delta P = P_C - P_B$ = Change in production.

$\Delta Y = Y_C - Y_B$ = Change in yield.

$\Delta A = A_C - A_B$ = Change in area.

A_B, P_B and Y_B are the area, production and yield of base year.

A_C, P_C and Y_C are the area, production and yield of current year.

Thus, the production is decomposed into 3 effects *viz*., yield effect, area effect and interaction effect. The decomposition analysis was done for 3 periods, *viz.* 2005-10, 2010-15 and 2015-20.

The work was done at G.B. Pant University of Agriculture and Technology, Pantnagar, District U. S. Nagar, Uttarakhand during the period 2022-23.

RESULTS AND DISCUSSION

Area, production and yield of pulses in Uttarakhand

The major pulses grown in state are pigeon pea, kidney bean, black gram, green gram, moth bean, horse gram, black soybean, chick pea, pea, lentil and cowpea.

Area, production and yield of pulses have shown increasing trends in Uttarakhand. The area under pulses increased from 51,478 ha in 2005-06 to 64,314 ha in 2020-21 indicating 25 per cent increase. The proportion of area under pulses with respect to gross sown area also showed increasing trend (Fig 1). The proportion increased from 4.25 in 2005-06 to 6.45 in 2020-21. Thus, it can be concluded that not only absolute area under pulses but also proportion of pulses in gross sown area increased which indicates substitution by and expansion of area under pulses.

The production of pulses in Uttarakhand increased from 28,811 tonnes in 2005-06 to 62,340 tonnes in 2020-21 thereby indicating an increase by 116 per cent. This could have possibly been due to increase in yield from 5.6 qt per ha in 2005-06 to 9.7 qt per ha in 2020-21, apart from increase in area. The technological advancement in pulses and increase in area under pulses could be attributed to schemes like National Food Security Mission - Pulses (NFSM-Pulses), Rashtriya Krishi Vikas Yojana (RKVY) and other schemes like Pradhan Mantri Krishi Sinchai Yojana (PMKSY) focusing on agricultural inputs. Under NFSM-Pulses, increase in pulses production was targeted through extension and promotion of improved technologies *i.e*., seed, Integrated Nutrient Management (INM) including soil amendments, micronutrients, Integrated Pest Management (IPM) and resource conservation technologies along with capacity building of the farmers. Incentives for purchase of conoweeders, knapsack sprayers and other farm implements were provided to farmers for cultivation of pulses and other crops under NFSM. However, under Re-vamped NFSM, according to its operational guidelines given in 2018 by Government of Uttarakhand (2023), increase in production of pulses and other crops under NFSM was targeted through area expansion and productivity enhancement but in a sustainable manner. Additionally, in Re-vamped NFSM, intercropping of commercial crops with pulses was also promoted. Under RKVY, states were incentivized to increase public investment in agriculture and allied sector. RKVY aimed for integrated development of major food crops including pulses as described in guidelines for NADP by Agriculture Department, Government of Uttarakhand (2007).

The production of pulses is linearly extrapolated to be 82,987 tonnes in 2035-36. However, this might not be in correspondence with increasing population. On an all-India basis, it is estimated that India needs an annual growth of 4.2 per cent to ensure projected demand of 30 million tonnes by 2030. Mukherjee (2018) reported that although pulses yield show an increasing trend, Uttarakhand lags behind Himachal Pradesh among north-western Himalayan states.

Growth and instability of area, production and yield of different pulses grown in Uttarakhand

Area under pulses

In Uttarakhand, horsegram had the highest area cover (13,340 ha) among all the pulses in 2020-21, followed by lentil (12,076 ha) and black gram (*kharif*) (11,944 ha) (Table 1). The least grown crops were moth bean (1 ha) and green gram (zaid) (2 ha). Table 2 shows that the diversification of pulses was quite high and stabilized between 0.8 and 0.9. It is evident from Table 1 that area under total pulses increased at the rate of approximately 1 per cent per annum with low instability. All *kharif* pulses showed increasing compound growth rates except moth bean and minor pulses (other *kharif* pulses). Minor pulses declined at a rate (-6.8 per cent per annum) higher than moth bean (-1.35 per cent per annum). Moth bean showed highly unstable decline whereas minor *kharif* pulses showed decline with medium instability. Kidney bean showed the highest CGR (6.24 per cent per annum) along with low instability among *kharif* pulses indicating a stable increase in area.

