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Pulses Based Cropping System under Changing Climate in Pakistan

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Abstract
Climate change threatens inclusive amount and cost-effective security of pulse crops. The declining import and availability of pulses emphasize that there is a bigger need for pulses than there is for production. Due to the restricted number of themes available, Pulse's integrated cropping algorithms are the only method used to enrich fabricated stories. There is a better output at the geographical and secular aspects. Intercropping, sequential cropping, sundry cropping, relay cropping, and Paira/utera cropping are all parts of the cropping system used with the above pulses. Together with partner crops, they strive for sunlight, area, long-lasting comfort, and open nutrients. They enhance soil qualities and reduce disease and creepy-crawly occurrence. The statement branch of pulses in the agricultural module consists of soil hydrogen fertilization, encouraging soil

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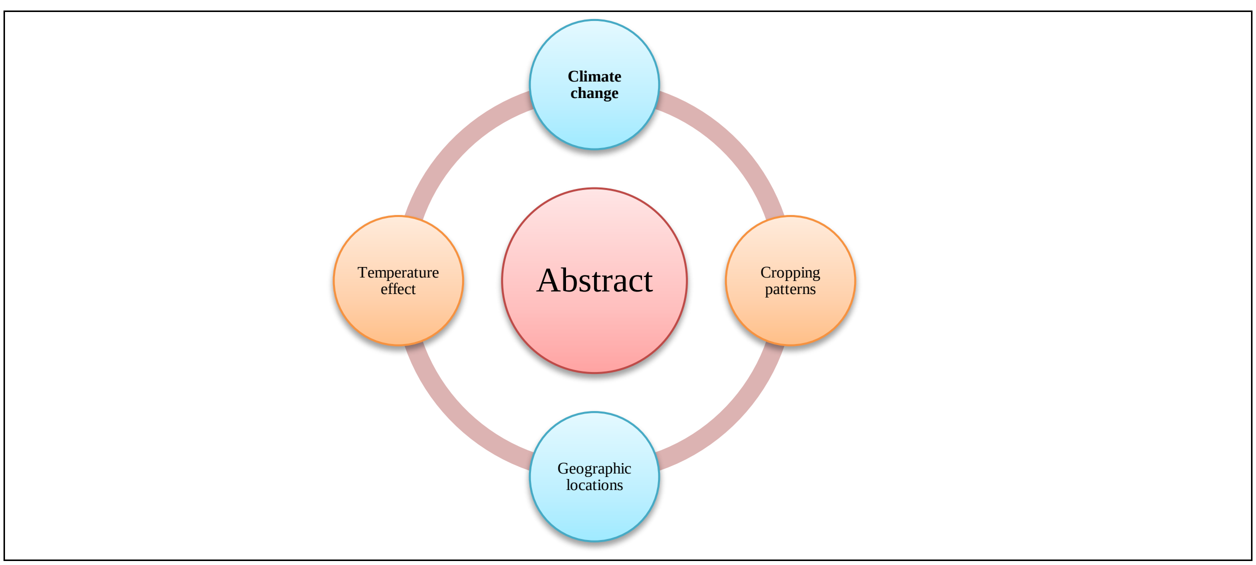
biodiversity, resting atmospheric nitrogen in the soils, dejected hose down footprint, and height carbon cheating capacity. They provide employment options for women because they are easy to raise. Pulses guarantee farmers a profit-making income. A potential, long-lasting, and economic liquid is now present in these feasible seeds for a buck. Over the past 60 years, there has been a general warming of the northern Great Plains' climate. The warming trend does have accelerated both temporally and regionally, puzzling trend analysis for climate indicators like a longer mounting season. Amendment in rain has been still further variable. Despite this variance, current trends in high temperatures and rain generally correlate with the government of expected climate change. The need for researching agricultural adaptation to climatic variations is reinforced by the synchronicity of current and emerging trends. Our article is listening carefully to the durability of pulse plants inside Great Plains in the north and the effects of climate change, focusing on improving and increasing yield in response to heat and moisture, as well as the environment limits and distinguish their geographical positions. In terms of preparing for climate change scenarios, it is difficult to predict pulse crops' tolerance to present meteorological conditions extremes including deficiency, surplus water, temperature, cool erode throughout grain stuffing, and severe chill. Skin talked on how increased CO_2 fertilization affects how efficiently crops use water, how senior circulating temperatures accelerate the growth tax, and how to quantify crop failures due to increased occurrence and degree of come through extremes. Pulse crops should be planted first, frost pulses should be worn out, crops should be sequenced during crop rotations, and the microclimate should be altered, for example, by guiding plantings into ranking stubble. The trimmed stalks of cereal plants which are still sticking out of the ground after the grain has been harvested are called as Stubble.

Key words: Pulses, cropping system, climate change, adoption and mitigations to climate change

Fig 1: Pulses behavior according to climate and geographic locations



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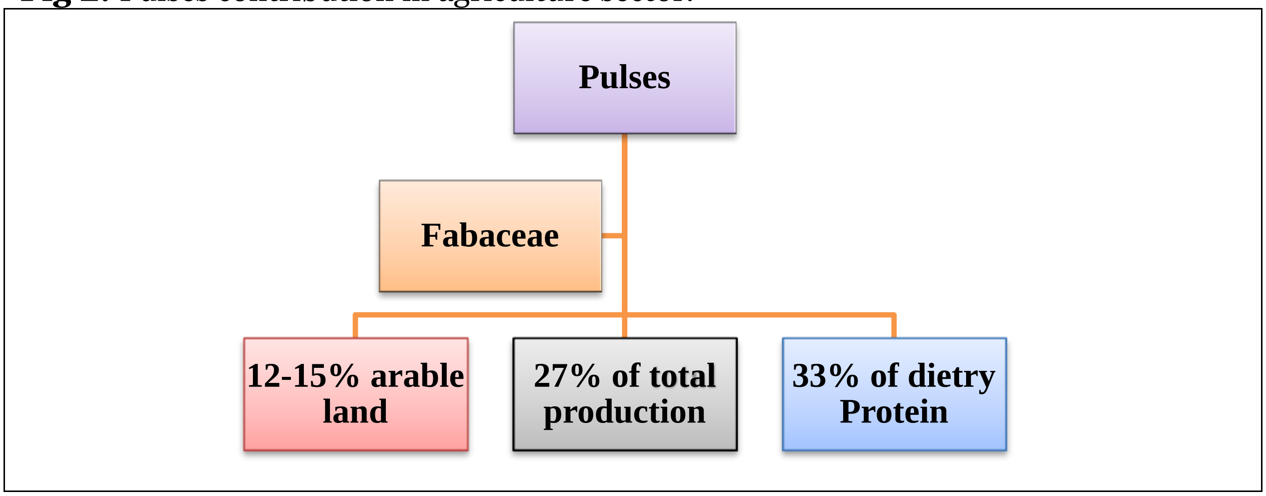
Introduction

Grain plants of the Fabaceae family include pulses. These provide the general people with more affordable alternatives of nutritious protein (Aguilera et al. 2013), they also have a big impact on farming ecosystems by symbiotically (fixing nitrogen) (Siddique et al. 1999; Rubiales and Mikic 2015). According to Mishra et al. (2014), globally, legumes yield 27% of all crops and offer 33% of dietary protein on 12–15% of arable land (fig 2). Because they are a fantastic form of protein, beans are a staple diet for millions of people and animals.

Fig 2: Pulses contribution in agriculture sector.



Pulses were marketed as nutrient-rich seeds for better growth after the United Nations designated 2016 as the Global Year of Pulses (fig. 3) (FAO 2016). Pulses are produced on 5.48 million ha of land worldwide, yielding 6.31 million tons at a rate of 1152 kg per ha (fig 3). However, grains are farmed on nearly 10 times more land worldwide than pulses, which makes pulses a secondary crop (Cernay et al. 2016). The global average for

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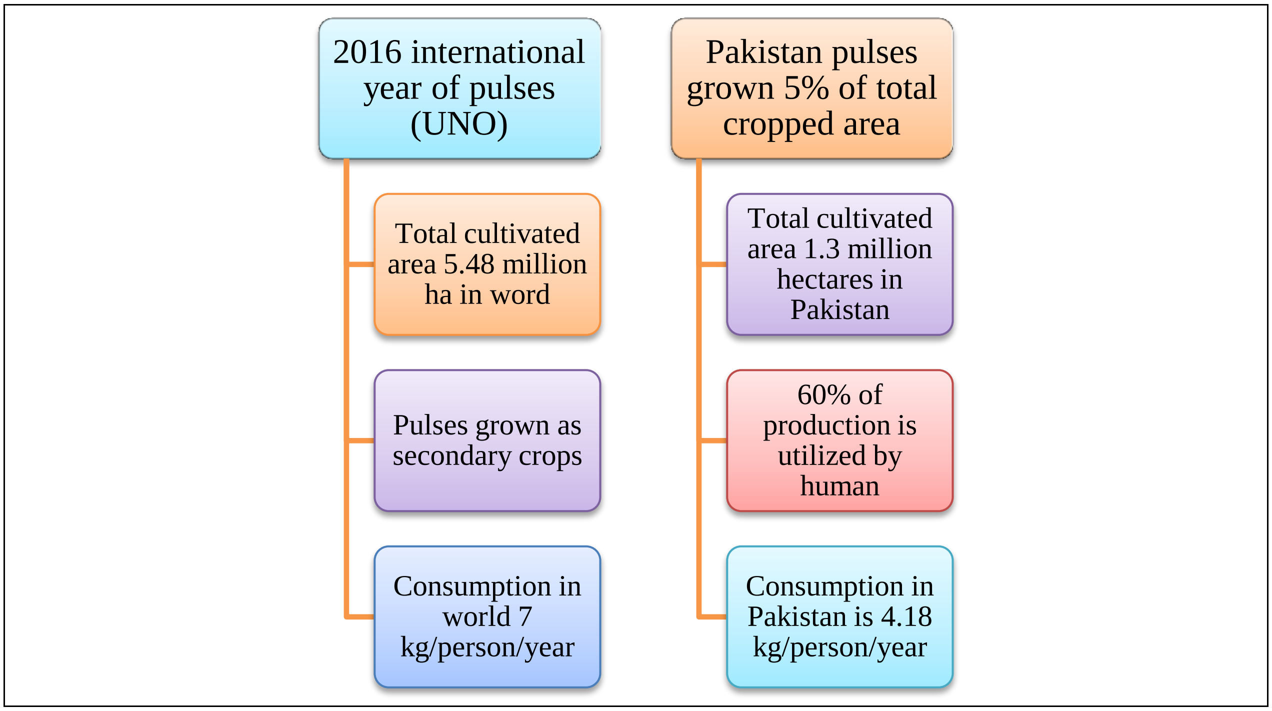

pulse usage is 7 kg/person/year (fig. 3) (available at https://www.fao.org/pulses-2016). There are 1.3 million hectares of important pulse crops growing throughout Pakistan. According to NARC 2017, 5% of Pakistan's cropland is used to grow pulses, and the population of world consumes over than 60% of the harvest, or 4.18 kg per person annually.

Fig 3: Pulses production and consumption in world and Pakistan

Lentil (Vigna radiata L. Wilczek), mungbean (Vigna arietinum L.), and chickpea (Lens culinaris Medic.), and mash bean are the chief pulse crops sown in Pakistan (Vigna mungo L. Hepper). [Vigna unguiculata L.] cowpea Pigeon pea [Cajanus cajan L. Walp]. Faba bean [Vicia1 3faba L.], Vigna aconitifolia (Jack) Merechal, and common bean (Phaseolus vulgaris L.) are further minor pulses (NARC 2017). Between 15% and 30% of grains and pulses are protein-rich (Hall et al. 2016). For example, protein content in chickpeas ranges from 17 to 19% (fig 4) (Cai et al. 2002; Sreerama et al. 2012); lentils from 23 to 31% (fig 4) (Fouad and Rehab 2015; Ghumman et al. 2016); mungbean from 21 to 31% (fig 4) (Anwar et al. 2007); and mashbean from 21-28% (fig 4) (Mashbean et al. 2016). (Kole et al. 2002). Pulses can aid in the recovery of damaged soils by biologically fixing nitrogen, mobilizing nutrients like phosphorus, adding organic compounds via root biomass and leaves drop, reducing land degradation through cover, and promoting the formation of aggregate particles through denser root systems (Venkateswarlu et al. 2007; Ganeshamurty 2009).

Fig. 4: Protein contents in different kind of pulses.

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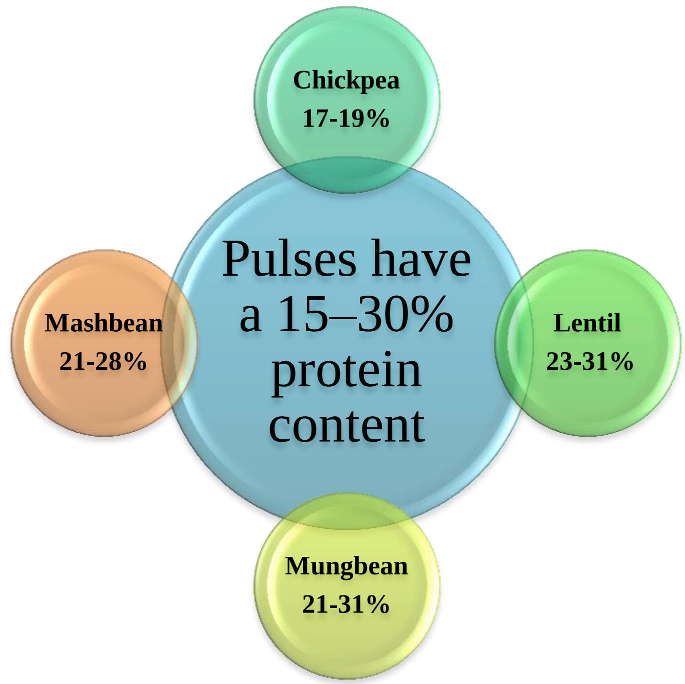

The main reasons for Pakistan's low pulse yield include a lack of genetic transformation and seed logistics operations, as well as abiotic factors like a dry spell, high temperatures, acidity, and cold, as well as biotic stresses like weeds, disease, and insect infestation as well as soil-related issues like growing on marginal soils with excessive pH, poor organic materials, low humidity, and high erosion. Additionally, pulses are replaced with main crops (cereals) in Pakistan because they are regarded as minor crops, which reduces the area planted in pulses and their overall yield. In addition, post-harvest losses, marketing (no-support pricing) restrictions, a shortage of agricultural equipment (for sowing, irrigation, plant protection, and chemical fertilizer), and post-harvest losses are obstacles to obtaining the requisite production levels for pulses. Another problem is climate change, which frequently causes droughts, heat waves, unpredictable rainfall, and seasonal changes.

