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PANEER FROM GIR COW MILK: PRODUCTION, FACTORS AFFECTING COMPOSITION, AND STORAGE

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ABSTRACT

Food products that include significant amounts of milk and other ingredients may be referred to as dairy products. Among the various dairy products, paneer is a popular Indian soft cheese variety which occupies a prominent place among traditional milk products. PFA (1954) described paneer as "A product made from cow or buffalo milk or the combination of the two via precipitation with sour milk, lactic acid or citric acid". Paneer is a rich animal protein, vitamin, calcium and iron source. In addition, whey is a valuable byproduct obtained during paneer production, containing lactose, whey protein, minerals and vitamins.

INTRODUCTION

Milk is a complete food as it fulfils all the nutritional ingredients. The importance of milk and milk products has been reported since the Vedic times. Traditional dairy products have the most enhancing role in society's social, economic and nutritional health (Gupta 1999). Due to the successful implementation of the "operation flood programme" in 1970s India, the exceptionable increment in milk production over the last few years has been achieved. So India has achieved the top rank in milk production worldwide. (NDDB 2009; Bhasin 2009) Out of total milk production in India, it is estimated that 5% of milk is processed as paneer and paneer production is growing annually at 13% (ICMR 2000; Chandan 2007a). The estimated milk production in India is about 198 million metric tons (MMT) in 2020, about 40% of the world's total milk production.

Paneer is one type of soft cheese popular in South Asia, and it is prepared by acid and heat coagulation of milk. Paneer's physical appearance and flour are mentioned as white in colour, sweetish, mild acidic taste, nutty flavour, spongy body and smooth texture. According to the PFA (2010), paneer means "Milk product processed from Buffalo or cow milk or a combination thereof, by acid precipitation with citric acid, sour milk, or lactic acid. The moisture content in it should be not more than 70%, and the fat content should not be less than 50% which is expressed on a dry matter basis. Bureau of Indian Standards (BIS 1983) mentioned that paneer's maximum moisture and minimum fat percentage should be 60% and 50%, respectively, on a dry matter basis.

Paneer is an indigenous milk product and is very popular in preparing several types of culinary dishes and snacks. Paneer production is now spreading worldwide (Aneja 2002). It is a rich source of casein protein, an animal protein and valuable animal protein for vegetarians. As paneer is a Protein-rich milk product and easy to digest for human beings, it's biological value ranges from 80 to 86% (Shrivastava and Goyal 2007). It is also a source of fat, vitamins, and minerals like calcium and phosphorus. Also, in refrigerated temperatures, it has a long shelf life.

MATERIALS

Gir cow milk, Lemon as source of citric acid, open pan, muslin cloth, stirrer, Paneer pressing machine, gas burner.

PREPARATION OF PANEER

The unorganized dairy sector follows traditional and very inefficient milk processing methods in paneer. The major role in the improvement of traditional methods of paneer manufacture was carried out by Bhattacharya et al. (1971).

Gir cow milk with 4.5% fat content was heated at 82°C in an open pan for 5 min and cooled to 70°C. After adding lemon juice as a source of citric acid (1% solution), precaution is to be taken here that it should be slowly added to boiled milk with continuous stirring till the coagulation and clear whey separated. This coagulated milk was kept for settling down for 10 min. Then, by using a muslin cloth, the whey was drained out. Here care should be taken for the temperature of whey maintained above 63°C. The coagulated mass was collected in a muslin cloth and kept for pressing under the pressing machine (hoop) by placing a weight of 45 kg for about 15–20 min. The pressed block of curd is removed from the hoop, cut into 6-8" pieces, and immersed in pasteurized chilled water (4-6°C) for 2–3 hr. It was stored at a refrigeration temperature (of 4±1°C).

A schematic approach for the manufacture of paneer is given below

Good quality cow milk

↓

Filtration Standardization

↓

Heating (82^0 C, 5 min)

↓

Cooling (70^0 C)

↓

Addition of Lemon juice (source of Citric acid solution at 70^0 C)

↓

Continuous stirring till clear whey separates out

↓

Settling for 10 min

↓

Draining of whey

↓

Pressing the coagulum after filling in muslin cloth lined hoops

↓

Immersion of paneer blocks in chilled water (40^0 C)

↓

Draining of water and wiping surface

↓

Packaging and storage at 40^0 C

CHEMICAL COMPOSITION OF PANEER

Nutritional Value of Paneer is more as it contains about 90% of the fat and protein as well as 50% of the minerals and lactose content 10% of the original milk. The proximate composition of Paneer is 54% moisture, 17.5% proteins, 25% fat, 2% lactose, and 1.5% minerals.

Table 1: Paneer Nutrition Facts (per 100 grams)

Nutrients	Composition /100 g
Total Fat	26.9 grams
Saturated Fat	18.1 g
Trans fatty acids	<0.1 g
Cholesterol	56.2 mg
sodium	22.1 mg
Total Carbs	6.1 g
Protein	19.1 grams
Vitamin A	210 mcg
Calcium	420 mg
Iron	2.16 mg

FACTORS AFFECTING THE QUALITY AND YIELD OF PANEER

1. TYPE OF MILK

Paneer prepared from buffalo milk possesses desirable frying properties, body and texture compared to cow milk. On the other hand, cow milk paneer is soft, weak and fragile and tends to disintegrate during cooking. However, mixed milk and buffalo milk in equal quantity yield a better product than cow milk. Production of Paneer from 1 lit buffalo milk is 200-250 grams, whereas cow milk is obtained from 150-200 grams. Paneer made from skim milk has a chewy, rubbery texture and a hard body. However, cow milk yields inferior quality paneer, especially in sensory characteristics, compared to buffalo milk. Such effect could be ascribed to different make-up of casein micelles and lower protein and calcium contents in cow milk compared to buffalo milk (Sindhu,1996).

2. QUALITY OF MILK

Milk must be fresh and free from off-flavour. The growth of psychrotrophic organisms should be minimized to restrict off-flavour development. Acidic milk having a titrable acidity of more than 0.20% lactic acid yields a product of inferior quality.

3. TYPE, STRENGTH AND TEMPERATURE OF COAGULANT

Product yield and moisture retention are directly influenced by the type and concentration of the acid and the mode of delivery and blending into the hot milk. Citric acid is generally used as a coagulant. Lemon, lime juice, or vinegar imparts a typical flavour to the product. 1% solution of citric acid yields a good quality paneer. Sufficient acid is added gently but quickly blended with the milk (within one min) to reach the optimum pH of coagulation. High acid concentration imparts acidic flavour and hardness and causes more significant solids loss. Whey cultured with Lactobacillus acidophilus at a level of 2% and incubated overnight at 37°C can be used as a substitute for citric acid. However, acidic whey must be heat treated to destroy these lactic organisms before use to prevent loss of the shelf life of paneer. Coagulation temperature influences the moisture content of paneer. It is reported that an increase in temperature from 60^0 C to 86^0 C decreases the moisture content from 59 to 49%. However, the optimum coagulation temperature for the best organoleptic and frying quality product is 76^0 C

4. HEAT TREATMENT OF MILK

This is one of the process's technological requirements, which affects the paneer's sensory and microbiological quality. The objective of heating milk is to prepare it for rapid precipitation, control the moisture content, develop a typical body and texture, create conditions conducive to the destruction of pathogenic and other microflora in milk, and ensure the safety and quality of the final product. The milk is heated to 90°C without holding or 82°C for 5min in order to maximize the total solids recovery. In addition, the high heat treatment imparts desirable cooked flavour by controlled liberation of sulphydryl compounds.