All *Rabi* pulses except pea showed overall decline in area as indicated by their negative growth rates (Table 1). Both chickpea and pea showed decline and increase respectively with medium instability whereas lentil and

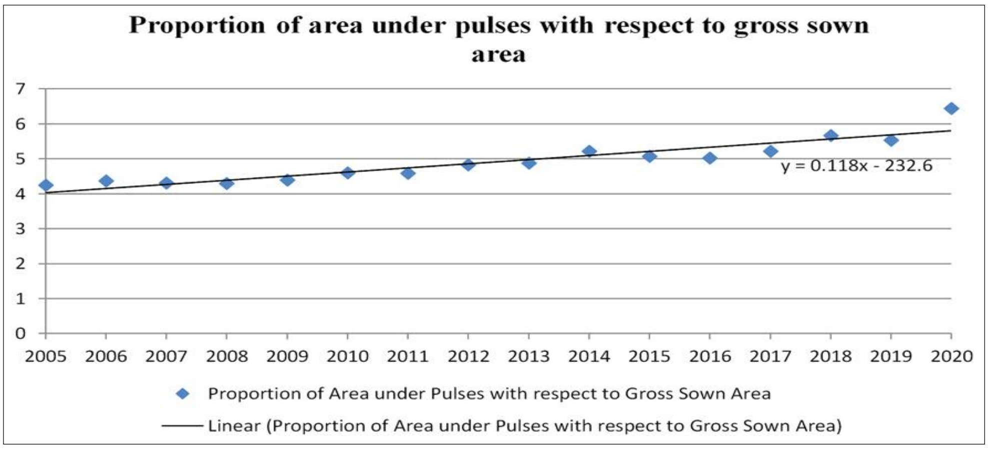

Fig 1: Proportion of area under pulses with respect to gross sown area in Uttarakhand.

Table 1: Compound growth rate and Cuddy Della Valle Instability Index of area under different pulses.

Crop	2005-06	2010-11	2015-16	2020-21	CGR (% per annum)	CDVI (%)
Kharif						
Pigeon pea	1612	1963	3334	3079	0.036***(0.0087) [3.7]	14.68
Kidney bean	-	-	5149	6236	0.061***(0.0125) [6.24]	9.99
Black gram (*Kharif*)	10688	10475	11940	11944	0.009***(0.0028) [0.89]	5.02
Green gram (*Kharif*)	1	102	3	16	-	-
Moth bean	9.0	22.0	15	1	-0.014NS(0.0782) [-1.35]	216.48
Horsegram	8571	9690	11580	13340	0.027***(0.0026) [2.76]	4.6
Black soybean	5058	6728	6458	7960	0.028***(0.0044) [2.86]	7.74
Other pulses (*kharif*)	7382	6291	5839	1335	-0.07**(0.0245) [-6.8]	26.6
Rabi						
Chickpea	904	728	646	838	-0.007NS(0.0093) [-0.7]	16.11
Pea	3837	6636	4983	7398	0.021*(0.011) [2.1]	18.91
Lentil	12972	11027	10043	12076	-0.012**(0.0044) [-1.22]	8
Other pulses (*Rabi*)	29	32	4	84	-0.097NS(0.0886) [-9.21]	143.03
Zaid						
Black gram (zaid)	399	176	59	66	-0.127***(0.019) [-11.96]	36.68
Green gram (zaid)	15	16	15	2	-	-
Whole year						
Black gram (All seasons)	11087	10651	11999	12010	0.01** (0.0033) [1]	4.85
Green gram (All seasons)	16	118	18	18	-0.096NS (0.078) [-9.12]	94.79
Total pulses	51478	53887	54920	64314	0.011*** (0.0019) [1.06]	3.49

***Significant at 1%, **Significant at 5%, *Significant at 10%, NS Non-significant

Figures written in () and [] are standard errors and compound growth rate respectively.

Data for kidney bean was unavailable before 2011. CGR and CDVI of green gram (*kharif*) and green gram (zaid) could not be computed because of inability of log function to take '0' input values.

minor Rabi pulses (other *Rabi* pulses) showed low and high instability respectively. Area under black gram (zaid) declined at a very high rate (11.96 per cent per annum) with high instability. Overall, area under black gram (whole year) increased at the rate of 1 per cent per annum with low instability whereas green gram (whole year) showed negative growth rate (9.12 per cent per annum) with high instability.