In Pakistan, the Thal Desert (which includes the districts of Jhang, Mianwali, Khushab, Bakhar, and Layyah) (fig 5) and the Barani region (which includes the districts of Chakwal, Attack, Jhelum, Narowal, and Rawalpindi), are the two main areas for the production of pulses (fig 5). Crop success in the two growing areas mentioned above depends on rainfall frequency. Over the last five decades, there has been a decline in the region and the growth of mung beans, mash beans, chickpeas, and lentils due to disease invasive species, insect pests, marketing issues, a lack of farm equipment designed specifically for these crops, altered rainfall pattern, heat waves, and low productivity. Due to their higher yield capability and superior financial returns compared to pulses, farmers prefer to cultivate other crops like cotton (Gossypium hirsutum L.), wheat (Triticum aestivum L.), and cotton.

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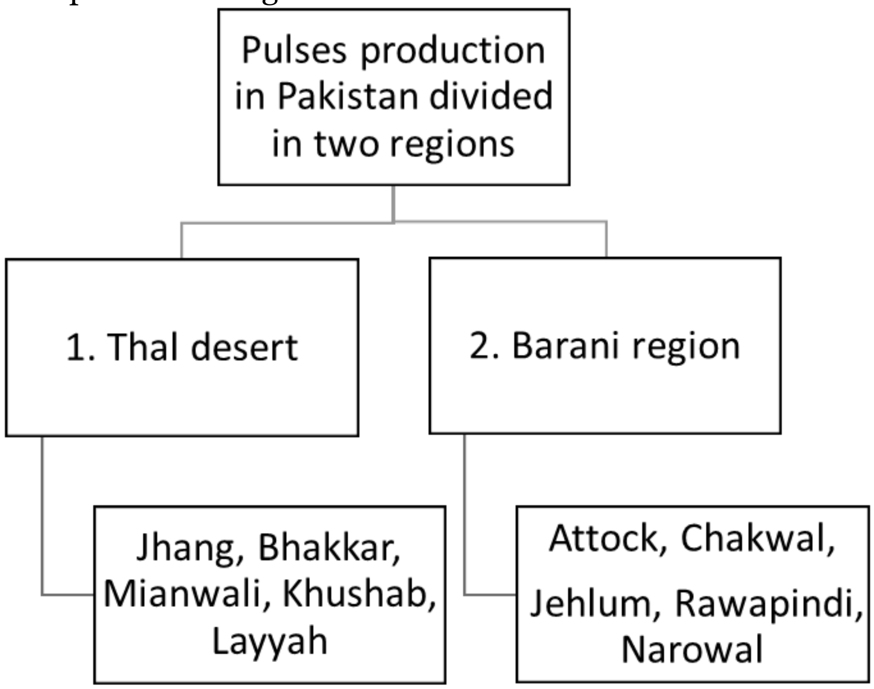
Fig. 5: Pulses production regions of Pakistan.



To satisfy the necessary needs of the nation, there are chances to boost the production of pulses. The most promising strategy in this area is crop improvement (creating early ripening, drought, heat, and disease resistance types). The production can also be improved by expanding the land under pulses, cultivating pulses as catch and intercrop crops (horizontal techniques), improving the seeds, and developing and disseminating a site-specific portfolio of production technology (vertical approaches).

Pakistan's current pulse situation

Pulses are farmed on 1.5 Mha of an area in Pakistan. The primary summertime pulse crop is mungbean, and the main wintertime pulse crop is chickpea. Mungbean covers 16% of the acreage used for pulse production, but chickpea uses 73% of that space and yields 76% of the total amount produced. However, each lentil and mash bean are cultivated on 5% of the land used to grow pulses, and they only provide 5% of the total (NARC 2017).

Chickpea

The main pulse crop and dietary protein source in Pakistan is the chickpea. It contributes significantly to the country's poor majority's access to nutritional security. Due to a growing population and decreased supply, chickpea demand has grown dramatically during the past few years. Pakistan must import chickpeas (also known as Kabuli) from Canada, Turkey, and Australia. In a rainfed agriculture system, chickpeas are grown. Worldwide scenario of chickpea production is discussed in (Table 1). Chickpea and mungbean production are the main sources of pulses; when these crops fail, there is a crisis in the country's pulse supply. It is grown on over 2.2 million acres of

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land in Pakistan. Thal consists of Mianwali, Bhakkar, Layyah, Khushab and Jhang (partly). Thal produces more than 80% of the nation's supply of chickpeas, with the other 20% being cultivated elsewhere (Faisalabad's Pulses Research Institute).

Table. 1: Worldwide production and yield of chickpea. (FAO Stat. 2018)

Country	Area (Lakh ha)	% Cont.	Country	Prod. (Lakh mond)	% Cont.	Country	Yield (mond/ha)
India	118.99	67	India	2580.94	66	Ethiopia	53.45
Australia	10.75	6	Australia	226.34	6	Mexico	45.25
Pakistan	9.77	5	Turkey	142.88	4	Canada	44.22
Russ. Fed	8.19	5	Russ. Fed	140.61	4	USA	42.37
Turkey	5.14	3	USA	131.08	3	Myanmar	34.6
Iran	5.01	3	Ethiopia	117.02	3	Spain	32.37
Myanmar	3.68	2	Myanmar	115.66	3	Turkey	30.62
USA	3.41	2	Mexico	79.83	2	Argentina	26.75
Ethiopia	2.41	1	Pakistan	73.25	2	Tanzania	23.72
Mexico	1.94	1	Canada	70.53	2	Australia	23.20
Others	8.84	5	Others	220.89	6	India	23.90
World	**178.5**		**World**	**3899.03**		**World**	**380.45**

Pakistan's primary pulse crop, chickpea, is cultivated on 73% of the country's pulse-growing land (fig 6). Chickpea (fig. 6) production is only profitable in the Thal Desert due to low production and a shortage of irrigation water. However, under water stress in underdeveloped areas of the Thal Desert, chickpea generates a respectable yield (NARC 2017). The average yield of chickpeas throughout the previous five decades—1970–1980, 1981–1990, 1991–2000, 2001–2010, and 2011–2019—was, respectively, 501, 616, 636, 678, and 670 kg ha1. Despite being the third-biggest grower of chickpeas after Australia and India (FAO 2014), Pakistan's output falls short of the country's needs. Varieties of chick pea is mentioned in table 2.

Table. 2: Different varieties of chick pea that is being sown in Pakistan

Sr. No.	Name of Variety	Releasing Year	Time of Sowing	Potential yield (mound/acre)
1	**Butal-2016**	**2016**	**15oct-10nov**	**40**
2	**Niab CH-2016**	**2016**	**15oct-10nov**	**37**
3	**Bhakar-2011**	**2011**	**15oct-10nov**	**35**
4	**Punjab-2008**	**2008**	**15oct-10nov**	**35**
5	**Punjab-2000**	**2000**	**15oct-10nov**	**34**

Lentil

Lentils are Pakistan's second-largest crop of winter pulses (fig 6). It is cultivated in 5% of the area used for pulses (fig. 5). (NARC 2017). Worldwide scenario of lentil

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production is discussed in (table 4). Pakistan's production of lentils in 2019 was 5,957 tons, according to (FAO stat). This is a decrease of 6.22% over the prior year. The average yield of lentils per hectare was 307, 449, 526, 554, and 545 kg across the five-decade span (1970–1980, 1981–1990, 1991–2000, 2001–2010, and 2011–2019), respectively. Recommended varieties of lentil is given in table 3.

Table.3: Different varieties of lentil that is cultivated in Pakistan

Sr. No.	Name of Variety	Releasing Year	Time of Sowing	Potential yield (mound/acre)
1	**Punjab Masoor-2020**	**2019**	**15 Oct-15 Nov**	**29**
2	**Punjab Masoor-2019**	**2019**	**15 Oct-15 Nov**	**25**
3	**Chakwal Masoor-2011**	**2011**	**1st Oct-15 Oct**	**20**
4	**Punjab Masoor-2009**	**2009**	**15 Oct-15 Nov**	**23**
5	**Masoor-93**	**1994**	**15 Oct-15 Nov**	**22**

Table. 4: Worldwide production and yield of lentil. (FAO Stat. 2018)

Country	**Area** (Lakh ha)	**% Cont.**	**Country**	**Prod.** (Lakh mond)	**% Cont.**	**Country**	**Yield** (mond/ha)
India	22.15	36	Canada	474.45	33	China	64.17
Canada	14.99	25	India	367.40	26	France	36.05
Kazakhstan	2.95	5	USA	86.40	6	Ethiopia	35.22
USA	2.91	5	Turkey	80.05	6	Canada	34.87
Turkey	2.59	4	Australia	57.83	4	Turkey	34.02
Russ. Fed.	2.48	4	Kazakhstan	57.60	4	USA	32.82
Australia	2.29	4	Nepal	56.47	4	Nepal	31.40
Nepal	1.99	3	Russ. Fed.	44.22	3	Bangladesh	28.55
Bangladesh	1.55	3	Bangladesh	40.14	3	Australia	27.87
Iran	1.47	2	China	39.00	3	Kazakhstan	21.52
Others	5.65	9	Others	132.67	9	India	18.27
World	**61.01**		**World**	**1436.23**		**World**	**364.76**

Fig 6: Pulses production and contribution to the agriculture sector of Pakistan.

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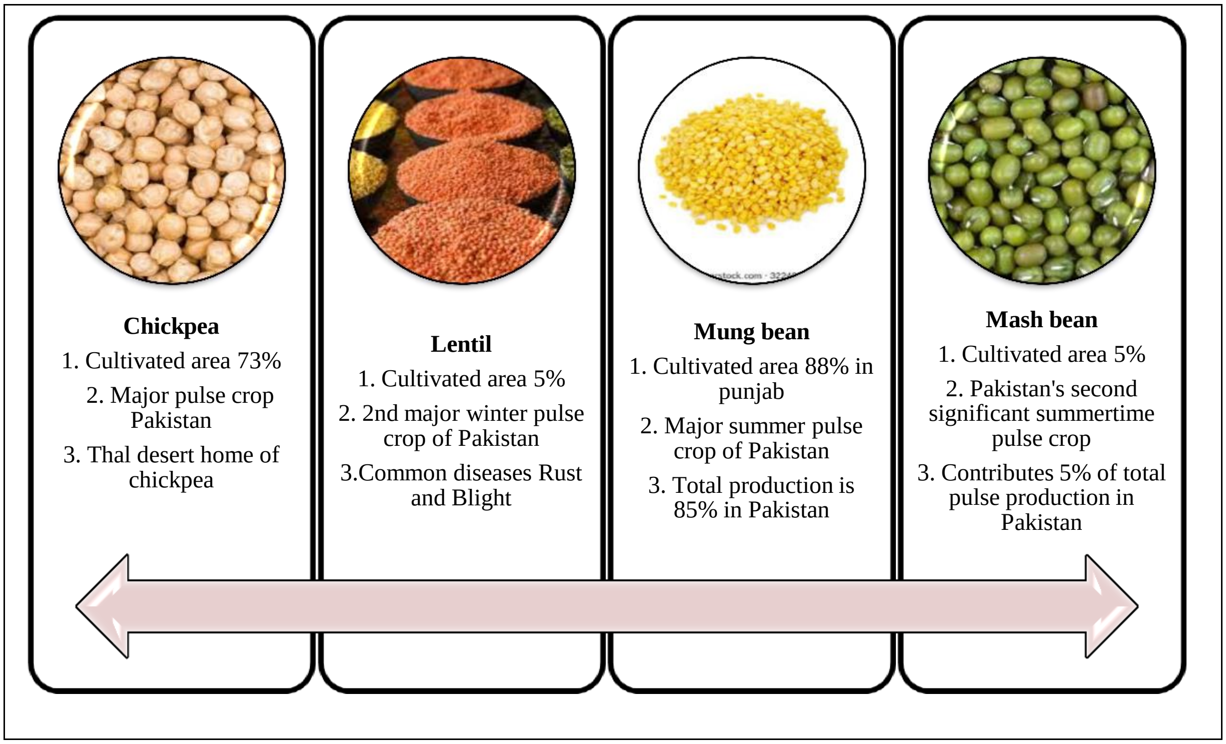

Mungbean

One of Pakistan's important Kharif pulse crops is mungbean. It is primarily grown in the provinces of Sindh and southern Punjab. Punjab is the main province for mungbean production, accounting for 80% of both area and output. Punjab produces and consumes enough mung beans on its own. Mungbean is the primary summer pulse in Pakistan. Approximately 88% of the territory in the Punjab province is cultivated with mungbean, which provides for 85% of the nation's overall production (fig 6) (NARC 2017). The average mungbean output in Pakistan for the previous five decades (from 1970 to 1980, 1981 to 1990, 1991 to 2000, and 2011 to 2019) has been 465, 498, 518, 597, and 598 kg per ha. Varieties of mung bean is mentioned in table 5.