5. COAGULATION TEMPERATURE

It influences the moisture content of the paneer. For example, an increase in temperature from 60^0 C to 86^0 C decreases the moisture in the paneer from 59 to 49%. At 70^0 C, Paneer made from buffalo milk has the best organoleptic and frying quality in shape retention, softness and integrity.

6. PH OF COAGULATION

De (1980) reported that, as there is a decrease in pH, the moisture retention in the paneer is also decreased. The optimum pH of milk coagulation at 70°C is 5.30-5.35 for better product quality and maximum solids recovery when made from buffalo milk. The moisture retention in paneer decreases with the reduction in pH; consequently, the yield decreases. At a pH of more than 5.35,

the paneer is very soft with a fragile and crumbly body. The optimum pH for paneer preparation from cow milk is 5.2.

STORAGE OF PANEER

1. The product can be stored under frozen conditions (below -18°C) for more than one year without any deterioration in its quality and used after careful thowing.
2. Paneer dipped in 5% brine solution lasts for about 22 days at 8-10°C.
3. The salting at the time of dipping into chilled water can extend the paneer's shelf life.
4. Dipping in benzoic acid (1200 ppm) increases the shelf life of paneer to 40 days at refrigerated temperature and 20 days at 37°C.
5. By adding sorbic acid to milk (0.15%) and wrapping paneer in sorbic acid-coated waxed paper, the shelf life of paneer can be increased to 36 days at room temperature.

CONCLUSION

Milk is a perishable commodity, and the farmer has to bear heavy losses. There will be an increase in demand from the diet-conscious consumer segment, both from India and abroad. Dairy products have many beneficial roles and can fulfil the human body's nutritional requirements. Paneer is quite popular in India, and there are very easy methods to make paneer, and the cost of making it is also very less. Paneer is a rich animal protein, vitamin, calcium and iron source. It appeals to the farmers to adopt this method as much as possible. This article aims to convert milk into value-added products such as paneer and get maximum profit.

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CASHEW APPLE: COMMERCIAL EXPLOITATION FOR HEALTH AND NUTRITION

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ABSTRACT

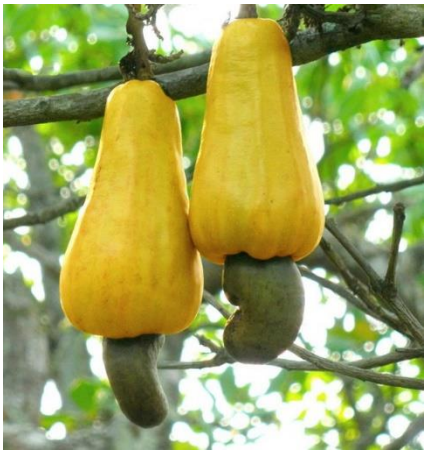
The Cashew apple, a tropical fruit rich in vitamins and minerals, is a delicious, fibrous, and nutrient-rich fruit. The cashew apple contains 8- 11% of fermentable sugars and Vitamin C, six times that of citrus fruits and ten times more than that of pineapple. The ascorbic acid content in cashew apples is high (240 mg/100 g), about six times that of citrus fruits (40 mg/100 g), a highly rich source of Vitamin C. However, due to its short production period and high perishability, more than a lakh of cashew apples are wasted in India without commercial exploitation. The value-added products from cashew apple is a thrust area of research for food technologists, industrialists and farmers and alternate cheap solution for nutritional source.

INTRODUCTION

Cashew fruit (*Anacardium occidentale*), commonly called apple, belongs to the *Anacardiaceae* family, is native to tropical America, and is widely available in several countries of Asia, Africa and Central America. Extensively cashew is grown for kidney-shaped nuts in tropical climates. However, the fruit which bears the nuts is also rich in vitamins and minerals. The cashew apple is an edible false delicious, fibrous and nutrient-rich fruit attached to the externally born nut by a stem. Contains sugars, amino acids, tannin, ascorbic acid (Vitamin C) and crude fibre. The ascorbic acid content in cashew apples is extremely high (240 mg/100 g), about six times that of citrus fruits (40 mg/100 g), a highly rich source of Vitamin C (Nagaraja, 2007). The cashew apple also has free soluble sugars, the majority of which are reducing sugars in addition to vitamin C. The crude fibre content of cashew apples, measured in terms of dry weight, ranges from 15 to 18%. Phenols, tannins, and flavonols present in cashew apples may act as natural antioxidants crucial in scavenging free radicals. The cashew apple is a good source of fibre and vitamin C. Consuming cashew apples may aid in overcoming constipation and a lack of Vitamin C (Sobhana, 2019). The cashew

apple, weighing about 8-10 times that of the nut, is an equally valuable product from the crop if it is economically exploited.

In India, cashew cultivation is popular in the states of Goa, Maharashtra, Karnataka, Kerala, Andra Pradesh and some pockets of Chhattisgarh and Jharkhand. However, about 95 per cent or more of the apple crop is not eaten, as the taste is not popular. For every tone of cashewnut produced, 8-10 tons of cashew apple is produced and more than 40 lakh tones completely wasted in India, without any commercial exploitation due to its short period availability and high perishability, except in Goa where it is profitably used for the production of feni, a fermented alcoholic beverage.



NUTRITIONAL VALUE OF FRESH CASHEW APPLE (PER 100g)

- Moisture :84.4- 88.7 g
- Protein :0.10- 0.162g
- Fat :0.05-0.50g
- Fiber :0.4-1.0g
- Carbohydrates :9.08-9.75g
- Calcium :0.9 -5.4 mg
- Phosphorous :6.1-21.4 mg
- Iron :0.19-0.71mg
- Carotene :0.03-0.742mg
- Ascorbic acid :146.6-372.0mg (Source: DCCD Kochi)

MULTIPLE USES OF CASHEW APPLE

1) INDUSTRIAL USES

About 10% of cashew apple juice is reduced sugar, and 20% of the cellulose in its bagasse is cellulose. The leftover fruits are utilized as a substrate for various microorganism fermentation processes. *Saccharomyces cerevisiae* made wine and bioethanol. *Lactobacillus casei* produces lactic acid and probiotic beverages. *Pseudomonas aeruginosa, Acinetobacter calcoaceticus* and *Bacillus subtilis* produced the biosurfactants rhamnolipids, emulsan, and surfactin, respectively. *Aspergillus spp*. developed tannase and pectinase during solid-state fermentation. The *Leuconostoc spp*. enzyme dextransucrase was used to

create prebiotic oligosaccharides. Depending on the type of microorganisms utilized, cashew apple has the potential to serve as a substrate for a wide range of goods.