Production of pulses

The production of pulses grew at the rate of approximately 4 per cent per annum with low instability (Table 3). All *kharif* pulses showed increasing production as indicated by their positive CGRs except minor *kharif* pulses (other *kharif* pulses). Kidney bean, black gram (*kharif*) and horsegram showed low instability. Black soybean and pigeon pea showed medium instability whereas moth bean and minor *kharif* pulses showed high instability.

All *rabi* pulses except minor *rabi* pulses (other *rabi* pulses) showed positive CGRs indicating increasing trends. Minor *rabi* pulses showed high instability whereas other pulses of *rabi* season showed medium instability. Black gram (zaid) showed negative CGR (-8.62 per cent per annum) with high instability indicating an unstable declining trend. Overall, black gram (all seasons) showed increasing trend with low instability.

Yield of pulses

The yield of pulses increased at the CGR of 2.98 per cent per annum with low instability (Table 4). All pulses showed positive CGRs of yield indicating technological advancement. The highest CGR of yield was observed in minor rabi pulses (other *rabi* pulses) (4.24 per cent per annum) followed by green gram (whole year) (4.07 per cent per annum) whereas lowest CGR of less than 2 percent per annum was observed in chickpea. Minor *kharif* pulses, minor *rabi* pulses, pea, lentil and black gram (zaid) showed medium instability. High instability was observed in green gram (whole year). Some authors like Kumar and Malik (2022) have also found positive compound growth rates for area (0.14 per cent per annum), production (1.09 per cent per annum) and yield (0.97 per cent per annum) of pulses in India.

Table 2: Pulses diversification in Uttarakhand.

Year	2005-06	2010-11	2015-16	2020-21
Simpson's diversification index for pulses	0.840	0.857	0.857	0.847

Table 3: Compound growth rate and Cuddy Della Valle instability index of pulses production.

Crop	2005-06	2010-11	2015-16	2020-21	CGR (% per annum)	CDVI (%)
Kharif						
Pigeon pea	880	1343	2740	3648	0.072***(0.0123) [7.5]	20.24
Kidney bean	-	-	5185	7206	0.094***(0.0169) [9.9]	13.05
Black gram (*Kharif*)	5771	8392	7876	12764	0.033***(0.0056) [3.37]	9.76
Green Gram (*Kharif*)	4	54	2	8	-	-
Moth bean	3.0	9.0	8	1	0.016NS(0.0706) [1.57]	199
Horsegram	5116	8179	10292	13101	0.049***(0.0049) [5.06]	8.4
Black Soybean	3217	6149	6432	8364	0.058***(0.0091) [5.98]	15.02
Other pulses (*Kharif*)	4018	6051	5623	985	-0.048NS(0.0326) [-4.71]	38.09
Rabi						
Chickpea	631	568	540	629	0.007NS(0.0106) [0.69]	17.06
Pea	2628	6785	4666	6509	0.035NS(0.02) [3.57]	27.11
Lentil	6422	8236	7523	9068	0.033***(0.0109) [3.39]	17.69
Other pulses (*Rabi*)	17	18	4	76	-0.053NS(0.0922) [-5.14]	168
Zaid						
Black gram (zaid)	101	100	26	39	-0.09**(0.0314) [-8.62]	55.07
Green gram (zaid)	7	9	9	1	-	-
Whole year						
Black gram (All seasons)	5872	8492	7902	12803	0.028***(0.007) [2.86]	9.48
Green gram (All seasons)	7	63	11	9	-0.062NS(0.0691) [-6.03]	93.11
Total pulses	28811	45894	45742	62340	0.040***(0.0042) [4.08]	6.44

***Significant at 1%, **Significant at 5%, *Significant at 10%, NS Non-significant

Figures written in ( ) and [ ] are standard errors and compound growth rate respectively.

Data for kidney bean was unavailable before 2011. CGR and CDVI of green gram (*kharif*) and green gram (zaid) could not be computed because of inability of log function to take '0' input values.