Table. 5: Varieties of mung bean that are cultivated in Pakistan

Sr. No.	**Name of Variety**	**Releasing Year**	**Time of Sowing**	**Potential yield (mound/acre)**
1	**NIAB Mung-2021**	**2021**	**15 Apr-20 May**	**26**
2	**AZRI Mung 2021**	**2021**	**15 Apr-20 May**	**27**
3	**PRI Mung-2018**	**2018**	**15 Mar-30 Mar 1st May-15**	**21**

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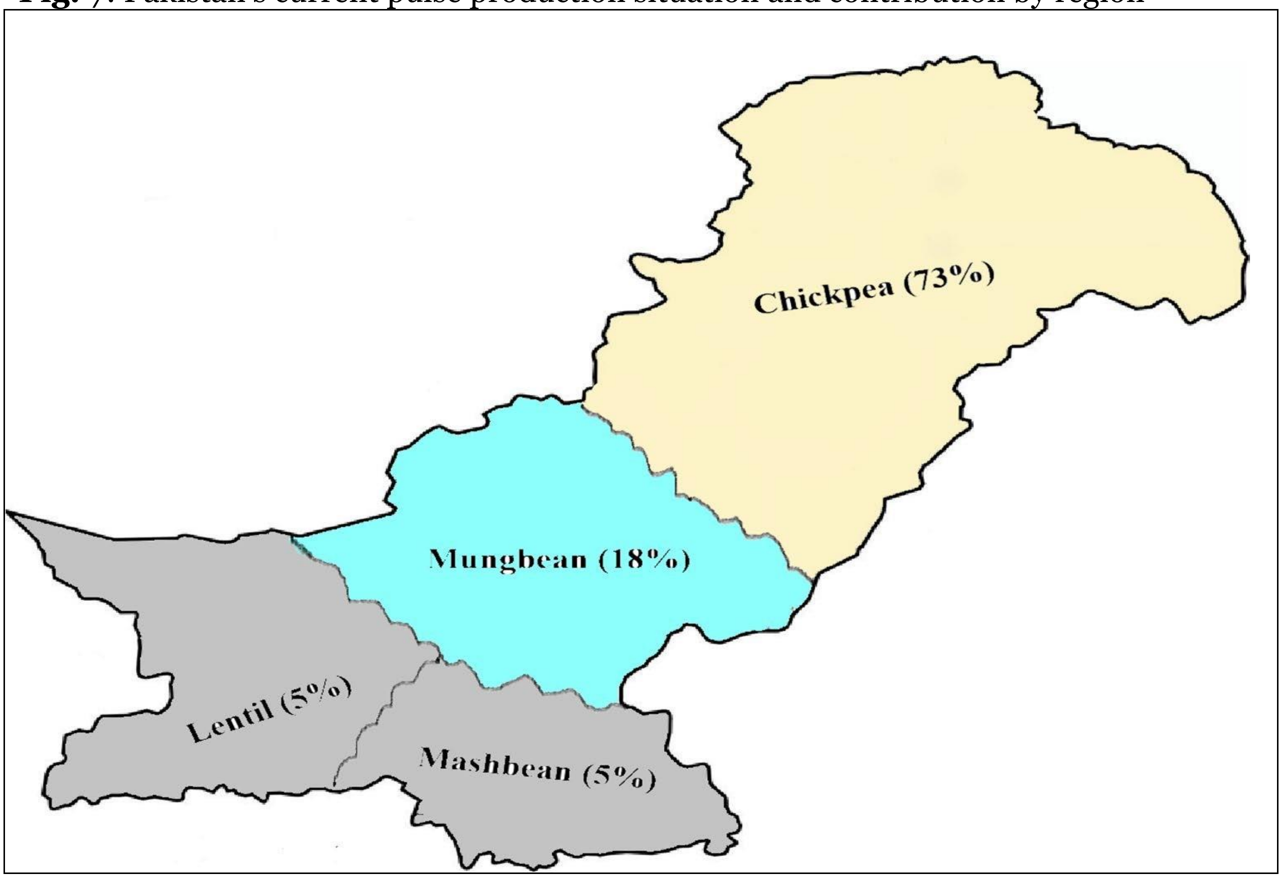
			June	
4	AZRI Mung-2018	2018	15 Apr-20 May	26
5	BWP Mung-2017	2017	15 Apr-20 May	25
6	NIAB Mung-2016	2016	15 Apr-20 May	27
7	NIAB Mung-2011	2011	15 Apr-20 May	25

Fig. 7: Pakistan's current pulse production situation and contribution by region



Mashbean

Mash bean is Pakistan's second-largest summertime pulse crop (fig. 6). It accounts for 5% of the country's overall pulse yield and is cultivated on 5% of the nation's overall pulse-growing region (fig 6). The main factors contributing to the low output of mash beans include a lack of high-yielding cultivars, cultivation on poor soils, and antiquated production machinery. The annual production of mash beans per hectare stayed at 479, 565, 610, 636, and 676 kg/ha for the last five decades (1970–1980, 1981–1990, 1991–

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2000, and 2011–2019), respectively. But the amount produced falls short of what the nation requires. Mash bean varieties are mentioned in table 6.

Table. 6: Different mashbean varieties sowing in Pakistan

Sr. No.	Name of Variety	Releasing Year	Time of Sowing	Potential yield (mound/acre)
1	**Arooj-11**	**2011**	**15 Mar-30 Mar 1st May-15 June**	**19**
2	**Mash-Chakwal**	**2000**	**1st June- Mid July**	**16**
3	**Mash-97**	**1997**	**15 Mar-30 Mar 1st May-15 June**	**16**
4	**Mash-88**	**1990**	**15 Mar-30 Mar 1st May-15 June**	**15**

Other Pulses

On a lower scale, Pakistan also cultivates other pulses such as pigeon pea (Cajanus cajan L. Millsp.), cowpea (Vigna unguiculate (L.) Walp.), common bean (Phaseolus vulgaris L.), moth bean (Vigna aconitifolia (Jack) Marechal), and Faba bean (Vicia faba L.). Pulses are grown in the summer on a 3.5 10-3 Mha area, yielding 2.7 10-6 Mt, and in the winter on a 4.0 10-4 Mha area, yielding 2.0 10-6 Mt (https://www.pbs.gov.pk). Worldwide production of field pea is mentioned in table 7.

Table. 7: Worldwide production and yield of field pea. (FAO Stat. 2018)

Country	**Area** (Lakh ha)	**% Cont.**	**Country**	**Prod.** (Lakh mond)	**% Cont.**	**Country**	**Yield** (mond/ha)
Canada	14.31	18	Canada	812.15	26	France	82.52
Russ. Fed	13.86	18	Russ. Fed	522.53	17	Germany	69.7
China	10.00	13	China	345.86	11	Canada	62.55
India	9.98	13	India	208.65	7	USA	55.25
Ukraine	4.26	5	Ukraine	175.99	6	Lithuania	50.30
USA	3.27	4	USA	163.97	5	Ukraine	45.5
Australia	2.91	4	France	139.70	5	Spain	44.05

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Ethiopia	2.31	3	Ethiopia	85.04	3	Russ. Fed	41.57
Tanzania	1.99	3	Australia	71.89	2	Ethiopia	40.62
Others	15.90	20	Others	543.63	18	India	23.07
World	**78.78**		**World**	**3069.41**		**World**	**515.13**

Table. 8: lists the varieties of chickpea and mungbean grown in Punjab, Pakistan.

Site names	Cultivars	
	Chickpea	Mungbean
Rahim Yar Khan	Buttel-2016, Bhakkar-2011, Punjab-2008	NIAB Mung-2016, NM-2021, Niab Mung 2011
Bahawalpur	Noor-2013, Taman-2013, NIFA- 2005, CM-2008	AZRI Mung-2006, Azri Mung-2018, BWP Mung-2017
Bahawalnagar	Noor-2013, Niab CH-2016, Punjab-2008, Bhakkar-2011	Bahawalpur Mung-2017, Azri Mung-2021, Niab Mung-2011
Multan	Buttel-2016, Noor-2016, CM-2008, Noor-2013	NIAB Mung-2011, PRI Mung-2018, Chakwal Mung-6
Layyah	Punjab-2008, Noor-2009, Taman-2013, Balkassar-2000	AZRI Mung-2018, Abbas Mung, Niab Mung-2021
Jhang	Niab CH-2016, Bhakkar-2011, Noor-2009, Wanahar- 2000	PRI Mung-2018, Niab Mung-2011, BWP Mung-2017
Faisalabad	Noor-2013, Thal-2006, CM-2008, Punjab- 2008	Niab Mung-2021, Chakwal Mung-6, Azri Mung-2018
Bhakkar	Bhakkar-2011, CM-2008, Noor-2009, Taman-2013	NIAB Mung-2016, Niab Mung-2011, PRI Mung-2018
Narowal	CM-2008, Punjab-2008, Niab CH-2016, Tamman- 2013	Niab mung-2021, Azri Mung-2021, Pri Mung-2018
Khushab	Bittle-2016, Punjab Noor-2009, CM-2008	BWP Mung-2017, NM-2011, Chakwal Mung-6
Gujrat	Noor-2013, Butal-2016, Punjab-2008, Cm-2008	Niab Mung-2021, ChakwalMung-6, Niab Mung-2011
Mianwali	Bhakkar-2011, NIAB CH-2016, Taman-2013, Noor-2009	Chakwal Mung-6, NM-2006, Abbas Mung, Pri Mung-2018
Chakwal	CM-2008, Bhakhar-2011, Noor-2011, Bittle-2016	Chakwal Mung-6, Dera Mung, Niab Mung-2021
Jhelum	Punjab-2000, Punjab-2008, Thal-2009, CM-2008	BWP Mung-2017, AZRI Mung-06, Abbas Mung
Rawalpindi	CM-2008, Niab CH-2016, Noor-2013, Noor-2009	Azri Mung-2021, Chakwal Mung-2006, Chakwal Mung-6

Classification of pulses on basis of its characteristics

i. A cropping system is made up of a mix of crops for both time and position. Any system's objective is to give the farmer a sizable and long-lasting balance of profits. Pulse crops are employed as a cut-up crop in several farming systems due to their exceptional characteristics (fig 8).

ii. Pulses excellently accommodate numerous multiple, relay, mixed, and intercropping systems, as well as a large range of crop periods and various evolving habits. In many intercropping systems, long-lasting pulses are employed as the primary crop in place of pigeon peas. Brisk-duration pulses like young gram, black gram, cowpea, and mount gram are appropriate intercrops in intercropping systems as well as sight or component crops in succession cropping systems.

iii. Pulses have the unusual property of repairing and maintaining soil fertility (fig 8). Rhizobium bacteria (micro-symbiont) live in soil nodules in a symbiotic relationship (fig 8) and suspend nitrogen from the atmosphere in the environment to assist pulse crops (macro-symbiont). Conservational gram, black gram, stallion gram, cowpea, pea, lentil, and pea all produce an average of 38.6, 42.9, 30.4, 56.3, 66.5, and 36.7 kg N/ha, respectively. After the crop is harvested, any future crops in the system are free to use the nitrogen that was left over in the soil. Along with N, these crops produce a lot of soil-related compounds.

iv. The system is ravaged by tense, shrieking pulses. They agree to take a position to extract nutrients and moisture from young soil layers. Pulse crops use the chemicals that shallowly rooted crop fields seep down.

v. Pulse roots act as a natural plow by moving downward roughly vertically and opening up to looser, poorer soil layers.

vi. In comparison to cereals, pulses are more tolerant of/resistant to new deficiencies. They don't require nearly as much rinsing as cereals do. Rice, wheat, maize, jowar, and ragi are examples of cereals that can be grown with 1000, 400, 550, 450, and 500 mm of water, respectively. The following pulses should be grown: young gram, black gram, Bengal gram, mount gram, cowpea, and pigeon pea. The water levels should be 150, 150, 150, 200, 200, and 200 mm respectively.

Fig. 8: Exceptional characteristics that a pulse must contain

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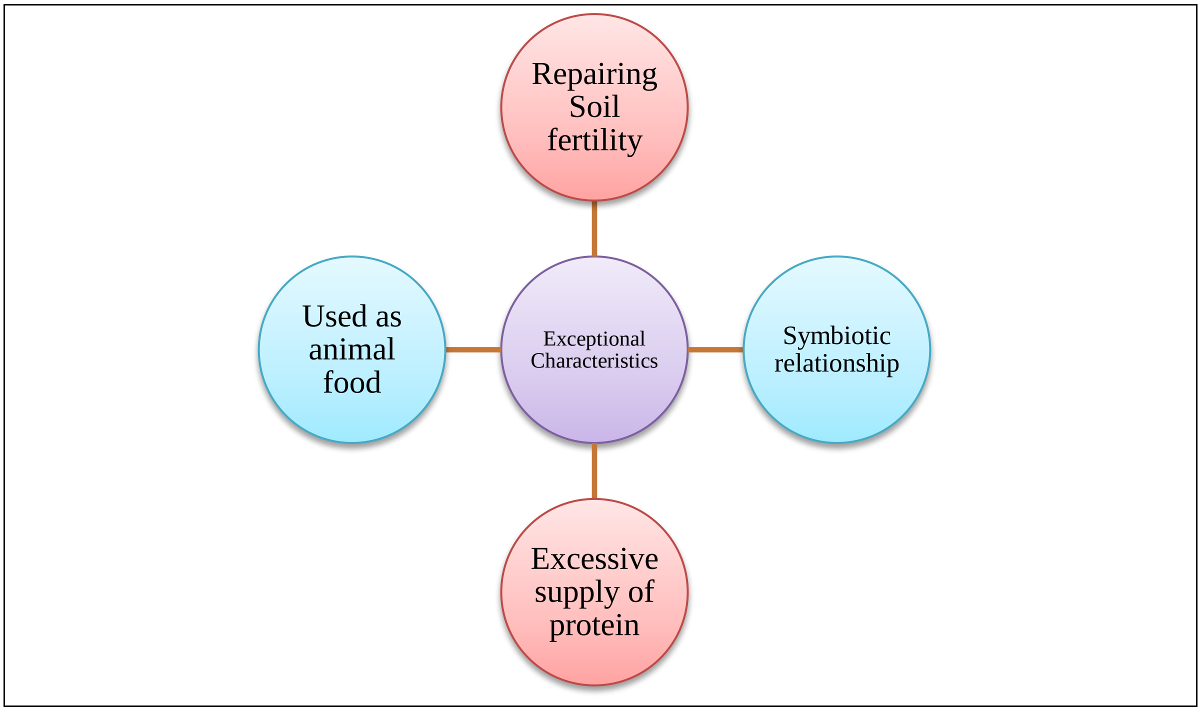

vii. Pulses perform a significant part in animal nutrition supplies and dietary guidelines. Pulses have 20–30% less protein than other grains and are therefore an excessive supply of protein for humans (fig 8). Whereas breakfast cornflakes protein is not sufficiently rich in lysine and a load in methionine and tryptophan, pulse protein is inadequate in S-containing important amino acids like methionine and tryptophan and sufficient in lysine. By combining morning cereal protein with pulse protein, the biological purchase price of proteins rises.

viii. A wide variety of pulses, including peas, beans, and cowpeas, trade in nutritious lime vegetables. They trade in conscientious animal food and cooperative sea country (fig 8).

ix. Pulse crops are developed and utilized as break crops in cropping systems. In some regions, persistently encouraging two rice harvests results in hosepipe down logging, a decrease in the physical, organic, and biological quality of the earth, a deficiency in micronutrients, an uptick in annoyances and diseases, and a continuous decline in system output. In addition to increasing pulse yield, environmentally sound gram/black gram ripening as a transition crop among two rice crops will also improve soil health and increase rice product yield. To improve soil health, intensive farming has a propensity to use pulse crops or emerald dung in cropping systems.