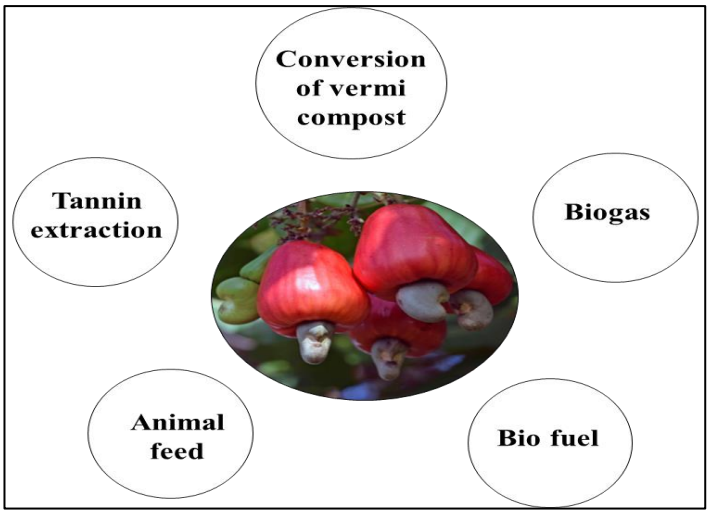
2) MEDICINAL USES

The fleshy cashew apple has 65-80% moisture, and its juice is rich in minerals, carbohydrates, polyphenols, and tannins. It can be used as a beverage and has potential therapeutic benefit for treating various illnesses. Fresh cashew apple juice is consumed more effectively to fight chronic diarrhoea, sore throats, and bone demineralization. Fresh or distilled cashew apple juice is believed to possess a special astringent property that relieves rheumatism and neuralgia. Cashew apples have a high caloric value, utilized as an energy booster to revive the body because the glucose in cashew apples serves as a quick source of energy, and the fructose controls insulin and stabilizes blood sugar. Copper improves blood vessel elasticity and increases oxygen-carrying capacity, while calcium promotes healthy bones and joints. It is also used as breath fresh and improves overall dental health for being a strong antioxidant (Mini *et al.*, 2005). In addition, fermented and fresh juice prevents age-related sleeplessness, macular degeneration and muscle cramps.

3) NEUTRACEUTICAL USES

The addition of cashew apple powder or cashew apple juice to food provides health benefits, including the prevention and treatment of disease

4) AGRICULTURAL USES



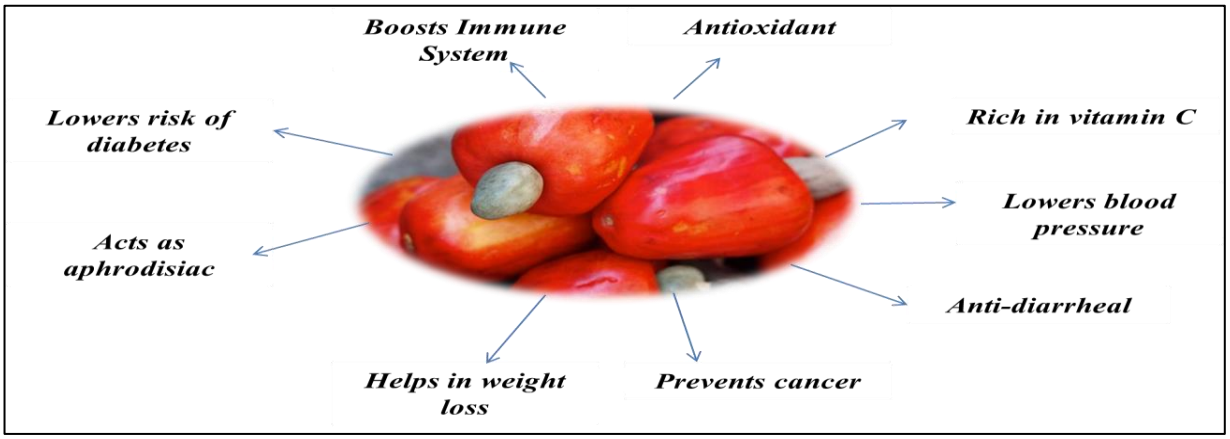
5) FOOD PRODUCTS

- Canned products
- Pulp products
- Confectioneries
- Culinary products
- Beverages: Fresh and Fermented

ANTI-NUTRITIONAL FACTORS

Antinutritional compounds such as cyanoglycosides (20.65 to 26.61 mg HCN/100g) and oxalic acid (1.2-1.7%) can be present in a measurable amount in cashew apples. Therefore, excessive intake may have a negative impact on people. Women experiencing IgE-mediated anaphylaxis reactions have seen cutaneous manifestation symptoms due to cardol and anacardic acid residual effects. Overconsumption of mango fruit, an anacardic counterpart of cashew, was found to cause similar allergy reactions. It is less utilized because of its astringent and acrid principles (Runjala and Kella 2017).

HEALTH BENEFITS



1. BOOSTS IMMUNE SYSTEM

   Cashew apple has anti-bacterial properties and is considered effective in treating stomach ulcers and gastritis, usually caused by *Helicobacter pylori* bacteria. Anarcardic acid is used in vivo to treat tooth abscesses and is efficient against gram-positive bacteria. The cashew apple is rich in natural vitamins, boosting the body's defences against infection and bacterial disorders. It strengthens our body and fights against microbial diseases because of the zinc that is present in it (Shobha *et al*., 2013).

2. ANTIOXIDANT

   Cashew apples have certain antioxidants that protect the body from damage that harmful molecules may cause. For example, anarcardic acid, an antioxidant found in cashew extract, has been proven to destroy cancer cells and decrease the effects of ageing-related pigmentation.

3. RICH IN VITAMIN C

   Cashew apples are extremely rich in vitamin C. When taken as juice or eaten as whole fruit, it supplies the body with sufficient vitamin C that has an anti-scurvy effect.

4. LOWERS BLOOD PRESSURE

   Consumption of cashew apples is beneficial in decreasing high blood pressure because of magnesium.

5. ANTI-DIARRHEAL

Cashew apple is effective in curing chronic dysentery and is also used as an anti-diarrheal remedy. In addition, it also serves as an ointment for aches of rheumatism and neuralgia.

6. PREVENTS CANCER

Moderate and regular eating of cashew fruits is highly beneficial in lowering the risk of cancer development because of compounds like flavonoids and antioxidants. These compounds can fight against tumour cells and prevent them from further dividing. In addition, Cashew fruits also help in fighting against cancerous cells due to the presence of copper.