Decomposition of production

For the period, 2005-10, change in production of total pulses was majorly due to positive yield effect (Table 5). Among *kharif* pulses, change in production was mainly due to positive yield effect in case of pigeon pea, black gram (*kharif*), horsegram, black soybean and minor *kharif* pulses whereas it was due to positive area effect in case of green gram (*kharif*) and moth bean. Among rabi pulses, change in production was observed mainly due to positive area effect in case of chickpea, pea and minor rabi pulses whereas in case of lentil it was due to positive yield effect.

In 2010-15, change in production of total pulses was again mainly due to positive yield effect (Table 6). Among *kharif* pulses, change in production was majorly due to positive yield effect in case of black gram (*kharif*) and black soybean whereas in case of pigeon pea, green gram (*kharif*), moth bean, horsegram and minor *kharif* pulses, it was due to positive area effect. In case of rabi and zaid pulses, positive area effect was dominant. Overall, change in black gram (whole year) production was dominated by yield effect whereas that in green gram (whole year) was dominated by area effect.

In the period 2015-20, change in production of total pulses was due to almost equal percentages of area effect (47.15 per cent) and yield effect (45.10 per cent) which indicates that both yield effect and area effect were prominent (Table 7). However, area effect was slightly more than the yield effect. Among *kharif* pulses, change in production was majorly due to positive yield effect in case of pigeon pea and black gram (*kharif*) whereas in case of kidney bean, green gram (*kharif*), moth bean, horsegram, black soybean and minor *kharif* pulses, it was due to positive area effect. In case of *rabi* and zaid pulses except black gram (zaid), positive area effect was dominant. Overall, change in both black gram (whole year) and green gram (whole year) production was dominated by positive yield effect.

Pulse-based mixed cropping systems in Uttarakhand

In India, various cropping systems are employed for the cultivation of pulses. These systems include sequential cropping, mixed or intercropping, relay cropping, catch cropping *and* ratoon cropping. Among these, intercropping is the most widely adopted method, covering approximately 70 percent of the pulse cultivation area in India as reported by Singh (2009).

In the state of Uttarakhand, a traditional cropping practice known as the “sari system” is prevalent. This method is particularly suitable for non-irrigated fields in hilly regions where pulses are cultivated alongside cereal crops on one terrace farm, while the opposite terrace farm is reserved for a single crop such as rice. The following year, this pattern of crops is swapped between the two terrace farms as reported by Chandra (2020). The primary goal of this practice is to

Table 4: Compound growth rate and cuddy della valle instability index of yield of pulses.

Crop	2005-06	2010-11	2015-16	2020-21	CGR (% per annum)	CDVI (%)
Kharif						
Pigeon pea	5.46	6.84	8.22	11.85	0.036*** (0.0057) [3.67]	10.22
Kidney bean	-	-	10.07	11.56	0.034*** (0.0062) [3.46]	5.1
Black gram (*Kharif*)	5.4	8.01	6.6	10.69	0.024*** (0.0058) [2.46]	10.28
Green gram (*Kharif*)	4.43	5.29	6.67	5.07	-	-
Moth bean	3.33	4.09	5.33	5	0.03*** (0.0093) [3.09]	13.79
Horsegram	5.97	8.44	8.89	9.82	0.022*** (0.0043) [2.24]	7.35
Black soybean	6.36	9.14	9.96	10.51	0.03*** (0.0062) [3.03]	10.62
Other pulses (*Kharif*)	5.44	9.62	9.63	7.38	0.022** (0.0097) [2.24]	17.33
Rabi						
Chickpea	6.98	7.8	8.36	7.51	0.014* (0.0076) [1.39]	11.4
Pea	6.85	10.22	9.36	8.8	0.014NS (0.0117) [1.44]	16.05
Lentil	4.95	7.47	7.49	7.51	0.046*** (0.0106) [4.67]	17.16
Other pulses (*Rabi*)	5.86	5.63	10.00	9.04	0.042** (0.0155) [4.24]	23.87
Zaid						
Black gram (zaid)	2.53	5.68	4.41	5.91	0.037** (0.0174) [3.8]	29.18
Green gram (zaid)	4.67	5.63	6	6.13	-	-
Whole year						
Black gram (All seasons)	5.3	7.97	6.59	10.66	0.018** (0.0068) [1.83]	9.06
Green gram (All seasons)	4.38	5.34	6	5.19	0.04* (0.0216) [4.07]	37.55
Total pulses	5.6	8.52	8.33	9.69	0.029*** (0.0039) [2.98]	5.46

***Significant at 1%, **Significant at 5%, *Significant at 10%, NS Non-significant

Figures written in ( ) and [ ] are standard errors and compound growth rate respectively.