Cropping systems

Crop rotations and sequencing

Crop sequencing in intercrops has the ability to significantly affect subsequent crop output and, as a result, crop rotation profitability as a whole. According to study,

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farmers would advantage from devoting a significant amount of thought to agricultural organization design to better predict the requirements of their specific processes. Through a number of complex interactions with soil water, soil nutrient availability, and disruption of insect cycles, pulse crops in a crop rotation have an effect on wheat output (Miller et al., 2002a). Depending on the crops planted before pulse crops, the years, and the regions, wheat yield responses might vary significantly (Table 9). In general, the information identifies categorized possessions made via prior pulse crop on the following wheat crop, as well as through the preservation of land moisture and/or soil nitrogen. The impact of pulse crops on crop production, however, is composite and poorly unstated.

Table. 9: The higher production of wheat was caused by the pre-filtrate crops. The grain production and protein response of fiery ruby red wheat seeded the next day into fallow, legume stubble, or green wheat stubble were adjusted in three trials in the northern Great Plains (adapted from Miller et al., 2002a).

	Carrington, ND (1999–2002)		Swift Current, SK (1999–2002)		Williston, ND (2000–2002)	
Crop residue	Yield	Protein	Yield	Protein	Yield	Protein
Fallow check	170	119	–	–	126	102
Dry pea	161	114	125	108	101	108
Lentil	131	114	123	108	97	109
Chickpea	146	114	119	108	–	–
Soybean	133	114	–	–	–	–
Spring wheat	100	100	100	100	100	100
High-N control	181	118	–	–	–	–
SE	8	3	5	1	9	4

†At Carrington, rapid existing area, and Williston, respectively, the grain yield average was 1.5, 1.9, and 1.8 Mg ha, and the meager protein levels in grains were 118, 142, and 142 g kg21 for full-fledged skip wheat on mechanism wheat straw. For each wheat plant that was fully matured in Carrington, the medium N compost treatments were 0, 50, and 86 kg N ha21, respectively. The projected 106 kg N per ha21 of High-N manipulation bounce wheat (grown from leap wheat stubble)

For instance, additional N from the earlier pulse crop is only beneficial for the subsequent crop if there is enough moisture to maximize the additional N and anywhere N restricts yield (Miller et al.,2002a). As long as reliable, improved agronomic practices are employed, such as weed, disease, and pest control, and wise sowing to produce a crop that is superior to the competition, morphological traits with ongoing stream accessibility designs, farmers can brag long-term assured yield and lucrative payback.

Dry pea, chickpea, and lentil cropping systems may be favorable for crop diversification in the dried-out semiarid grassland (Miller et al., 2001). According to Miller et al., pea

grain yields on uninteresting soil were effectively reduced to an average of 103% of adult wheat yields on unimaginative soil and 135% of mature wheat yields on wheat stubble (2001). Chickpea, lentil, and bitter pea all produced 76, 77, and 90% of their fallow-field yields once they were established on stubble, demonstrating that pulse crops have considerable potential for expanding cropping systems in the dry semiarid pampas by replacing summer fallow in crop rotations. Given that wheat produced just 66% of fallow-field yields when grown fully on wheat stubble, wheat is not as well-suited to farming on wheat straw as the pulse crops. Dehydrated peas consumed 107% less water on stubble than they did on fallow ground, as opposed to 84%, 81%, and 84%, respectively, for chickpeas, lentils, and wheat on stubble.
According to Miller et al. (2002b), Wheat grain yield reached a record high during the period it was produced on pulse crop stubbles, but it did not differ from wheat grain yield during the time it was developed properly on oilseed stubbles. Grain protein for wheat adults was superior to that for full-grown wheat on a combination of pulse and oilseed crop stubbles. According to Gan et al. (2003), On the pulse, there is completely developed durum wheat as well as oilseed twigs institute a similar domino effect. Because pulse crop stubbles significantly increased the soil's nitrogen content, the manure N food for canola, mustard, and spring wheat grown on pulse stubble was concentrated to a standard of roughly 15 kg N/ha. In this 5-year drought near immediate Current, Saskatchewan, stubble-related variations in the soil's preexisting irrigation did not affect the wheat crop's analysis in the wetter-than-average conditions.

Single crops

Legumes for cold-climate cooking, including peas, lentils, and chickpeas, are typically more finely tuned to intensity than legumes for warm-climate cooking, like cowpea, pigeon pea, and mung bean. Warmth Stress in pulses during the reproductive phase is by and large associated to pollination failure, flower bud abscission, and buried kick a husk with significant yield loss. The Northern regions of countries will have elevated levels of warming with a balloon in nighttime temperatures as the 21st-century advances. With a changing environment, crops are exposed to new blank carried out and high position evapotranspiration, and the marvel of dew spit is sluggish but undeniably heartbreaking in the northern rainfed areas. For every pulse crop that is dwindling in the category of C3 crops, this carbon fertilization approach is extremely spicy. The dispersion, frequency, and severity of parasites and ailments are all changing due to climate variation, and it is projected that yields in pulses with the C3 apparatus of photosynthesis may increase by 10–25 for both cents little atmospheric CO_2 contact up to the horizontal of 550 ppm. However, the chief atmospheric fever corrections to green components construction produce will adversely alter the physiological processes and productivity (IPCC, 2007). Changes in temperature, irregularities in the amount and distribution of rain, differences in seasonality, the incidence of drought, high CO_2 levels in the air, and other excessive practices mess with insect behavior in a cropping system. Since insects are often poikilotherms, mechanisms like lump and appearance require a novel understanding of temperature. Any stage of environmental fever is horizontal to the direction of the insect activities that are more recent than those of plants and

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superior animals. Gram bradawl (Helicoverpa armigera) has historically been a main pest of pigeon peas in several areas of the nation.

Pigeon pea

Pigeon peas, a crop of good color, won't be made pompous by an increase in ambient temperature. In the partially Zimbabwe's dry tropics in the 21st century, Dimes et al. (2008) estimated yield decreases of 16 percent for both cereals (sorghum and hybrid maize), 31 percent for groundnut, but just 3 percent for pigeon pea, with a frequent formerly a day heat increase of 3.1°C. Worldwide production and yield of pigeon pea is mentioned in the (table 10). If there is excessive rain at this time of sowing, it will impact seed germination. It has an ingrained urge to ascend the paramount. When the crop is at the seedling stage, weeds perform better.

Table. 10: Worldwide production and yield of pigeon pea. (FAO Stat. 2018)

Country	**Area** (Lakh ha)	**% Cont.**	**Country**	**Produ.** (Lakh mnds)	**% Cont.**	**Country**	**Yield** (mnds/ha)
India	55.83	80	India	972.95	72	Philippines	46.425
Myanmar	5.33	8	Myanmar	153.31	11	Malawi	43.575
Tanzania	3.00	4	Malawi	98.65	7	Myanmar	31.75
Malawi	2.50	4	Tanzania	71.66	5	Burundi	28.675
Kenya	1.37	2	Haiti	19.95	1	Dom. Republic	26.90
Haiti	0.89	1	Kenya	19.50	1	Tanzania	26.325
Uganda	0.40	1	Nepal	5.66	0.4	Nepal	24.675
Others	0.62	1	Others	10.43	0.8	India	19.20
World	**69.93**		**World**	**1352.11**		**world**	**247.25**

By planting seeds in wide beds or ridges in skyscraping muzzle locations, the fix is bright and can be prevented. Transplanting seedlings can maintain the ideal deposit populace. The long-established types are gradually becoming fully developed in the ethnic belts of Eastern nations. After the start of the monsoon, the narrow fit in enkindle in Odisha is sowed in June. During the damp season, the crop passes the vegetative growth stage. At I'm sorry, pinnacle and because place take place. The earth is lacking moisture as time draws closer. The good-looking pods result in sparse grain and chaffy. The urban design of the street period varieties is intended to increase yield. If planted in June, the premature cultivars will reach their peak in September or October. A powerful globule will display beautiful spit and box settings. Combat on the peapod crumb graduation day will be postponed immediately due to high excitement and relative humidity. Due to never-ending rain, there are many instances where the introduction of sanctuary chemicals to stop brawl condemnation will be futile. To avoid the developing period coincident with a crucial rainfall, sowing times may be modified or style duration varieties may be fully developed.

Fig. 9: Schematic diagram of single crops

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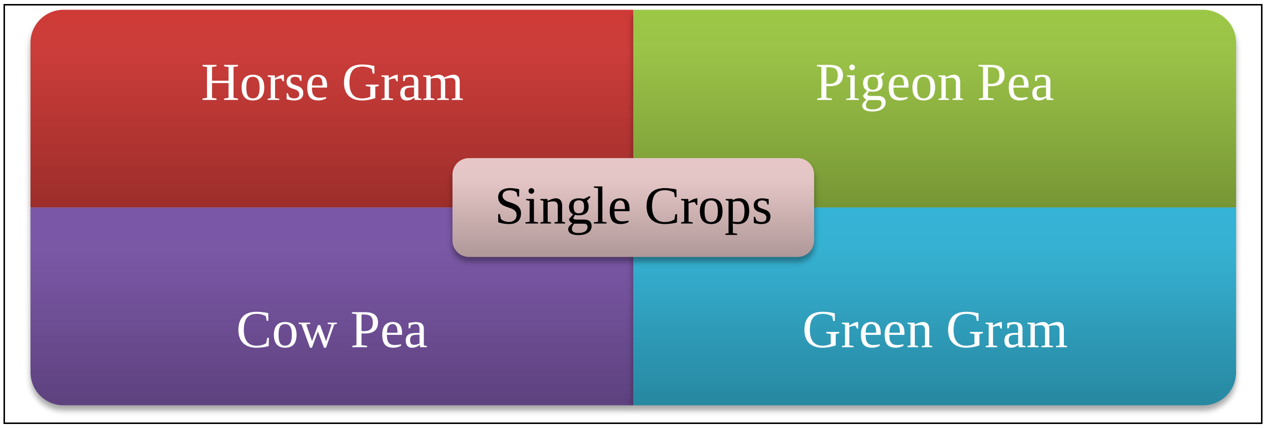

Green gram / black gram

Typical variants frequently include prolonged duration. They are planted following a significant downpour, and once the monsoon has ended, they are collected in October and November. Varieties available now allocate come to live to durations between 60 and 70 days. If these types are sown in June, they will produce the ideal amount of excitement during the foggy season. The reproductive phase will follow a period of heavy rain. There will be few fruits and low height. Attack from the creation will be directed against seeds. Black gram and whole gram are amiable stage crops. These are Kharif crops that are sown. These were sown as rabbi crops in the regions with mild winters. Freezing-resistant/tolerant cultivars are anticipated to be planted and harvested for rabbi crops. According to Baisakh et al. (2013), beneficial kingdom races of emerging gram that came from various regions of Odisha were trained donors for distance tolerance at all phases of cotyledonary exposure to an exaggerated fever of 10 Co. These containers are used to promote types that can withstand cold temperatures.

Cowpea

When compared to low night heat (33/20 ^{o}C), an area of exciting night time temperature (33/30 ^{o}C) enhances the production of minor, dried-out pollen in cowpea (Ahmed et al. 1992). According to (Kumar and Kumar 2015), there is a negative association between aphid populations and peapod crumb with the family element moist and a positive correlation between aphid populations and temperature regulation.

Horse gram

Pony gram is planted as a Kharif crop in regions with trickle-down rain, such as Rajasthan. It is a behind-Kharif crop in Odisha with available flood and stored moisture levels. The types offered at this particular store have a longer duration. At the time of the crest and seed set, they permit damp stress.

1. Breeding to improve experimental varieties and seeding of basic varieties to air journey filled pause of damp discrepancy can both boost productivity.
2. Adding organic manure or complete nutrition to the crop or the crop before it can improve the soil's sustenance capacity.

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Sequence cropping
Rice-green gram
In rice's ecologically conscious gram sequence cropping technique, environmentally friendly gram is grown industrially as a medicinal crop. Immature grain production is dependent on soil moisture retention and patches of variable expression hail. To safeguard the crop from aphid attack and brittle mildew, good tolerant types must be used. To increase organic carbon at a time when it is declining and to cram with tears to increase the soil's capacity, Dinkha in situ maturing's, or a remedy of plenty of organic manuring is intended to be broken in rice.