7. HELPS IN WEIGHT LOSS

They are rich in 'heart-friendly' monounsaturated fatty acids like oleic and palmitoleic acids. These essential fatty acids help lower harmful Low-Density Lipoprotein cholesterol while increasing good High-Density Lipoprotein cholesterol in the blood. Moreover, the fibre-rich cashew apple increases the level of fat oxidation in adipose tissue and cholesterol hence recommended at a moderate level for those looking for weight reduction.

8. ACTS AS APHRODISIAC

Cashew apple is acrid, sweet, digestible, aphrodisiac, and anthelmintic. The spirit distilled from the fruit is considered rubefacient and is used as a diuretic.

9. LOWERS RISK OF DIABETES

Cashew apple helps in reducing the risk of type 2 diabetes because of their low sugar content and zero cholesterol. It is an excellent fruit for people who have diabetes as it is capable of preventing and treating other diabetes complications like obesity, cardiovascular risk and arterial hypertension

CONCLUSION

Cashew apple pseudo fruit is rich in vitamins and minerals and filled with delicious juicy and fibrous. In India, Cashew is grown mainly for its nut; after processing the nut, the apple fruit is discarded and completely wasted worldwide. Although the fruit has higher economic and nutritional health benefits, its full potential is not tapped for commercial exploitation due to its short-period availability and high perishability. Utilizing the fruit for its minerals and nutrients could be exploited with value-added products. Value addition is a thrust area of research for food nutritionists, industrialists and farmers forming an alternate solution for nutritional sources.

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RAJMASH (KIDNEY BEAN):

A high potential cash crop for nutrition and human health

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ABSTRACT

Rajmash plays a very important role in nutritional security by serving as an excellent source of protein and hence is labelled as a vegetarian analogue of meat. It contains a good source of cholesterol-lowering fibre. Consumption of Rajmash is beneficial in preventing and managing diabetes. Due to its high fibre content, it helps with weight loss. It is also a high-value cash crop, and it has an integral role in the livelihood security for rural and tribal peoples residing in higher hills where very limited options of livelihood exist.

INTRODUCTION

Rajmash (*Phaseolus vulgaris* L.) is known as Kidney bean, Common bean, Snap bean and French bean. Kidney beans are also known as the chilli bean because of their dark red colour and their visual resemblance to a kidney's shape. It is a highly significant grain legume crop predominantly cultivated in the Indian states of Maharashtra, Karnataka (Chickmagalur hills), Tamil Nadu (Nilgiri and Palani hills), Kerala (parts of Western Ghats), Himachal Pradesh, Uttarakhand, Jammu & Kashmir, Gujarat, West Bengal (Darjiling hills) and parts of North-Eastern states. The common bean is the most significant legume crop grown worldwide. Traditionally, Rajmash is grown in the Himalayan slopes during the *Kharif* season. However, a high yield is attainable in *Rabi* in plains due to better management. Local cultivars of rajmash grown in hills are known for their premium quality, which might have resulted due to its climatic conditions, the age-old practice of farmers, sensory qualities, and adaptation to this region's prevalent harsh climatic conditions. Uttarakhand's Munsiyari Rajma holds a GI (Geographical Indication) label, indicating that the unique taste and aroma are limited to a specific place. This crop is used as a source of food, feed and fodder. Green pods and leaves are used as vegetables, and grain as pulses. Its leaves are used to control household insects by some tribal groups in India, and its seeds are utilized as herbal treatments.

HEALTH BENEFITS OF RAJMASH

Kidney beans are essential for human health. Some of the health benefits of kidney beans are as follows:

1. Rajmash may help prevent cancer disease: Black and Bayo cultivars of common beans contain fermentable substrates that prevent early and advanced colon cancer development. In addition, epidemiological studies have found that bean consumption relates to a lower risk of breast cancer.
2. It controls blood sugar levels and may prevent diabetes: Consumption of Rajmash is beneficial in preventing and managing diabetes. Clinical studies show that consuming three or more servings of beans in a week decreases the menace of diabetes by almost 35%, compared to less or non-consumption of beans.
3. It is a high source of protein and helps in bone strength
4. It helps to prevent bad cholesterol: Continuous consumption of beans reduces cholesterol and LDL (Low-Density Lipoprotein) serum levels. Hence lowering total cholesterol and LDL cholesterol (the bad cholesterol) reduces the risk of heart disease.
5. It helps in maintaining healthy skin
6. It also keeps our hearts healthy
7. Due to its high fibre content, it helps with weight loss.

RECOMMENDED VARIETIES FOR CULTIVATION

Sr. No.	States	Recommended varieties
1	Uttar Pradesh	HUR-137 (Malviya Rajmash-137), Varun, HUR 15 (Malviya Rajma 15), Uday, Amber, Utkarsh, Arun
2	Bihar	IPR 96-4 (Amber), Utkarsh, Uday
3	Maharashtra	Varun, HPR-35
4	Karnataka	Arka Anup, Arka Komal, Arka Suvidha
5	Rajasthan	Ankur
6	Uttarakhand	VL Rajmash, 63VL Rajmash 125, VL Bean-2
7	Gujrat	Gujrat Rajma-1
8	Punjab	RBL 6
9	Haryana	CZM 45, CZM 99
10	Himachal Pradesh	Him Palam Kanchan Rajmash and Him Palam Triloki Rajmash
11	West Bengal	Uday, Amber, Utkarsh

(***Source:*** *ICAR-IIPR, Kanpur and Seed net GOI, Ministry of Agriculture & Farmer Welfare*)

CLIMATIC REQUIREMENTS

It grows well in tropical and temperate areas receiving an annual rainfall of 60-150 cm. However, the rajmash crop is highly sensitive to water logging and frost condition. It is grown during the *Kharif* season in hilly regions of the Himalayas and in the spring season in the lower hills and *tarai* region of India. However, it is cultivated in the *Rabi* season in the north-eastern plains and in Maharashtra state's hilly tracts. For proper growth and development, 10-27^{0}C temperature is required. Flower drop is a serious problem in the areas where temperature rises above 30^{0}C, and below 5^{0}C the flowers and developing pods and branches are damaged.

SOIL REQUIREMENT

Rajmash crops can thrive on a wide variety of soils. It can be grown in light loamy sand to heavy clay soil under adequate moisture. However, well-drained loamy soils are the best for their cultivation. This crop is very sensitive to salinity conditions. Therefore, the soil must be free from excessive soluble salts and neutral in reaction. The soil pH should be 5.5-7.0 to obtain a better yield. The acidic soils of the hills must be treated with lime before sowing.

LAND PREPARATION

Rajmash having bold and hard seed coat requires a fine seedbed and moisture in the soil for better germination of the seeds. A good seed bed have friable, but compact soil, adequate moisture and is free from weeds and plant debris of earlier crop. A deep ploughing followed by 2-3 harrowing should be given, and soil must be pulverized with a levelled field, making the fine soil tilth. The field should have proper drainage so that water stagnation can be avoided.