Data for kidney bean was unavailable before 2011. CGR and CDVI of green gram (*kharif*) and green gram (zaid) could not be computed because of inability of log function to take ‘0’ input values.

Table 5: Decomposition of production for the period 2005-10.

Crop	2005-10 Yield effect	2005-10 Area effect	2005-10 Interaction effect
Kharif			
Pigeon pea	48.05	41.39	10.46
Kidney bean	-	-	-
Black gram (*Kharif*)	106.43	-4.39	-2.12
Green gram (*Kharif*)	0.17	89.49	17.37
Moth bean	11.40	72.15	16.47
Horsegram	69.12	21.81	9.02
Black soybean	47.96	36.23	15.83
Other pulses (*kharif*)	151.78	-29.19	-22.43
Rabi			
Chickpea	-117.66	195.00	22.91
Pea	31.11	46.12	22.69
Lentil	180.21	-53.07	-27.02
Other pulses (*Rabi*)	-66.70	175.80	-6.90
Zaid			
Black gram (zaid)	-12568.50	5641.90	7024.50
Green gram (zaid)	72.00	23.35	4.80
Whole year			
Black gram (All seasons)	112.99	-8.82	-4.44
Green gram (All seasons)	2.74	79.78	17.49
Total pulses	87.99	7.90	4.12

Table 6: Decomposition of production for the period 2010-15.

Crop	2010-15 Yield effect	2010-15 Area effect	2010-15 Interaction effect
Kharif			
Pigeon pea	19.39	67.13	13.54
Kidney bean	-	-	-
Black gram (*Kharif*)	286.24	-227.42	40.03
Green gram (*Kharif*)	-27.07	100.71	26.27
Moth bean	-272.80	286.30	86.80
Horsegram	20.64	75.49	4.03
Black soybean	194.95	-87.20	-7.82
Other pulses (*kharif*)	-1.47	101.59	0.11
Rabi			
Chickpea	-145.60	228.43	16.40
Pea	26.93	79.72	-6.71
Lentil	-3.09	103.09	0.28
Other pulses (*Rabi*)	-99.89	112.60	87.40
Zaid			
Black gram (zaid)	30.21	89.81	-20.08
Green gram (zaid)	NA	NA	NA
Whole year			
Black gram (All seasons)	249.13	-182.09	31.53
Green gram (All seasons)	-14.98	102.69	12.69
Total pulses	673.59	-579.02	12.91

enhance crop diversity and restore soil fertility. Another traditional technique known as "Barahanaja" involves the cultivation of multiple crops simultaneously in the same field. According to Gururani (2021), this method is pursued with the objectives of ensuring food and nutritional security, promoting agro-biodiversity and maintaining environmental health.

In Uttarakhand, there are three major pulse-based mixed cropping systems of *kharif* season (Finger millet + Black Soybean, Finger millet + Black Gram, Finger millet + Horsegram) whereas two major mixed cropping systems (Wheat + Lentil, Wheat + Chickpea) are followed in rabi season. Area under all the mixed cropping systems registered negative CGRs indicating declining trends. The decline was stable in all of the cases except wheat + chickpea (Table 8).

Role of pulses in food and nutritional security

In the Uttarakhand state, 27% children below 5 are seen to be stunted, 13.2% wasted and 21% underweight. It was reported that 13.9% women and 16.2% men had BMI below normal and 58.8% children below 5 and 42.6% women in reproductive age were anemic.

The Food and Nutrition Insecurity Atlas for Uttarakhand 2019-20 as released by Directorate of Economics and Statistics (2023a) states that out of 13 districts 9 districts each were food and nutrition insecure, respectively. Analyzing the status of pulses, it was reported that the per capita net production of pulses was very low in the state. It was 10.44 g/day as against the ICMR norms of 40 g/day. This indicates the low availability of pulses. On the other hand, the per capita consumption of pulses was 52 g/day reflecting good accessibility. The average intake of pulses (g/day) for adults was reported to be 59. But these data were compared to previous set norms of 40 g/day, which has currently revised and therefore there is a need to redefine the availability and accessibility of pulses in the light of the new RDA guidelines which recommend 80 g/day of pulses for a sedentary man and 60 g/d for sedentary woman.