Rice-field pea/gram
In places of moist retentive heavy soil, sphere peas/gram are mature. These are cool stretch crops, and the necessary succinct funding from top to bottom hotness time will enable their vegetative display to function well. Thermo-insensitive varieties must reach full maturity in order to be productive.

Rice-lentil
The management of nutrients in the previous rice crop affects the system's production. In Varanasi, Maruthi Sankar et al. (2013) reported the best yields of lentils (993 kg/ha) and rice (1704 kg/ha), both utilizing only organic nitrogen.

Intercropping systems
Intercropping is the combining of two or more crops for a constant portion of the benefit. It is the expansion of time and liberty dimensions being cropped. Intercropping has been shown to be more profitable and productive than solitary cropping when left-handed aberrations are present (Willey et al., 1981). This pledge forbids worldwide agricultural collapse due to intolerable locations or nuisance epidemics. During the Kharif season, pulse-based intercropping techniques increase productivity and profitability in the tranquil country of your birth. These technologies increase the full-blown yield for the entire frenzy area throughout the rabbi season, increase native gain garbage efficiency, and inhibit weeds, bug mice, and disease-causing organisms. The entire system of rage pulse-based intercropping for the Kharif season is adjusted in (table 11).

Table 11: Intercropping techniques based on pulses during the Kharif season

Intercropping System	Row ratio	Set specification of the system	Row distance (cm)	Remarks
Rice + Green gram	4:1	Every 5th row is intercrop	15	Lawrence and Gohain (2011), Mandal *et al*. (1989)
Rice + Black gram	4:1	Every 5th row	15	Mandal *et al*. (1989),

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		is intercrop		Sengupta *et al*. (1985)
Rice + Black gram	5:2	30-90-30	15	Mishra *et al*. (2012)
Rice + Groundnut	4:1	Every 5th row is intercrop	15	Mandal *et al*. (1989)
Maize + Cowpea	2:2,1: 1	30-90-30	30	Behera and Senapati (2001) and Takim (2012.)
Arhar + Groundnut	2:5	30-180-30	30	Dutta and Bandyopadhyay (2006)
Arhar + Groundnut	1:5	-	-	Reddy *et al. (*1989)
Arhar + Sesamum/	1: 3	30-150-30	30	Darshan *et al. (*2009)
Arhar + Green gram	1: 2	-	-	Sharma and Guled (2012)
Arhar + Black gram	1: 1	-	-	Kumawat *et al. (*2012)
Arhar + Ragi	2: 4	30-100-30	20	Behera *et al*. (1999)
Arhar + Ragi	2:8	-	-	Poornima *et al. (*2012)
Arhar + Rice	2:5	30-120-30	20	Behera *et al. (*2005)
Arhar+Maize	2: 2	Uniform rows	30	Behera *et al. (*2007)
Arhar+Turmeric	2: 10	30-330-30	30	Behera *et al. (*2008)
Groundnut + Mung	6:2	Uniform rows	30	Nayak and Patra (2000)
Castor + Mung/Biri	2:3	-	-	Gupta and Rathore (1993), *AgarwaL and Porwal (2006)*
Cotton+Mung /Biri/cowpea	1:2	-	-	Reddy and Mohammad (2009)

Fig. 10: Intercropping pattern between different crops.

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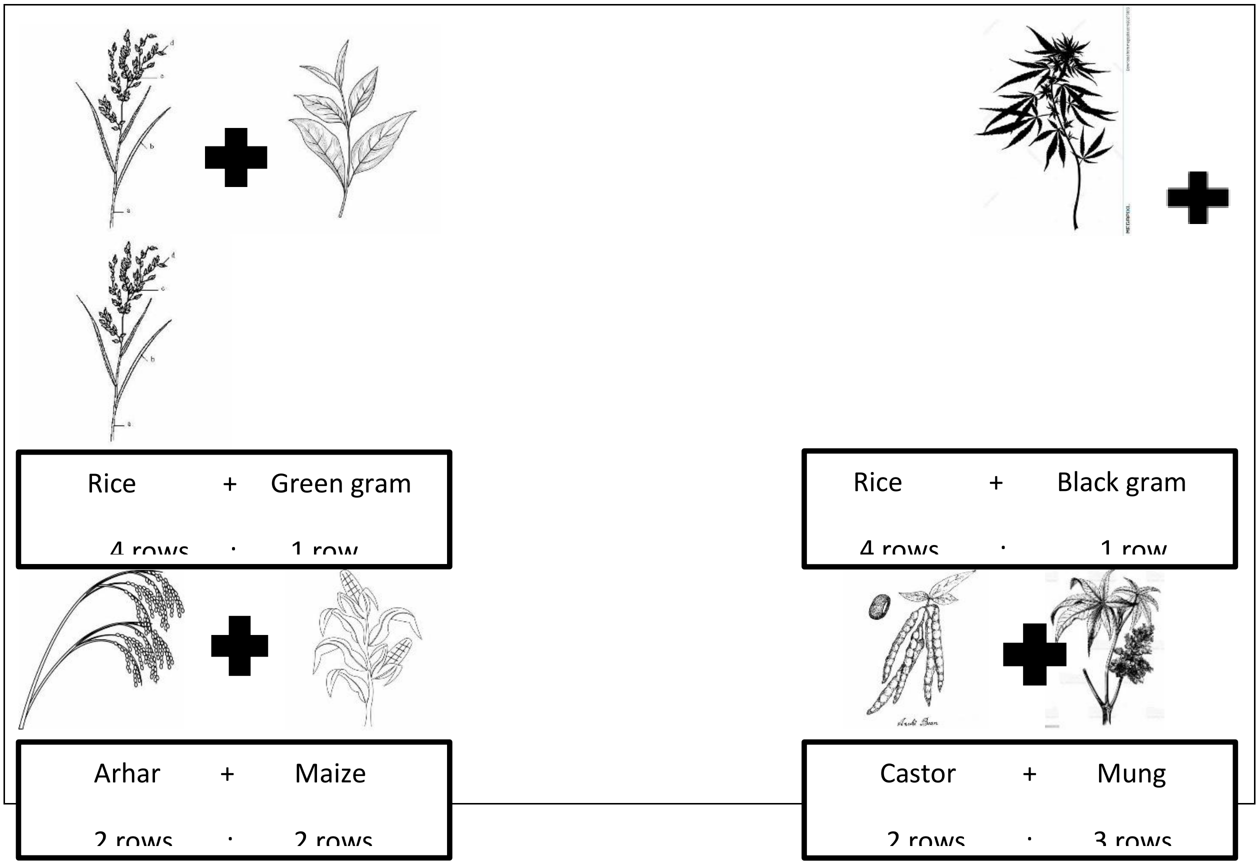

In a beef-up setting, Behera et al. (2009) and Behera et al. (2013) planned a pigeon pea rice (2: 5) intercropping system for six existences between 2001 and 2006. The use of organic manures improved the physical and organic characteristics of the land and maintained the yield of an intercropping system that included cooperating morning cereal and legume plants over subsistence in an unfavorable environment (Table 9).

Pulse based intercropping systems during rabbi season

Pulse-based intercropping systems increased overall yield in every region during the rabbi season, improved soil use effectiveness, and decreased weeds, insect pests, and disease-causing pathogens. In table 12, the popular pulse-based intercropping techniques for rabbi time are prepared.

Table. 12: Pulses based cropping system during rabbi season

Intercropping system	Place	Remarks
Chick pea+ wheat	Eastern plateau region of India,	Banik et al (2006)
Chickpea + linseed 3:3,	Northern India	

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chickpea + safflower at 6:3, chickpea + sunflower in 6:3	Maharashtra, Northern India	Wasu et al. (2013)
Lentil (Lens culinaris M.) and mustard (Brassica juncea L.)	Northern India	Singh et al. (2009)
Raj mash + vegetables cabbage, potato, tomato and cauliflower garden pea and carrot	High hill dry temperate conditions of north-western Himalayas	Sharma et al. (2006)

Pulses and climate change

Better varieties

The wide genetic diversity of pulses makes it possible to choose and breed better variants. This variety is a crucial quality since it allows for the development of additional strains that are climatically adaptable. For instance, researchers at the Intercontinental Center of Humid Agriculture are working to develop a rinsing of pulses that can endure temperature that are higher than the traditional "comfort zone" for the crop. Environment professionals forecast that hotness trauma will represent the largest threat to bean production in the next decades, making these upgraded pulse types essential, especially for low-input systems of agricultural production. (N. Russell, 2015).

Improved breeding tools and genetic resources

The discovery of genetic improvement that will release the enormous latent potential for genetic transformation (fig 11) is the highlight in several studies on this issue. The less well-understood grain legumes especially have difficulty in the development of efficient phenotyping and breeding methods (fig 11). Low genetic variation in breeding programs limits modern breeding attempts to increase production, quality and resilience to disease. Grain legume seeds kept in gene banks have a significant amount of genetic variation, but active breeding programs do not fully utilize these seeds. Cowling et al. (2017) investigates the idea of creating genes libraries by managing genetic diversity and long-term genetic gain in populations before reproduction, through the use of optimal contribution selection (fig 11). Using a founder population created by crossing elite crop types with exotic lines of field pea, they mimicked pre-breeding by submitting 30 rounds of the process of identifying for an index on the population made up of four economically significant features (fig 11). They conclude that the optimal contribution selection provides the control necessary to actively create gene banks for economic attributes while keeping high levels of genetic diversity. Growers will have access to priceless genes that are missing due to contemporary breeding programs thanks to this ground-breaking plant breeding technology. By mating genetically varied exotic lines with elite lines, cowling et al. (2017) state’s plant breeding method creates evolving gene banks by capturing beneficial bringing genes from wild relatives into the breeding

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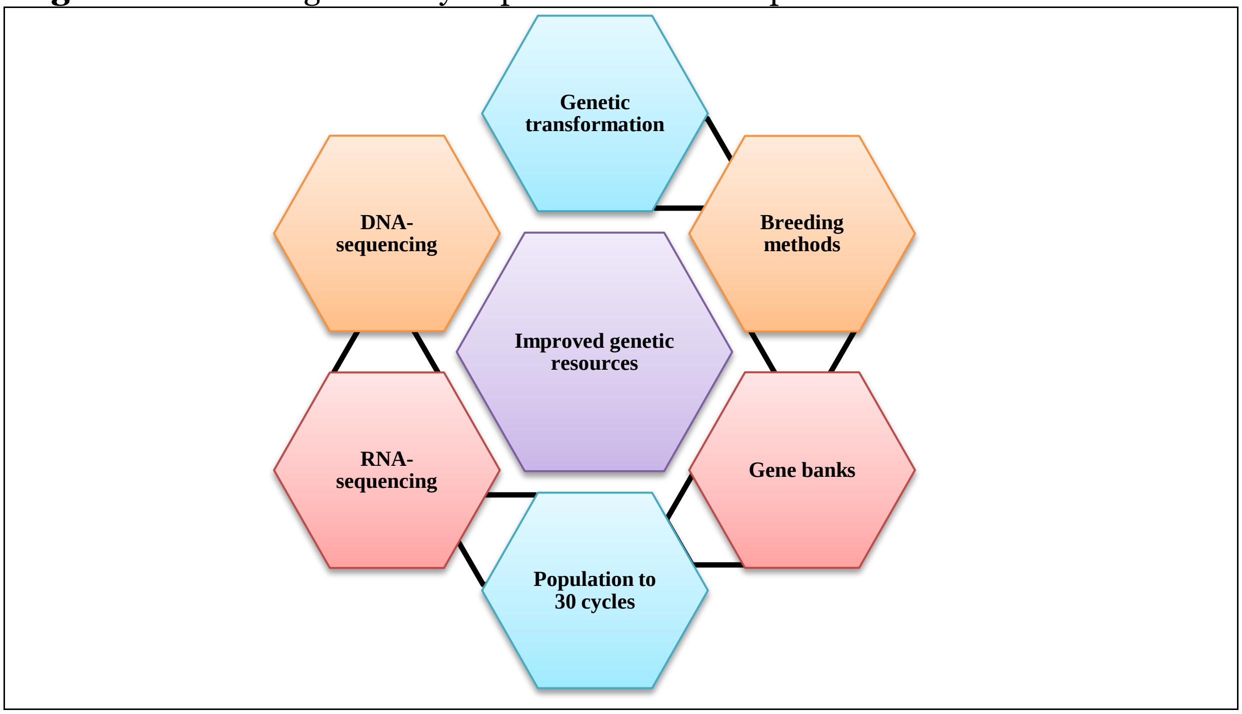
facility. The immediate problem is to confirm the results in industrial pulse crops. All plant breeders will eventually profit from the new rapid-cycle plant breeding method, which may also help crop development and adaptation to climate change.

Fig. 11: Creation of genetically improved varieties of pulses



The grain legume with the largest yield and most widespread plantings, and one of the five key crops, is soybean (Foyer et al., 2016). The need of enhancing soybean resilience to various climate change scenarios is covered in Li et al (2017) thorough assessment of the available genomic resources, which range from operational sequences to epigenetics. A variety of legumes are being subjected to high-throughput genomic technologies such as transcriptome sequencing (RNA-seq), Re-sequencing the genome (DNA-sequencing) (fig 11), and genome analysis. Cooper et al. (2017), who combined DNA-seq and RNA-seq to enhance soybean genomic resources, offer fresh insights into the gigantic faba bean (Vicia faba) genome. Using RNA-seq analysis, Du et al. (2017) reveals fascinating new information on the transcription factors that regulate soybean seed germination and seed size and identify hub genes that have an impact on these processes.

Ecological footprint

Pulses are crucial in this context because more effective farming methods can significantly lower emissions of greenhouse gases hence lowering the requirement for fertilizers. Pulses crucial in the fight against climate change, along with better fertilizer management techniques such as Precise farming, improved fertilization planning, and integrated nutrient uptake.