SOWING TIME

Sowing time is the most critical factor for achieving higher productivity of kidney beans. Advanced or delayed sowing may cause a substantial reduction in yield. Kidney beans are cultivated in both *Kharif, Rabi* and spring seasons in various parts of India. The best time for sowing is as follows

1. *Kharif* (Hills): last week of June to the first week of July
2. *Rabi* (Plains): 2nd fortnight of October and
3. Spring (Lower hills): February to 2nd fortnight of March.

SEED RATE & SPACING

For obtaining a good yield 100-125 kg/ha seed rate is required depending on sowing time and field condition. For sowing, during the *Kharif* season in hills, a spacing of 45-50 cm × 8-10 cm and for *Rabi* & Spring season, a spacing of 40 × 10 cm for irrigated conditions and a spacing of 30 cm x 10 cm is required

for the rain-fed condition. In hills, it is grown as an intercrop with maize in 1:2 ratios (between two rows of maize sown at 90 cm apart). In plains, it is grown as a spring season crop after harvesting potato and mustard. It is also found quite compatible for intercropping with early potatoes in 2:2 or 2:3 row ratios.

NUTRITIONAL REQUIREMENT

Rajmash is very inefficient in biological nitrogen fixation due to poor nodulation. Therefore, it requires relatively higher doses of fertilizer nitrogen. For optimum growth and development and enhanced productivity, the application of 100-125 kg N/ha is required. Rajmash responds well to phosphorus applications like cereals. Its phosphorus requirement is distinctly higher than other pulse crops. This crop requires 60-80 kg P_2O_5 per ha, and adding potassium hardly affects the yield. A full dose of phosphorus and half of the nitrogen should be applied as basal during sowing and the rest half as a top dressing after the first irrigation.

IRRIGATION AND WATER MANAGEMENT

Rajmash crop requires pre-sowing irrigation for better germination of the seed. It is the most irrigation-responsive pulse crop due to its shallow root system and high nutrient requirements. The critical stage for irrigation is about 3 to 4 weeks after sowing, followed by irrigation 75 days after sowing. It requires 2 to 3 irrigations in North Eastern Plain Zone and 3 to 4 irrigation in Central Zone to achieve a higher yield. The soil should have excellent drainage to avoid water logging.

WEED CONTROL MEASURES

Rajmash crop suffers from weeds in its initial stages, and the first month is critical to control the weeds. Application of a pre-emergence herbicide like pendimethalin @ 0.75 to 1 litre a.i./ha in 500-600 litres of water immediately after sowing. If the weed population is more, one-hand weeding or hoeing at 30-35 days after sowing should be done to keep the losses by weeds below Economic Threshold Level. A post-emergence application of imazethapyr 100 g/ha at 20-25 DAS followed by the application of quizalofop-ethyl 100 g/ha at 30-35 DAS is recommended to control weeds in rajmash crop (Goud *et al*., 2016).

PLANT PROTECTION MEASURES

INSECT-PEST CONTROL

Leaf miners, stem flies, black aphids, and pod borers are the major pest of a kidney bean.

Leaf Miner: It may be seen in the vegetative stage. Severely attacked seedlings are stunted, and leaves may turn yellow. To control leaf miners, spray metasystox @ 1 ml/litre of water twice at 15 days intervals. Regularly handpick and destroy the infected leaves. Neem-based products such as neem oil and neem leaf water extract give good control of leaf miners.

Stem fly: Young seedlings and plants wilt and die. To control this pest, treat the seed with Chlorphyriphos @ 8ml/kg seed and Soil application by Phorate 10 G @ 10 kg/ha is recommended.

Pod borer: Pod borer damages the pod and seeds. To control the pod borer, spray the crop with a systemic insecticide.

DISEASE MANAGEMENT

Stem Blight, Anthracnose and Angular leaf spot are the major diseases of Rajmash.

Stem Blight: Small water-soaked lesions are the first symptoms observed on leaves & appear within 4 to 10 days of infection. Develop, centre spots become dry and brown. Early or timely sowing and planting in well-drained soil reduce the disease infection to some extent. To control this disease, a foliar spray of Carbendazim or mancozeb @ 0.2 % is recommended.

Anthracnose: The main symptoms of this disease are pale brown sunken spots on the cotyledons. This disease infects both leaves and stems. Lesions on leaves are dark brown and restricted to the veins on the lower leaf surface. On stems, lesions are elongated and sunken. Frequent showers, heavy dews, temperatures of 20-30^{O}C and overcrowding of plants favour the spread and development of anthracnose. To control this disease, treat the seed with Carbendazim & Thirum in a ratio of 1:1. Spray (2-3 spray) the crop with Mancozeb 0.25 % or Carbendazim 0.1 % at 40-45 DAS and repeat 2-3 sprays at 15 days interval to get best results. The field should be free from crop debris after harvest, and overhead irrigation should be avoided.

HARVESTING, THRESHING AND YIELD

Rajmash crop is ready for harvesting when the pods turn brown and are ready for harvesting in 120-130 days, depending on variety and crop season. When plants have severe leaf fall, changing the colour of pods and hardness of the grains cut the crop with sickles and kept it in the field for 3-4 days for sun drying. Threshing is done by beating with sticks or trampling under bullocks' feet; the seed should be cleaned with a winnower. The seed should be sun-dried for 3-4 days to bring its moisture content to 9-10% and store the seed in the seed bin. Under irrigated plain conditions, a well managed crop can easily give 20-25q/ha yields and 5-10 q /ha under rain-fed hill conditions. A farmer can get about 40-50q/ha straw for cattle as fodder.

CONCLUSION

Kidney bean is a storehouse of protein and an ideal replacement for red meat. Kidney beans are an excellent source of minerals such as copper, iron, manganese, phosphorus, molybdenum and vitamins B_1 and folate. The goodness of fibre in rajmash is beneficial in lowering the risk of heart disease. It has negligible sugar content and is an ideal addition to a diabetic diet. Scientific cultivation will help improve the yield and quality of Rajmash. Adding Rajmash to the human diet may help improve human health by reducing the chances of the occurrence of various diseases.

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CURRENT STATUS, FUTURE PROSPECTS, AND OBSTACLES FOR PROTECTED CULTIVATION IN INDIA

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ABSTRACT

Protected cultivation is an important and innovative approach. However, the high cost of the structure and lack of knowledge about these technologies are the major challenges or barriers in the path of adaptation of protected cultivation for the farmers. With the innovations and ongoing developmental projects in polymer science, the protected cultivation technology will become modernized gradually. The current global and local demand for off-season products is the major driving force in adopting protected cultivation technologies. Supportive initiatives from the Government are helping advance the techniques and awareness related to protected agriculture.