It was seen that only 57 per cent consumed pulses on the daily basis in the state. A 26.6 per cent consumed

Table 7: Decomposition of production for the period 2015-20.

Crop	2015-20 Yield effect	2015-20 Area effect	2015-20 Interaction effect
Kharif			
Pigeon pea	133.29	-23.08	-10.19
Kidney bean	37.96	54.16	8.01
Black gram (*Kharif*)	99.91	0.05	0.03
Green gram (*Kharif*)	-8.16	142.27	-34.13
Moth bean	4.55	107.43	-4.22
Horsegram	38.34	55.70	5.83
Black soybean	18.38	77.43	4.28
Other pulses (*kharif*)	28.33	93.52	-21.85
Rabi			
Chickpea	-61.70	180.35	-18.34
Pea	-15.14	122.65	-7.34
Lentil	1.30	98.56	0.26
Other pulses (*Rabi*)	-0.53	111.16	-10.62
Zaid			
Black gram (zaid)	68.08	23.75	8.08
Green gram (zaid)	-2.43	100.34	2.09
Whole year			
Black gram (All seasons)	99.65	0.15	0.09
Green gram (All seasons)	78.82	11.90	-1.60
Total pulses	45.10	47.15	7.71

Table 8: Compound growth rate and cuddy della valle instability index of area under pulse-based mixed cropping systems.

Pulse-based Mixed cropping system	2005	2010	2015	2018	CAGR (per cent per annum)	CDVI (per cent)
Finger millet + black soybean	13039	11134	10999	9309	-0.017*** (0.0037) [-1.72]	5.55
Finger millet + Black gram	14644	12807	10239	6090	-0.053*** (0.0069) [-5.14]	8.99
Finger millet + Horsegram	8289	7760	6065	5012	-0.032*** (0.0049) [-3.15]	6.87
Wheat + Lentil	10875	7228	5253	3023	-0.074*** (0.0103) [-7.13]	14.27
Wheat + Chickpea	234	550	202	234	-0.015NS (0.057) [-1.53]	66.91

pulses twice/thrice a week and 14 per cent once a week. The protein intake at the state level was 78g/CU/day/ individual as against the RDA of 60 g. However, this was true for only 69 percent of the cases whose average protein intake was more than or equal to the RDA (60 g). Rest 31 per cent intake was less than the RDA *i.e.* deficient in protein intake. Almost one-third of population is lacking in protein intake in the state. This has to be explored from the lens of bioavailablity of protein from the food sources as being vegetarian could be one of the possible reasons. Plant protein has lower digestibility and quality compared to the animal protein sources owing to presence of antinutritional factors and imbalance of amino acids. As per the Sample Registration Survey Baseline 2014 statistics, conducted by Saxena (2016) on 27 per cent of population in Uttarakhand were reported to be vegetarian, which means that animal source protein is not included in their daily diet and therefore may be the reason for protein deficiency. Also, low availability of pulses may have contributed to the protein deficiency. Inflation in prices of pulses adversely affecting the affordability could be another probable factor.

Nonetheless, the recent ICMR (2023) guidelines set the RDA for protein at 54 g for men and 46g for women and this opens the room to reassess the state of pulses and protein intake on the basis of new guidelines.

CONCLUSION

In this study, dynamics of area, production and yield of pulses along with their diversification, production decomposition and proportion in gross sown area were studied. Although the area under pulses and production of pulses is showing satisfactory growth, but probing into availability, accessibility and absorption of protein rich pulses, especially for vegetarians in the state is required as still there are 9 districts in the state which show food insecurity as well as nutritional insecurity at various levels. The decline in area under all major pulse-based cropping systems implies that there is scope to reap more benefits of pulse-based cropping systems as part of a holistic approach towards ensuring sustainability and food security. Also, the various government policies and schemes to attain food and nutritional security in the state are faring well but it needs to be complemented with nutritional awareness component. Reviving the traditional method of cropping and consuming pulses in hilly terrains is necessitated. Encouraging an integrated farming approach suitable for hills as well as plains to curb the demand-supply gap is the need of time.

Conflict of interest

All authors declare that they have no conflict of interest.

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