Utilizing symbiotic bacteria, pulses in crop rotations fix N2, which is then partially transferred to succeeding crops to boost yields. In fodder pulse/grass mixtures, N2 is

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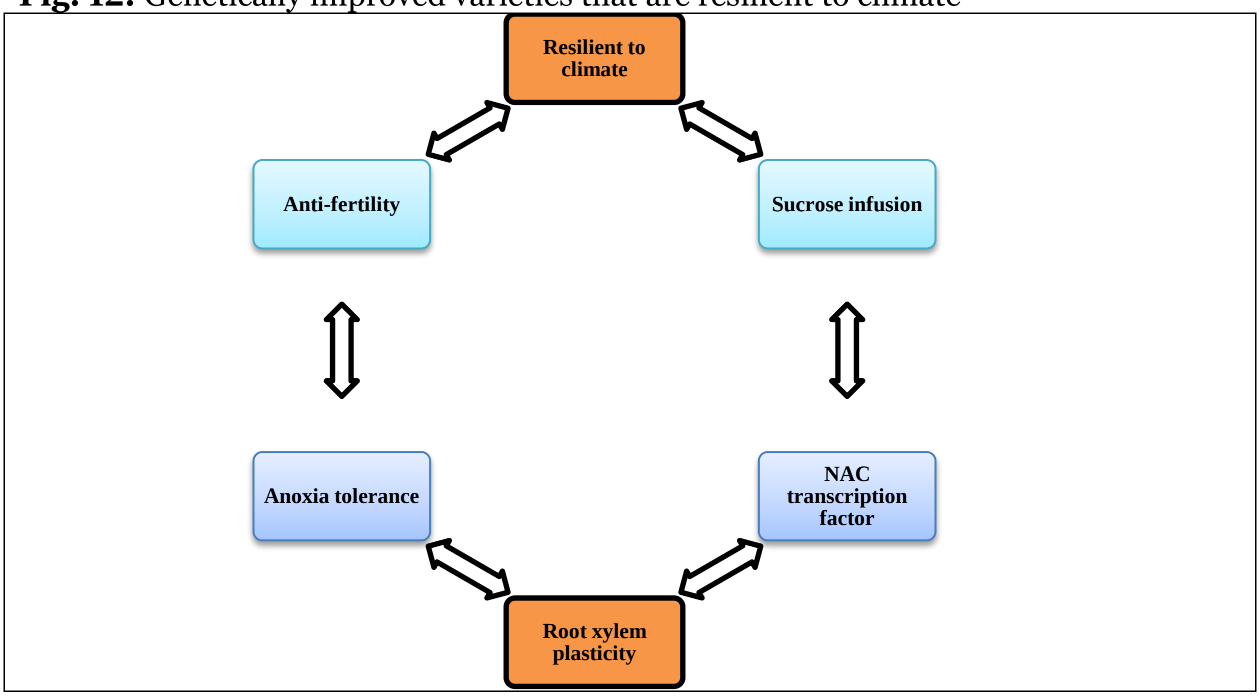
transferred from the pulse to the grass, increasing pasture yield. Pulses' high protein content when added to cattle feed increases the food conversion ratio while reducing ruminant methane emissions, which also reduces greenhouse gas emissions (FAO. 2016).

Improved resilience

Including pulses in a farm, the output may be essential for boosting climate change resistance. By assisting farmers in diversifying their income streams, agroforestry systems that contain pulses like pigeon peas produced concurrently with other crops help maintain the food security of farmers. Pulses are more resilient than most crops and contribute to soil nutrient retention, making agroforestry systems better suited to weather climate extremes (fig 12). The productivity of crops is rising, and this affects crop yields, according to farmers. It's crucial to keep in mind that trees, and thus agroforestry systems, store more carbon than field crops alone, in addition to adapting (Wallenberg et. Al 2012).

Fig. 12: Genetically improved varieties that are resilient to climate



Khan et al. (2017) illustrate the advantages of sucrose infusion throughout the reproductive stage of chickpea development, including evidence that salt-stressed chickpea is carbon-limited (fig 12). Due to this, plants exposed to high salt levels develop more vegetative and reproductively when sugar is provided (Khan et al., 2017). According to recent findings, the drought-responsive legume miR1514a stimulates the production of phase RNA by altering the activity of the NAC transcription factor (fig. 12) (Sosa-Valencia et al., 2017). The processes behind legume tolerance to drought are further described by an inventive research of the root xylem's flexibility (fig. 12) and its function in enhancing water consumption efficiency in stressed soybean plants (Prince et al., 2017). These and other research in this special issue emphasize the importance of accessibility to water for legume agriculture, as well as the current and future issues that drought and floods provide to soybean and forage legume production (Striker and Colmer, 2017). Their extensive analysis of the variation in forage legumes for flooding tolerance may be particularly intriguing to those who are interested in learning more about the physiology of drought resistance in legumes. Researchers and agronomists working on fodder planting in flood-prone areas can also utilize it practically. Data for a few important species are given, for which our understanding of ecophysiology is still restricted. Future research should concentrate on this important group of plants' capacity to continue symbiotic N_2 fixation despite poor drainage in the field and the discovery of characteristics enabling recovery once water levels drop over time. Understanding anoxia tolerance in roots is also crucial (fig 12) (Striker and Colmer, 2017).

Cao et al. (2017) and Ozga et al. (2018) studies provide thoughtful and assumed descriptions of various elements of reproductive physiology. The analysis of the impact of soybean blooming and stem development patterns on day length by Cao et al. (2017) highlights the interplay between photosynthetic rate and microRNA flowering mechanisms in soybean. Ozga et al (2018) study on grain legumes went beyond soybeans to look at how hormones interact with high-temperature stress throughout the vegetative development, from meiosis to flowering, fruit set, and seed maturity. A pigeon pea gene regulation atlas is also mentioned (Pazhamala et al., 2017), and this information was used to gain new insight into the genes related to pollination fertility and germinating seeds.

Some grain legume species, such as the pigeon pea (Cajanus cajan) and the faba bean, display crossbreeding features and are somewhat dependent on animal vectors for pollination. Grain legume reproduction can be negatively impacted by climate variation and related severe climatic conditions, including rapid spikes in temperature during blooming. This can have an immediate physiological impact as well as an indirect impact on plant-pollinator interactions. In a controlled setting and the field, Bishop et al. (2017) discovered that heat stress greatly increased the quantity of insect pollination outcrossing in faba beans. If there are no bees around, the faba bean has the ability to self-pollinate or "antifertility," is discussed by Stoddard in his Insight article (fig 12) (Stoddard, 2017). Dependence on wild pollinators is said to be a dangerous tactic when the climate is also changing. Future faba bean crops may require more honey bee availability to ensure adequate pollination, according to some experts.

Pulses are climate smart because they can adapt to climate change while also helping to lessen its consequences.

Adaptations to the soil microbiome

Grain legumes perform a variety of special tasks in the soil. Because symbiotic root nodules on them can fix nitrogen from the air, these plants offer hope for a more effective application of nitrogen composts in crop classifications. An overview of the bactericide courses of illness in legume roots that leads to the development of synergetic

nodes is given by Ibanez et al. (2017). The alterations among the root-hair entrance and the intercellular invasion are highlighted by these writers as they look into the development of this procedure. However, nodulation is reduced in loams rich in nitrogen, such as those found in farms that have used nitrogen fertilizer for a long time. Murray et al. (2017) investigates this phenomenon and give a thorough overview of current research on legume nitrogen sensing. They also take note of the complex signals and reactions seen in cellular and morphological structures. With a focus on the function of nitrate and other carriers in sensing nitrogen availability, Murray et al. (2017) looks into how the signaling activities of such transporters may alter nodulation.
The importance of legumes to current and next agriculture cannot be overstated. Grain legumes are also a flexible, long-lasting supplement to human diets and a crucial source of plant-based protein and amino acids for people all over the world, although making up a minor fraction of modern human diets. To stop and reverse the growing worldwide obesity pandemic, treat chronic diseases, the FAO advises eating them every day as part of a balanced diet (fao.org/ pulses-2016). In the future, expect more from these tiny miracles.

Policies for agroecosystems that are more resilient

How to provide enough food for a growing population without further depleting the environment and accelerating climate change is the challenge facing policymakers and agricultural professionals today. Agricultural policies must be created in conjunction with social and economic policies; they cannot be developed independently. To end hunger and promote livelihoods, policy should place an emphasis on farmers, herders, fishermen, and consumers (IPCC 2015).

Conclusion

For a successful evolution and yield, pulses require a careful start in the soil and climatic environment. The nitrogen fixation, growth, and yield are governed by climatic factors such as soil and temperature, rainfall, family element humidity, high-pitched sunshine hour, bend velocity, soil structure, aeration, function asset capacity, soil organic carbon, the allure of stone nutrients (Ca, P, S, Mo, B, etc.), soil pH, and ease of access of nitrogen putting in leave bacteria. The negative effects of construction projects are currently another community concern related to global warming. Relocating beneficial pulls to an ever-increasing zone, readjusting sowing realistic for a location, breeding for the development of climate intelligent to make progress varieties, running through of improve agronomic practices, honestly annoyance of your subsistence management practices, inclusion as intercrop/catch crop, and crop diversification are some examples of climate compliant pulse on the rise practices.

References

Abbo, S., Berger, J., & Turner, N. C. (2003). Evolution of cultivated chickpea: four bottlenecks limit diversity and constrain adaptation. *Functional Plant Biology*, *30*(10), 1081-1087.

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Allen, L. H., Pan, D., Boote, K. J., Pickering, N. B., & Jones, J. W. (2003). Carbon dioxide and temperature effects on evapotranspiration and water use efficiency of soybean. *Agronomy Journal*, *95*(4), 1071-1081.

Angadi, S. V., Gan, Y., Miller, P. R., McConkey, B. G., Zentner, R. P., & McDonald, C. L. (2003, February). Water use and water use efficiency of field pea and chickpea under the semiarid Canadian Prairie conditions. In *Soils and Crops Workshop*.

Baisakh, B., Jena, B., Das, T. R., & Panigrahi, K. K. (2013). Genetic architecture of yield and cold tolerance in land races of green gram from Odisha. *J. Food Legumes*, *26*(1-2), 20-25.

Banik, P., Midya, A., Sarkar, B. K., & Ghose, S. S. (2006). Wheat and chickpea intercropping systems in an additive series experiment: advantages and weed smothering. *European Journal of agronomy*, *24*(4), 325-332.

Behera, B., Jena, S. N., & Sat apathy, M. R. (2016). Pulse Based Cropping Systems and Climate Change Challenges in India.

Behera, B., Jena, S. N., & Sat apathy, M. R. (2016). Pulse Based Cropping Systems and Climate Change Challenges in India.

Behera, B., Jena, S. N., & Sat apathy, M. R. (2016). Pulse Based Cropping Systems and Climate Change Challenges in India.

Birthal, P. S., Khan, T., Negi, D. S., & Agarwal, S. (2014). Impact of climate change on yields of major food crops in India: Implications for food security. *Agricultural Economics Research Review*, *27*(2), 145-155.

Bishop, J., Jones, H. E., O'Sullivan, D. M., & Potts, S. G. (2017). Elevated temperature drives a shift from selfing to outcrossing in the insect-pollinated legume, faba bean (Vicia faba). *Journal of Experimental Botany*, *68*(8), 2055-2063.

Canada. Agriculture and Agri-Food Canada. Canada-Saskatchewan Agriculture Green Plan Agreement, Miller, P., & Brandt, S. (1998). *New crop types for diversifying and extending spring wheat rotations in the Brown and Dark Brown soil zones of Saskatchewan*.

Cao, D., Takeshima, R., Zhao, C., Liu, B., Jun, A., & Kong, F. (2017). Molecular mechanisms of flowering under long days and stem growth habit in soybean. *Journal of Experimental Botany*, *68*(8), 1873-1884.

Change, I. C. (2001). Impacts, Adaptation and Vulnerability. IPCC Working Group II, Third Assessment Report. McCarthy, JJ, OF Canziani, NA Leary, UK.

Chen, Y., Ghanem, M. E., & Siddique, K. H. (2017). Characterizing root trait variability in chickpea (Cicer arietinum L.) germplasm. *Journal of Experimental Botany*, *68*(8), 1987-1999.

Cooper, J. W., Wilson, M. H., Derks, M. F., Smit, S., Kunert, K. J., Cullis, C., & Foyer, C. H. (2017). Enhancing faba bean (Vicia faba L.) genome resources. *Journal of Experimental Botany*, *68*(8), 1941-1953.

Cowling, W. A., Li, L., Siddique, K. H., Henryon, M., Berg, P., Banks, R. G., & Kinghorn, B. P. (2017). Evolving gene banks: improving diverse populations of crop and exotic germplasm with optimal contribution selection. *Journal of Experimental Botany*, *68*(8), 1927-1939.

Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Cullis, C., & Kunert, K. J. (2017). Unlocking the potential of orphan legumes. *Journal of experimental botany*, *68*(8), 1895-1903.

Cutforth, H. W., McConkey, B. G., Ulrich, D., Miller, P. R., & Angadi, S. V. (2002). Yield and water use efficiency of pulses seeded directly into standing stubble in the semiarid Canadian prairie. *Canadian journal of plant science*, *82*(4), 681-686.

Cutforth, H. W., McConkey, B. G., Woodvine, R. J., Smith, D. G., Jefferson, P. G., & Akinremi, O. O. (1999). Climate change in the semiarid prairie of southwestern Saskatchewan: Late winter–early spring. *Canadian Journal of Plant Science*, *79*(3), 343-350.

Cutforth, H., O'Brien, E. G., Tuchelt, J., & Rickwood, R. (2004). Long-term changes in the frost-free season on the Canadian prairies. *Canadian journal of plant science*, *84*(4), 1085-1091.

Derksen, D. A., Anderson, R. L., Blackshaw, R. E., & Maxwell, B. (2002). Weed dynamics and management strategies for cropping systems in the northern Great Plains. *Agronomy Journal*, *94*(2), 174-185.