INTRODUCTION

Protected cultivation is the cultivation of crops under a controlled environment suitable for optimum plant growth and production. These structures can significantly improve crop yield in areas where the climate is a major problem. Protected cultivation is a new alternative to cultivating seasonal and mainly off-seasonal vegetables (Jadhav & Rosentrater, 2017). Farmers can substantially maximize their profit by producing seasonal vegetables under a controlled environment in greenhouse technology, as they do not get a remarkable return after producing vegetables in their regular season for the larger availability of seasonal vegetables in the market. For example, cucurbits can be grown in the off-season using low-plastic tunnel technology in the northern plains of India.

The last two decades intimates a familiarity between the new agricultural practices or technologies and the growth, i.e., economic enhancement. The aptitude for agricultural improvement strategies is generally a mixture of growth and failure. If there is an appreciative achievement on the one hand, then the other will be fulfilled with missing opportunities (Nimbrayan et al., 2018). India needs new and developed production technologies to remain a self-sufficient country or provide the ultimate surety of feeding all the individual natives. Besides this, to become an exporter of good quality vegetables and fruits, farmers should

adopt the greenhouse technology required to continuously improve productivity, profitability and respectability of the Indian agricultural sector. Economic return from high-quality agricultural produce under protected conditions can be maximized substantially through protected cultivation by reducing the residues of chemical insecticides and pesticides on the crop grown in a greenhouse environment.

PRESENT STATUS OF PROTECTED CULTIVATION IN INDIA

Being a diversified climatic country, India has to show a tremendous increment in the field of protected cultivation for the growth of the Indian agriculture sector. However, depending upon various climatic conditions, the success rate of protected cultivation in this country varies significantly. Like in the northern part of the country, this type of technology is facing big challenges due to severe climatic conditions. Whereas areas like Bengaluru and Pune, the mild climatic condition becomes easily adaptive to this controlled cultivation technology. So, it is too tough to succeed in greenhouse cultivation all over India. Nearly 30,000 hectares of areas are under protected cultivation till now in India (Somasundaram et al., 2020).

Table1: Area under protected cultivation in different countries

Country	Area (ha)
China	27,60,000
Korea	57,444
Spain	52,170
Japan	49,049
Turkey	33,515
India	30,000
Italy	26,500
Mexico	11,579
Netherland	10,370
France	9,620
USA	8,425

The technical knowledge for adapting protected cultivation techniques is not remarkable now. Different Indian public sector now collaborates with institutions of developed countries for research and development project which contains technical designs and suitable modification of different greenhouse structure ideal for Indian climatic conditions, mainly specific region based. Protected cultivation techniques need careful planning, full attention and knowledge about the timing of crop production and, the most vital part, harvesting time for getting good market prices, selection of varieties which can easily adapt to the off-season conditions and produce higher economic yields of good quality produce.

Generally, the basic growth of protected cultivation depends on the different government policies which provide this country with a handsome amount of subsidies. There are various government institutions like NHM (National Horticulture Mission), RKVY (Rashtriya Krishi Vikas Yojana), NHB (National Horticulture Board) etc., who have launched several schemes to encourage the farmers to adopt this new technology.

PRESENT STATUS OF PROTECTED CULTIVATION IN THE WORLD

Nowadays, crop production in the greenhouse is a flourishing reality throughout the world, with a calculable amount of 405,000 hectares of greenhouses present all over the continents (Patel *et al*., 2017). More than 55 countries in modern times are associated with this technology. The protected cultivation was started in China during the nineties. As a result, they are the most advanced and developed in agriculture. Until now, the area that comes under greenhouse cultivation is more than 2.5 m ha, and 90 per cent area is under vegetables only (Jain *et al*., 2021). Israel also made their agriculture sector more advanced by adopting protected cultivation technology. The advantage of greenhouse techniques for producing high-quality vegetables, flowers, and fruits has been taken in desert areas where water is a limiting factor. A thousand acres of areas are under glass houses now in the United States, and comparatively larger areas can be found in England and Holland. Horticulture was practised under glasshouses over a century ago. India is now associated with international countries like Israel to adopt their protected cultivation technologies, which is expected to boost agricultural productivity significantly.

POTENTIAL AND STRATEGIES

Under different climatic environments, protected cultivation technique has remarkable potential over the country. In the protected farming method, farmers can provide suitable conditions to the plants for optimum growth and artificially increase production amount. A wide scale of interventions has been required for the highest potential areas like-

- ✓ The potential of plug tray nurseries nowadays can be used for cultivating horticultural crops on a commercial scale which can rise up as a profitable business.
- ✓ Uses of the insect-proof net house in large-scale units for hybrid seeds and vegetable production. This type of net house is also used for hybrid seed production in vegetables to maximize the farmer's overall return. In addition, fruit crops like pomegranate and papaya are also cultivated on a large scale.
- ✓ In arid and semi-arid regions under harsh environments, naturally ventilated poly houses are used on a large scale.
- ✓ Plastic mulches are practised on a large scale for commercial cultivation of vegetables in open fields, under the greenhouse and in net houses.

- ✓ Micrografted techniques on a medium scale can be used to increase the resistance of plant material against soil-borne pathogens.
- ✓ Protected cultivation is the only solution for every issue regarding farming. With this technique, farmers can solve all the problematic and uncertain climatic conditions, climate change, inappropriate uses and minimum productivity or availability of natural substances, nutritional security and activity in topography, environmental pollution because of pesticide uses, etc.
- ✓ Covering plant-protected cultivation controls different problematic climatic conditions but never disturbs the incoming and outgoing sunlight. As a result, plants get sufficient light required for photosynthesis, proper fertilization, optimum watering, and other productive factors.

SCOPE OF PROTECTED CULTIVATION IN INDIA

Protected cultivation has a tremendous scope to make elite the Indian horticulture sector. If it is organized popularly, there will be an extensive scope to protect the farmers from economic losses.

- ✓ In India, different problematic conditions like uncultivated or unproductive fallow lands, barren lands and desert areas are the major problems in terms of the utilization of uncultivated space. So, if these unproductive areas come under protected cultivation, it will be great for the inhabitants, who can yield substantial returns.
- ✓ High-quality vegetables and ornamentals have a massive demand throughout the year in technically developed cities. Also, cities' demand for off-season vegetables and high-priced fresh crops remains. Therefore, greenhouse production is mainly promoted to accomplish urban needs.
- ✓ There are adequate international demands for farming produce, mainly ornamental like cut flowers.
- ✓ Many healthful herbs and a wide range of orchids are generally cultivated on a large scale in India. So, a greenhouse can be the proper style for cultivating those rear plants in a controlled environment.

PROSPECTS OF PROTECTED CULTIVATION IN INDIA

1. Future aspects of protected cultivation in an arid and semi-arid region

In arid and semi-arid regions, climatic extremes like temperature fluctuations, low soil fertility, high wind velocity, and high solar radiation adversely affect open land area crop cultivation. Water is also a limiting factor in this region. That's why protected cultivation is the only way to promote agricultural practices in an arid and semi-arid regions. Low vegetation cover in this area favoured the protected cultivation as it constricts the place for pathogen survival on alternative hosts in the time of the non-cropped season. The humidity is also comparatively low in the environment, which is not favourable for pest epidemics and diseases to occur (Ghanghas *et al.*,

2018). So, taking this benefit of the climate, modification of existing protected cultivation structures can happen according to the cultivated crops and availability of resources in the particular region. Since the major viral, bacterial and fungal diseases are fewer in arid and semi-arid areas, horticultural crop cultivation in protected technology becomes supportive.

2. Cost-effectiveness of protected cultivation

The profit margin always depends upon the input, for all agricultural operations and output, after selling produce crops, which is comparatively low in open field conditions. The main aspect of increasing a farmer's monetary gains is maximizing production. Product quality is not much superior in open field conditions, and chemical residues are too high because of their excessive usage. The investment in protected cultivation is comparatively low as this technology reduces chemical usage and increases crop quality. These high-quality produce crops have all the access for export to different international markets and fetch more profit than open-field production.

3. Economic opportunity and employment services:

Protected cultivation will create a spectacular opportunity for this country's agriculture students to set their skills, economic opportunities, etc. They can quickly adapt to new technologies and move forward with protected technology. The potentiality of creating new jobs will be remarkable for the current unemployment situation all over India. Agricultural universities can play a significant role in capitalizing on students to promote greenhouse technology. If this happens, there will be effective market growth and exploding of new jobs alongside opportunities for chartering new innovations of ground-level technologies. It will be a pathway for further development of our country's agricultural economy in the coming years. A vertical farming process like Cocoponics can positively impact India's rural economy. Cocoponics is a cycling process of making compost from agricultural residues and is used as a soil medium for growing crops under protected cultivation (Majid, 2020). This method can generate new revenue and income opportunities for farmers, especially those living near barren or wastelands.

CHALLENGES OF PROTECTED CULTIVATION IN INDIA

1. Lack of trained professional and skilled labour

Protected cultivation is all about technology by which adverse environmental effects can be controlled and generate a suitable environment for the optimum growth of plants. For designing and fabrication of the greenhouse structure and maintenance throughout the year, well-skilled and technically experienced human resources will be needed. Unfortunately, this sector's development rate is minimal due to the lack of trained professionals and skilled labourers.

2. Non –availability of region-specific design

The availability of protected structures for the diverse climatic condition in India is so poor that the technology can't take off to its prime. The lack of advisory committees and practical training institutions in protected cultivation is one of the biggest challenges to overcoming the current situation. Small industries are taking advantage of the fabrication of greenhouse structures as they gradually rise up as big businesses by using low-quality materials to make more profit (Kumar et al., 2017). However, they also lack knowledge about basic steel, structural materials and cladding material quality.

3. Lack of availability of crop varieties and planting material

Specific variety or planting material is needed for protected cultivation. Farmers have to choose only those varieties with high commercial value in the market. Only some private sectors are doing business with specific planting materials needed for protected cultivation, and the cost is too high. Government should look into this matter. Active government seed agencies should serve quality seeds among farmers.

4. Lack of marketing for high-priced produce

Protected cultivation produce needs a good market to sell out with high-value efficiency as farmers can't let it at a low premium price. Massive cities are a suitable market for this. People should know low chemical residue levelled and high-quality products so they can show interest in it. A proper market strategy will be needed for the proper disposal of high-quality produce.

CONCLUSION

Protected cultivation is an important and innovative approach. However, the high cost of the structure and lack of knowledge about these technologies are the major challenges or barriers in the path of adaptation of protected cultivation for the farmers. With the innovations and ongoing developmental projects in polymer science, the protected cultivation technology will become modernized gradually. The current global and local demand for off-season products is the major driving force in adopting protected cultivation technologies. Supportive initiatives from the Government are helping advance the techniques and awareness related to protected agriculture.

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WATER-SAVING TECHNOLOGY FOR CULTIVATED FIELDS

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ABSTRACT

The flood irrigation method is primarily used in Indian agriculture and has a very low water use efficiency due to significant transportation and distribution losses. Water-saving strategies such as the renovation of bunds, laser levelling, adjustment of dates of sowing, and use of efficient varieties, mulching and drip irrigation etc., to improve the water use efficiency. Compared to the traditional surface technique of irrigation, which has a water use efficiency of just 35–40%, the drip method of irrigation, which we'll discuss above, may prove to be an effective approach for conserving water and enhancing water use efficiency.

INTRODUCTION

The foundation of Indian agriculture has increasingly become groundwater. Security of both the environment and the water supply. Nearly 62 per cent of groundwater is used for agriculture, 85% of rural water supply, and 50% of urban water supply. However, the country's ever-growing thirst for water has forced groundwater extraction in some areas to exceed annual replenishment. Adverse environmental effects include diminishing groundwater levels, de-saturation of aquifers, and deterioration of water quality. This decrease in water level is especially pronounced in the northern states of Punjab, Haryana, and Uttar Pradesh, where widespread acceptance of paddy-wheat monoculture has increased farmers' dependence on irrigation water supplies. In Punjab alone, where over 15 lakh tube wells are contributing to more than 70% of the irrigated area and endangering the state ground reserves, Despite numerous attempts at crop diversification, Punjab's paddy area has grown to 31.49 lakh hectares, making paddy agriculture eventually the primary factor in excessive groundwater consumption. In Punjab, out of 150 assessment units (blocks), 117 units (78%) have been labelled as "Overexploited," 6 units (4%), "Critical," 10, "Semi-Critical," and 17 units (11.33%) as "Safe" (National compilation on groundwater resources of India, 2020). As a result, Punjab, formerly known as the "Land of Five Rivers (Punj-aab)," is today India's most "overexploited" state due to the dire state of its groundwater resources.

Additionally, rising water from lower depths demands more energy, which has increased agricultural costs. This worrying situation necessitates effective water management measures to stop the

indiscriminate use of valuable groundwater supplies. Here are a few effective water management strategies and practical options for crops:

1) Irrigation channels should be repaired and cleaned

Before planting crops this season, irrigation channel maintenance should be done. The loss of irrigation water during transportation can be minimized by using an underground pipeline system. Create smaller field areas by dividing larger ones. This saves water due to uniform irrigation water application and shorter irrigation times.