Dimes, J. P., Cooper, P. J., & Rao, K. P. C. (2008). Climate change impact on crop productivity in the semi-arid tropics of Zimbabwe in the 21st century.

Du, J., Wang, S., He, C., Zhou, B., Ruan, Y. L., & Shou, H. (2017). Identification of regulatory networks and hub genes controlling soybean seed set and size using RNA sequencing analysis. *Journal of experimental botany*, *68*(8), 1955-1972.

Dutta, D., & Bandyopadhyay, P. (2006). Production potential of intercropping of groundnut (Arachis hypogaea) with pigeonpea (Cajanus cajan) and maize (Zea mays) under various row proportions in rainfed Alfisols of West Bengal. *Indian Journal of Agronomy*, *51*(2), 103-106.

Easterling, D. R., Karl, T. R., Gallo, K. P., Robinson, D. A., Trenberth, K. E., & Dai, A. (2000). Observed climate variability and change of relevance to the biosphere. *Journal of Geophysical Research: Atmospheres*, *105*(D15), 20101-20114.

Fand, B. B., Kamble, A. L., & Kumar, M. (2012). Will climate change pose serious threat to crop pest management: A critical review? *International journal of scientific and Research publications*, *2*(11), 1-14.

Fikre, A., Negwo, T., Kuo, Y. H., Lambein, F., & Ahmed, S. (2011). Climatic, edaphic and altitudinal factors affecting yield and toxicity of Lathyrus sativus grown at five locations in Ethiopia. *Food and chemical toxicology*, *49*(3), 623-630.

Foyer, C. H., Lam, H. M., Nguyen, H. T., Siddique, K. H., Varshney, R. K., Colmer, T. D., ... & Considine, M. J. (2016). Neglecting legumes has compromised human health and sustainable food production. *Nature plants*, *2*(8), 1-10.

Giorgi, F., Shields Brodeur, C., & Bates, G. T. (1994). Regional climate change scenarios over the United States produced with a nested regional climate model. *Journal of Climate*, *7*(3), 375-399.

Growers, S. P. (2000). Pulse production manual 2000. *Saskatchewan Pulse Growers, Saskatoon, SK pp*, 6-1.

Gupta, I. N., & Rathore, S. S. (1993). Intercropping in castor (Ricinus communis) under dryland condition in Rajasthan. *Indian Journal of Agronomy*, *38*(2), 182-186.

Harris, H. C. (1978). Some aspects of the agroclimatology of West Asia and North Africa. In *Food legume improvement and development: proceedings*.... IDRC, Ottawa, ON, CA.

Haskett, J. D., Pachepsky, Y. A., & Acock, B. (2000). Effect of climate and atmospheric change on soybean water stress: a study of Iowa. *Ecological Modelling*, *135*(2-3), 265-277.

Hayhoe, K., Jain, A., Pitcher, H., MacCracken, C., Gibbs, M., Wuebbles, D., ... & Kruger, D. (1999). Costs of multigreenhouse gas reduction targets for the USA. *Science*, *286*(5441), 905-906.

Ibáñez, F., Wall, L., & Fabra, A. (2017). Starting points in plant-bacteria nitrogen-fixing symbioses: intercellular invasion of the roots. *Journal of Experimental Botany*, *68*(8), 1905-1918.

Izaurralde, R. C., Rosenberg, N. J., Brown, R. A., & Thomson, A. M. (2003). Integrated assessment of Hadley Center (HadCM2) climate-change impacts on agricultural productivity and irrigation water supply in the conterminous United States: Part II. Regional agricultural production in 2030 and 2095. *Agricultural and Forest Meteorology*, *117*(1-2), 97-122.

Johnston, A., Miller, P., & McConkey, B. (1999, January). Conservation tillage and pulse crop production—western Canada experiences. In *Momentum in northwest direct seed farming. Proc. Northwest Direct Seed Cropping Syst. Conf., Spokane, WA* (pp. 5-7).

Kakani, V. G., Prasad, P. V. V., Craufurd, P. Q., & Wheeler, T. R. (2002). Response of in vitro pollen germination and pollen tube growth of groundnut (Arachis hypogaea L.) genotypes to temperature. *Plant, Cell & Environment*, *25*(12), 1651-1661.

Kalra, N., Chakraborty, D., Sharma, A., Rai, H. K., Jolly, M., Chander, S., ... & Sehgal, M. (2008). Effect of increasing temperature on yield of some winter crops in northwest India. *Current science*, 82-88.

Karl, T. R., & Knight, R. W. (1998). Secular trends of precipitation amount, frequency, and intensity in the United States. *Bulletin of the American Meteorological society*, *79*(2), 231-242.

Karl, T. R., Knight, R. W., Easterling, D. R., & Quayle, R. G. (1996). Indices of climate change for the United States. *Bulletin of the American Meteorological Society*, *77*(2), 279-292.

Kato, T., Scholze, M., & Knorr, W. THE IMPACT OF CO2 FERTILIZATION ON THE GLOBAL TERRESTRIAL CARBON CYCLE AND INTERANNUAL CHANGES IN CO2 STUDIED THROUGH A CARBON CYCLE DATA ASSIMILATION SYSTEM. *QUEST*, *1*, 1.

Khan, H. A., Siddique, K. H., & Colmer, T. D. (2017). Vegetative and reproductive growth of salt-stressed chickpea are carbon-limited: sucrose infusion at the reproductive stage improves salt tolerance. *Journal of Experimental Botany*, *68*(8), 2001-2011.

Kim, Y., & Cullis, C. (2017). A novel inversion in the chloroplast genome of marama (Tylosema esculentum). *Journal of Experimental Botany*, *68*(8), 2065-2072.

Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Kimball, B. A., Kobayashi, K., & Bindi, M. (2002). Responses of agricultural crops to free-air CO2 enrichment. *Advances in agronomy*, *77*, 293-368.

Kobiljski, B., & Dencic, S. (2001). Global climate change: challenge for breeding and seed production of major field crops. *JOURNAL OF GENETICS AND BREEDING*, *55*(1), 83-90.

Krupinsky, J. M., Bailey, K. L., McMullen, M. P., Gossen, B. D., & Turkington, T. K. (2002). Managing plant disease risk in diversified cropping systems. *Agronomy journal*, *94*(2), 198-209.

Kumar, A., & Kumar, A. (2015). Effect of abiotic and biotic factors on incidence of pests and predator in cowpea [Vigna unguiculata (L.) walp.]. *Legume Research*, *38*(1), 121-125.

Kumar, S. (2002). Effect of planting pattern and fertilizer management on castor (Ricinus communis)-based intercropping system. *Indian Journal of Agronomy*, *47*(3), 355-360.

Kumawat, N., Singh, R. P., Kumar, R., Kumari, A., & Kumar, P. (2012). Response of intercropping and integrated nutrition on production potential and profitability on rainfed pigeonpea. *Journal of Agricultural Science*, *4*(7), 154-162.

Kurdali, F. (1996). Nitrogen and phosphorus assimilation, mobilization and partitioning in rainfed chickpea (Cicer arietinum L.). *Field Crops Research*, *47*(2-3), 81-92.

Larney, F. J., Lindwall, C. W., Izaurralde, R. C., & Moulin, A. P. (2017). Tillage systems for soil and water conservation on the Canadian prairie. In *Conservation tillage in temperate agroecosystems* (pp. 305-328). CRC Press.

Laurila, H. (2001). Simulation of spring wheat responses to elevated CO2 and temperature by using CERES-wheat crop model.

Lawrence, H., & Gohain, T. (2011). Intercropping of Green Gram (Vigna radiata L) with Upland Rice (Oryza sativa L) under Rainfed Condition of Nagaland. *Indian J Hill Frmg*, *19*(1&2), 12-15.

Lawson, B. D. (2003). Trends in winter extreme minimum temperatures on the Canadian prairies. *Atmosphere-ocean*, *41*(3), 233-239.

Lean, J., & Rind, D. (1998). Climate forcing by changing solar radiation. *Journal of Climate*, *11*(12), 3069-3094.

Lee, J. J., Phillips, D. L., & Dodson, R. F. (1996). Sensitivity of the US corn belt to climate change and elevated CO2: II. Soil erosion and organic carbon. *Agricultural Systems*, *52*(4), 503-521.

Lemmen, D. S., & Warren, F. J. (2004). Climate change impacts and adaptation: A Canadian perspective.

Leport, L., Turner, N. C., French, R. J., Tennant, D., Thomson, B. D., & Siddique, K. H. M. (1998). Water relations, gas exchange and growth of cool-season grain legumes in a Mediterranean-type environment. *European Journal of Agronomy*, *9*(4), 295-303.

Li, M. W., Xin, D., Gao, Y., Li, K. P., Fan, K., Muñoz, N. B., ... & Lam, H. M. (2017). Using genomic information to improve soybean adaptability to climate change. *Journal of Experimental Botany*, *68*(8), 1823-1834.

Mandal, B. K., Dhara, M. C., Mandal, B. B., Das, S. K., & Nandy, R. (1989). Effect of intercropping on the yield components of rice, mungbean, soybean, peanut and blackgram. *Journal of Agronomy and Crop Science*, *162*(1), 30-34.

McCarthy, J. J., Canziani, O. F., Leary, N. A., Dokken, D. J., & White, K. S. (2001). Intergovernmental Panel on Climate Change, 2001. *Working Group II. Climate change*.

McGinn, S. M., & Shepherd, A. (2003). Impact of climate change scenarios on the agroclimate of the Canadian prairies. *Canadian Journal of Soil Science*, *83*(5), 623-630.

McKenzie, R. H., Middleton, A. B., Flore, N., & Bremer, E. (2004). Evapotranspiration efficiency of pea in south and central Alberta. *Canadian journal of plant science*, *84*(2), 473-476.

Miller, P. R., & Holmes, J. A. (2005). Cropping sequence effects of four broadleaf crops on four cereal crops in the northern Great Plains. *Agronomy journal*, *97*(1), 189-200.

Miller, P. R., Gan, Y., McConkey, B. G., & McDonald, C. L. (2003). Pulse crops for the northern Great Plains: II. Cropping sequence effects on cereal, oilseed, and pulse crops. *Agronomy Journal*, *95*(4), 980-986.

Miller, P. R., Gan, Y., McConkey, B. G., & McDonald, C. L. (2003). Pulse crops for the northern Great Plains: II. Cropping sequence effects on cereal, oilseed, and pulse crops. *Agronomy Journal*, *95*(4), 980-986.

Miller, P. R., McConkey, B. G., Clayton, G. W., Brandt, S. A., Staricka, J. A., Johnston, A. M., ... & Neill, K. E. (2002). Pulse crop adaptation in the northern Great Plains. *Agronomy journal*, *94*(2), 261-272.

Miller, P. R., McDonald, C. L., Derksen, D. A., & Waddington, J. (2001). The adaptation of seven broadleaf crops to the dry semiarid prairie. *Canadian Journal of Plant Science*, *81*(1), 29-43.

Miller, P. R., Waddington, J., McDonald, C. L., & Derksen, D. A. (2002). Cropping sequence affects wheat productivity on the semiarid northern Great Plains. *Canadian Journal of Plant Science*, *82*(2), 307-318.

Mishra, A., Behera, B., Pal, A. K., Mohanty, S. K., Rath, B. S., Subudhi, C. R., ... & Sahoo, N. (2012). Performance of rice and blackgram with different nutrient management practices in rainfed upland. *ORYZA-An Intl J Rice*, *49*(4), 273-279.

Motha, R. P., & Baier, W. (2005). Impacts of present and future climate change and climate variability on agriculture in the temperate regions: North America. *Climatic Change*, *70*(1), 137-164.

Murray, J. D., Liu, C. W., Chen, Y., & Miller, A. J. (2017). Nitrogen sensing in legumes. *Journal of Experimental Botany*, *68*(8), 1919-1926.

Nayak, B. C., & Patra, A. K. (2000). Intercropping of green gram (Phaseolus radiatus) with groundnut (Arachis hypogaea). *Indian Journal of Agronomy*, *45*(2), 288-292.

Ney, B., & Turc, O. (1993). Heat-unit-based description of the reproductive development of pea. *Crop Science*, *33*(3), 510-514.

Nielsen, D. C. (2001). Production functions for chickpea, field pea, and lentil in the central Great Plains. *Agronomy Journal*, *93*(3), 563-569.

Nielsen, D. C., Unger, P. W., & Miller, P. R. (2005). Efficient water uses in dryland cropping systems in the Great Plains. *Agronomy Journal*, *97*(2), 364-372.

Ormrod, D. P., Woolley, C. J., Eaton, G. W., & Stobbe, E. H. (1967). Effect of temperature on embryo sac development in Phaseolus vulgaris L. *Canadian Journal of Botany*, *45*(6), 948-950.

Ozga, J. A., Kaur, H., Savada, R. P., & Reinecke, D. M. (2017). Hormonal regulation of reproductive growth under normal and heat-stress conditions in legume and other model crop species. *Journal of Experimental Botany*, *68*(8), 1885-1894.

Padbury, G., Waltman, S., Caprio, J., Coen, G., McGinn, S., Mortensen, D., ... & Sinclair, R. (2002). Agroecosystems and land resources of the northern Great Plains. *Agronomy Journal*, *94*(2), 251-261.

Pang, J., Turner, N. C., Khan, T., Du, Y. L., Xiong, J. L., Colmer, T. D., ... & Siddique, K. H. (2017). Response of chickpea (Cicer arietinum L.) to terminal drought: leaf stomatal conductance, pod abscisic acid concentration, and seed set. *Journal of Experimental Botany*, *68*(8), 1973-1985.

Parmesan, C., & Yohe, G. (2003). A globally coherent fingerprint of climate change impacts across natural systems. *nature*, *421*(6918), 37-42.