2) Land levelling with a laser

To use water wisely, precision land levelling is the first stage, and a laser land leveller is one such tool that could encourage effective water use. In an agricultural field, laser levelling is a laser-guided precision levelling technology used to achieve very fine levelling with the specified grade. With laser levelling, a laser transmitter unit continuously emits a 360° rotating beam parallel to the necessary field plane. A laser receiver (also known as a receiving unit) installed on a mast on the scraper unit picks up this beam. A two-way hydraulic control valve automatically changes the scraper level in accordance with the converted cut and fill level adjustments from the signal received. Before employing the laser land leveller, the field is prepared by cultivating and planking. The efficient use of various agricultural inputs, including fertilizers, insecticides, and herbicides, is improved by laser levelling and saving water, electricity, and time. Additionally, this causes the crop to mature uniformly, improving the crop's quality and yield. An additional 5–10% yield advantage saves around 15–25% of irrigation water.

3) Prevent rice from being transplanted too soon

For better grain quality, water conservation, and a reduction in the growth of stem borers, Punjab should limit rice transplanting to a timely schedule (Jun 20 to Jul 5). This is because the warmth and evaporation are higher during the early stages of transplanting, increasing the crop's need for water. Conversely, seedlings moved after Jun 20 require fewer irrigations because the monsoon typically arrives at the end of June or relative humidity rises, lowering the warmth and evaporation rate. Therefore, delaying transplanting from June 15 to July 5 will result in significantly higher apparent and total water productivity and saving of irrigation water of 23.6 cm.

4) Variety of short duration

Grow short-duration PR varieties in accordance with the Ludhiana-based Punjab Agricultural University's advice. These short-duration cultivars, PR 126, PR 130, PR 127, PR 129, PR 121, and PR 128, mature after transplanting in 93, 105, 107, 108, 110, and 111 days, respectively, and stay on the

field for a shorter period, requiring fewer irrigations. These short-duration types not only conserve irrigation water but also leave the field early, making it simple to manage the straw for the timely seeding of wheat crops. Avoid growing non-PR kinds since they have a longer maturation period and need 15–25% more water than PR varieties.

5) Alternately wetting and drying

After transplanting, only leave the water constantly standing for two weeks to allow the seedlings to establish themselves properly. Irrigation is used two days after the ponded water has soaked into the soil following two weeks of continual submersion. The field is consequently alternately flooded and unflooded. However, caution should be made to prevent the field from developing fissures. Therefore, farmers can readily use alternate wetting and drying (AWD) in their fields to reduce the need for irrigation water. This method has demonstrated irrigation water savings of 15% to 25% without affecting crop output. On the other hand, continuous submersion does not increase yields; rather, it wastes irrigation water and may lead to an increase in the prevalence of pests and diseases.

6) Direct seeding of rice (DSR)

In comparison to puddled transplanted rice, direct seeding of rice (tar-water conditions) in medium to heavy textured soil also aids in saving 15 to 20% irrigation water. Apply the first irrigation using DSR technology about 21 days after sowing. After that, depending on the soil type and rainfall, apply irrigation every 5-7 days.

7) Diversity of crops

It attempts to replace the water-guzzling paddy grown on more than 85% of Punjab's cropland with less water-intensive crops and is seen as a successful solution to address the province's agri-water issues. To conserve groundwater, the state aims to convert 1.2 million ha of paddy (out of a total of 3 million ha) to alternative crops (maize, sugarcane, oilseeds and pulses, vegetable crops, and fruit plantations). The literature also points to several advantages of crop diversity, including groundwater preservation, soil regeneration through the growth of nitrogen-fixing plants, increased productivity, resource usage efficiency, ecological benefits, job creation, and sustainable agriculture.

8) Planting in the Ridge/Bed

Paddy can be transplanted on ridges (60 cm) or beds (67.5 cm) on heavy textured soils to conserve irrigation water. With a plant to plant distance of 9 cm on beds and 10 cm on ridges, irrigate the furrows before planting seedlings in the middle of the slopes (on both sides). Apply water regularly for the first 15 days after transplanting. After the ponded water has soaked into the soil for two days, start applying irrigation in furrows. Every effort should be made to prevent furrow cracking in the field.

Similar to this, two rows of wheat can be sown 20 cm apart in a bed that is 37.5 cm broad, with a 30 cm wide furrow between the two beds. For effective water and fertilizer use, reduced weed emergence, and other benefits, beds can also be used to plant other crops, including gobhi sarson, soybean, maize, cotton, moong, mash, mentha, chickpea, etc.

9) Drip irrigation

The process of drip irrigation, also known as trickling irrigation, involves pouring water onto the soil extremely slowly from a network of pipes made of small-diameter plastic and equipped with emitters or drippers. In contrast to surface irrigation, which includes watering the entire soil profile, water is supplied close to the plants so that just the portion of the soil where the roots develop is moist. Unlike other approaches, drip irrigation uses water applications more frequently (typically every 1-3 days), resulting in a more hospitable moisture level in the soil where plants thrive. The emitters release water and nutrients into the soil, which are then carried by capillary action and gravity into the root zone of the plants. By doing this, the plant's loss of moisture and nutrients is nearly immediately replaced, preventing it from ever experiencing water stress and improving quality, high yield, and optimum growth. Drip irrigation can conserve between 26 and 46% of irrigation water in the crops potato, chilli, onion, wheat, spring maize, pea, brinjal, turmeric cotton, mentha, gobhi sarson, and kinnow.

10) Mulching

The soil or ground is covered to create more favourable conditions for plant growth, development, and effective agricultural production. Mulching conserves soil water by lowering soil evaporation and

controlling soil temperature, reducing the need for irrigation during crop cultivation periods. By blocking sunlight from penetrating the soil's top layer, mulch decreases weeds' germination. Mulch also lessens rain's kinetic energy and pauses its effect, preventing runoff and giving the soil more time to absorb the rain. Additional moisture encourages plant root growth, which further contributes to soil stabilization. Using polythene sheets or crop waste, such as paddy straw, sugarcane garbage, etc., mulching can be done. Punjab generates a significant amount of paddy straw, which is easily used as a mulch for field crops, helping to address the state's serious residue-burning issue.

S. No.	Crops	Paddy straw mulch (q/acre)
1	Maize	30
2	Sugarcane	20-25
3	Mentha	24
4	Turmeric	36

Dynamic groundwater resources of India and Punjab (Year: 2020)

Parameter	India	Punjab
Total Annual Ground Water Recharge (BCM*)	436.15	22.80
Annual Extractable Ground Water Resources (BCM)	397.62	20.59
Annual Ground Water Extraction (BCM)	244.92	33.85
Stage of Ground Water Extraction (%)	61.60	164.4

Source: Central Ground Water Board, Government of India (* billion cubic meter)

CONCLUSION

The flood irrigation method is primarily used in Indian agriculture and has a very low water use efficiency due to significant transportation and distribution losses. Water-saving strategies such as the renovation of bunds, laser levelling, adjustment of dates of sowing, and use of efficient varieties, mulching and drip irrigation etc., to improve the water use efficiency. Compared to the traditional surface technique of irrigation, which has a water use efficiency of just 35–40%, the drip method of irrigation, which we'll discuss above, may prove to be an effective approach for conserving water and enhancing water use efficiency.