Pazhamala, L. T., Purohit, S., Saxena, R. K., Garg, V., Krishnamurthy, L., Verdier, J., & Varshney, R. K. (2017). Gene expression atlas of pigeonpea and its application to gain insights into genes associated with pollen fertility implicated in seed formation. *Journal of Experimental Botany*, *68*(8), 2037-2054.

Poornima, D. S., Shankaralingappa, B. C., Kalyana Murthy, K. N., & Savitha, H. R. (2010). Economics of transplanted pigeonpea in sole cropping and finger millet based intercropping system. *Int. J Agric. Sci*, *6*(2), 501-503.

Prince, S. J., Murphy, M., Mutava, R. N., Durnell, L. A., Valliyodan, B., Shannon, J. G., & Nguyen, H. T. (2017). Root xylem plasticity to improve water use and yield in water-stressed soybean. *Journal of experimental botany*, *68*(8), 2027-2036.

Raddatz, R. L., Maybank, J., & Atkinson, G. B. (1991). Mean daily temperature normals from 1901-30 to 1961-90 on the eastern Canadian Prairies. *Climatological Bulletin*, *25*(2), 118-123.

Raper, C. D., & Kramer, P. J. (1987). Stress physiology. p. 589–641. JR Wilcox (ed.) Soybeans: Improvement, production, and uses. ASA, CSSA, and SSSA, Madison, WI. *Stress physiology. p. 589–641. In JR Wilcox (ed.) Soybeans: Improvement, production, and uses. 2nd ed. ASA, CSSA, and SSSA, Madison, WI*.

Reddy, S. N., Reddy, E. R., Reddy, M. V., Reddy, M. S., & Reddy, P. V. (1989). Row arrangement in groundnut/pigeonpea intercropping. *Tropical agriculture*, *66*(4), 309-312.

Reilly, J., Tubiello, F., McCarl, B., Abler, D., Darwin, R., Fuglie, K., ... & Rosenzweig, C. (2003). US agriculture and climate change: new results. *Climatic Change*, *57*(1), 43-67.

Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Roberts, E. H., Summerfield, R. J., Ellis, R. H., & Stewart, K. A. (1988). Photothermal time for flowering in lentils (Lens culinaris) and the analysis of potential vernalization responses. *Annals of Botany*, *61*(1), 29-39.

Rosenberg, N. J., Brown, R. A., Izaurralde, R. C., & Thomson, A. M. (2003). Integrated assessment of Hadley Centre (HadCM2) climate change projections on agricultural productivity and irrigation water supply in the conterminous United States: I. Climate change scenarios and impacts on irrigation water supply simulated with the HUMUS model. *Agricultural and Forest Meteorology*, *117*(1-2), 73-96.

Roughley, R. J. (1970). The influence of root temperature, Rhizobium strain and host selection on the structure and nitrogen-fixing efficiency of the root nodules of Trifolium subterraneum. *Annals of Botany*, *34*(3), 631-646.

SANKAR, G. M., Sharma, K. L., Reddy, K. S., Pratibha, G., Shinde, R., Singh, S. R., ... & Venkateswarlu, B. (2013). Efficient tillage and nutrient management practices for sustainable yields, profitability and energy use efficiency for rice-based cropping system in different soils and agro-climatic conditions. *Experimental Agriculture*, *49*(2), 161-178.

SANKAR, G. M., Sharma, K. L., Reddy, K. S., Pratibha, G., Shinde, R., Singh, S. R., ... & Venkateswarlu, B. (2013). Efficient tillage and nutrient management practices for sustainable yields, profitability and energy use efficiency for rice-based cropping system in different soils and agro-climatic conditions. *Experimental Agriculture*, *49*(2), 161-178.

Sauchyn, D., Barrow, E., Hopkinson, R., & Leavitt, P. (2002). Aridity on the Canadian plains. *Geography physique et Quaternaire*, *56*(2-3), 247-259.

Sauchyn, D., Barrow, E., Hopkinson, R., & Leavitt, P. (2003). Aridity on the Canadian Plains: Future trends and past variability. *Summary Document*, 12.

Schneider, S. H. (1994). Detecting climatic change signals: are there any" fingerprints"? *Science*, *263*(5145), 341-347.

Sengupta, K., Bhattacharyya, K. K., & Chatterjee, B. N. (1985). Intercropping of upland rice with blackgram [Vigna mungo (L.)]. *The Journal of Agricultural Science*, *104*(1), 217-221.

Sharma, A., & Guled, M. B. (2012). Effect of set-furrow method of cultivation in pigeonpea+ green gram intercropping system in medium deep black soil under rainfed conditions. *Karnataka Journal of Agricultural Sciences*, *25*(1).

SHARMA, A., Sharma, J. J., Rana, M. C., & SOOD, S. (2006). Evaluation of Phaseolus vulgaris as intercrop with vegetables for enhancing productivity system and profitability under high hill dry temperate conditions of north-western Himalayas. *Indian journal of agricultural science*, *76*(1), 29-32.

Shen, S. S. P., Yin, H., Cannon, K., Howard, A., Chetner, S., & Karl, T. R. (2005). Temporal and spatial changes of the agroclimate in Alberta, Canada, from 1901 to 2002. *Journal of Applied Meteorology and Climatology*, *44*(7), 1090-1105.

Shepherd, A., & McGinn, S. M. (2003). Assessment of climate change on the Canadian prairies from downscaled GCM data. *Atmosphere-Ocean*, *41*(4), 301-316.

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Siddique, K. H., Regan, K. L., Tennant, D., & Thomson, B. D. (2001). Water use and water use efficiency of cool season grain legumes in low rainfall Mediterranean-type environments. *European Journal of Agronomy*, *15*(4), 267-280.

Singh, T., Rana, K. S., Shivay, Y. S., Ramanjanayul, A. V., & Rahal, A. (2009). Productivity and sustainability of mustard (Brassica juncea L.) and lentil (Lens culinaris L.) intercropping system as affected by moisture conservation practices and fertility levels under rainfed conditions. *Archives of Agronomy and Soil Science*, *55*(2), 183-196.

Skinner, W. R., & Gullett, D. W. (1993). Trends of daily maximum and minimum temperature in Canada during the past century. *Climatological Bulletin*, *27*(2), 63-77.

Skinner, W. R., & Majorowicz, J. A. (1999). Regional climatic warming and associated twentieth century land-cover changes in north-western North America. *Climate Research*, *12*(1), 39-52.

Smit, B., & Skinner, M. W. (2002). Adaptation options in agriculture to climate change: a typology. *Mitigation and adaptation strategies for global change*, *7*(1), 85-114.

Smith, D. L., & Almaraz, J. J. (2004). Climate change and crop production: contributions, impacts, and adaptations. *Canadian journal of plant pathology*, *26*(3), 253-266.

Soltani, A., Hammer, G. L., Torabi, B., Robertson, M. J., & Zeinali, E. (2006). Modeling chickpea growth and development: phenological development. *Field Crops Research*, *99*(1), 1-13.

Sosa-Valencia, G., Palomar, M., Covarrubias, A. A., & Reyes, J. L. (2017). The legume miR1514a modulates a NAC transcription factor transcript to trigger phasing formation in response to drought. *Journal of experimental botany*, *68*(8), 2013-2026.

Stoddard, F. L. (2017). Climate change can affect crop pollination in unexpected ways. *Journal of Experimental Botany*, *68*(8), 1819.

Striker, G. G., & Colmer, T. D. (2017). Flooding tolerance of forage legumes. *Journal of Experimental Botany*, *68*(8), 1851-1872.

Summerfield, R. J., Hadley, P., Roberts, E. H., Minchin, F. R., & Rawsthrone, S. (1984). Sensitivity of chickpeas (Cicer arietinum) to hot temperatures during the reproductive period. *Experimental Agriculture*, *20*(1), 77-93.

Summerfield, R. J., Roberts, E. H., Erskine, W., & Ellis, R. H. (1985). Effects of temperature and photoperiod on flowering in lentils (Lens culinaris Medic.). *Annals of Botany*, *56*(5), 659-671.

Swensen, J. B., & Murray, G. A. (1983). Cold Acclimation of Field Peas in a Controlled Environment 1. *Crop science*, *23*(1), 27-30.

Takim, F. O. (2012). Advantages of maize-cowpea intercropping over sole cropping through competition indices. *Journal of Agriculture and Biodiversity Research*, *1*(4), 53-59.

Talwar, H. S., Yanagihara, S., Yajima, M., & Hayashi, T. (1999). Physiological basis for heat tolerance during flowering and pod setting stages in groundnut (Arachis hypogaea L.). *JIRCAS Working Report*, *14*, 47-65.

Thimmegowda, M. N., Ramachandrappa, B. K., Devaraja, K., Savitha, M. S., Babu, P. N., Gopinath, K. A., ... & Rao, C. S. (2016). Climate resilient intercropping systems for rainfed red soils of Karnataka. *Indian Journal of Dryland Agricultural Research and Development*, *31*(2), 39-44.

Thomson, A. M., Izaurralde, R. C., Rosenberg, N. J., & He, X. (2006). Climate change impacts on agriculture and soil carbon sequestration potential in the Huang-Hai Plain of China. *Agriculture, ecosystems & environment*, *114*(2-4), 195-209.

Turner, N. C., Davies, S. L., & Plummer, J. A. (2005). UNDER WATER DEFICITS, WITH EMPHASIS. *Advances in agronomy*, *87*, 211.

Turner, N. C., Wright, G. C., & Siddique, K. H. M. (2001). Adaptation of grain legumes (pulses) to water-limited environments.

Valliyodan, B., Ye, H., Song, L., Murphy, M., Shannon, J. G., & Nguyen, H. T. (2017). Genetic diversity and genomic strategies for improving drought and waterlogging tolerance in soybeans. *Journal of experimental botany*, *68*(8), 1835-1849.

Vaz Patto, M. C., & Rubiales, D. (2014). Resistance to rust and powdery mildew in Lathyrus crops.

Venkataraman, S. (1992). *Crops and weather*. Publications and Information Division, Indian Council of Agric. Res.

Wang, J., Gan, Y. T., Clarke, F., & McDonald, C. L. (2006). Response of chickpea yield to high temperature stress during reproductive development. *Crop Science*, *46*(5), 2171-2178.

Wasu, R. M., Gokhale, D. N., Dadgale, P. R., & Kadam, G. T. (2013). Effect of chickpea based intercropping systems on competitive relationship between chickpea and intercrop. *International Journal of Agricultural Sciences*, *9*(1), 351-353.

Welbaum, G. E., Bian, D., Hill, D. R., Grayson, R. L., & Gunatilaka, M. K. (1997). Freezing tolerance, protein composition, and abscisic acid localization and content of pea epicotyl, shoot, and root tissue in response to temperature and water stress. *Journal of Experimental Botany*, *48*(3), 643-654.

Wery, J., Turc, O., & Lecoeur, J. (1993). Mechanisms of resistance to cold, heat and drought in cool-season legumes, with special reference to chickpea and pea.

White, J., McMaster, G., & EDMEADES, G. (2004). PREFACE: PHYSIOLOGY, GENOMICS AND CROP RESPONSE TO GLOBAL CHANGE. *Field Crops Research*, *90*(1), 1-3.

Willey, R. W., Rao, M. R., & Natarajan, M. (1981). Traditional cropping systems with pigeonpea and their improvement. In *Proceedings of the International Workshop on Pigeon peas, Patancheru, 15 19 Dec 1980, vol. 1.* (pp. 11-25). ICRISAT.

Yadav, S. S., Redden, B., McNeil, D. L., Gan, Y., Rizvi, A., Vrema, A. K., & Bahl, P. N. (2010). Strategies to combat the impact of climatic changes. In *Climate Change and Management of Cool Season Grain Legume Crops* (pp. 433-445). Springer, Dordrecht.

Yu, M., Gao, Q., & Shaffer, M. J. (2002). Simulating interactive effects of symbiotic nitrogen fixation, carbon dioxide elevation, and climatic change on legume growth. *Journal of environmental quality*, *31*(2), 634-641.

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Zentner, R. P., Campbell, C. A., Biederbeck, V. O., Miller, P. R., Selles, F., & Fernandez, M. R. (2001). In search of a sustainable cropping system for the semiarid Canadian prairies. *Journal of Sustainable Agriculture*, *18*(2-3), 117-136.

Zentner, R. P., Wall, D. D., Nagy, C. N., Smith, E. G., Young, D. L., Miller, P. R., ... & Derksen, D. A. (2002). Economics of crop diversification and soil tillage opportunities in the Canadian prairies. *Agronomy Journal*, *94*(2), 216-230.

Zhang, H., Pala, M., Oweis, T., & Harris, H. (2000). Water use and water-use efficiency of chickpea and lentil in a Mediterranean environment. *Australian Journal of Agricultural Research*, *51*(2), 295-304.

Zhang, X., Vincent, L. A., Hogg, W. D., & Niitsoo, A. (2000). Temperature and precipitation trends in Canada during the 20th century. *Atmosphere-ocean*, *38*(3), 395-429.

Zhou, L., Tucker, C. J., Kaufmann, R. K., Slayback, D., Shabanov, N. V., & Myneni, R. B. (2001). Variations in northern vegetation activity inferred from satellite data of vegetation index during 1981 to 1999. *Journal of Geophysical Research: Atmospheres*, *106*(D17), 20069-20083.

Ziska, L. H., & Bunce, J. A. (2000). Sensitivity of field-grown soybean to future atmospheric CO2: selection for improved productivity in the 21st century. *Functional Plant Biology*, *27*(10), 979-984.

Ziska, L. H., Bunce, J. A., & Caulfield, F. (1998). Intraspecific variation in seed yield of soybean (Glycine max) in response to increased atmospheric carbon dioxide. *Functional Plant Biology*, *25*(7), 801-807.

Ziska, L. H., Bunce, J. A., & Caulfield, F. A. (2001). Rising atmospheric carbon dioxide and seed yield of soybean genotypes. *Crop Science*, *41*(2), 385-391.