The Forgotten Grains – Millets: A Review

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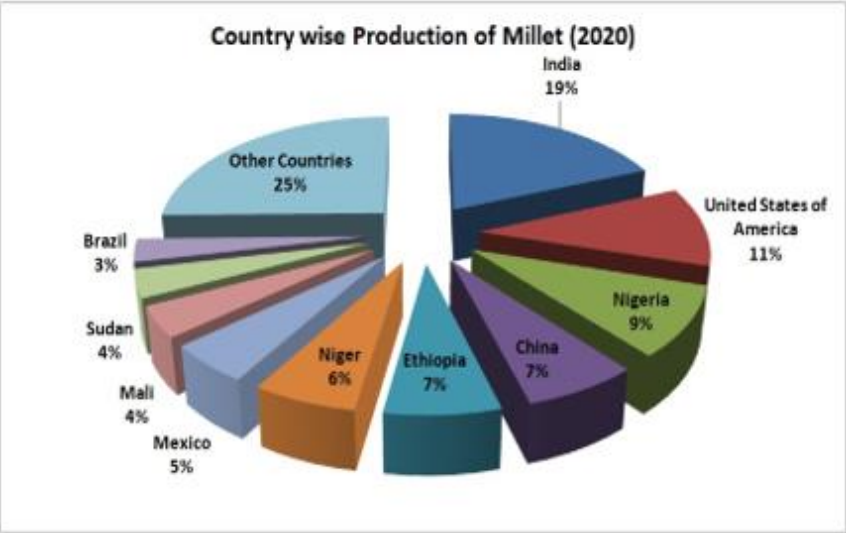
Abstract**—** *One of the earliest meals consumed by humans, millets may have been the first cereal grain employed in household cooking. Since ancient times, millets have been a primary source of nutrition for the inhabitants in semi-arid tropics in Asia and Africa, where other crops do not thrive. India and Asia have both been major millet consumers for centuries. Millet seeds are mashed and used to make the Indian flatbread roti. Despite all of these remarkable traits and capabilities of millet farming systems, the area dedicated to millet production has been declining over the past 50 years, and this decline accelerated during the green revolution. The little "grain" is free of gluten and rich in vitamins and minerals. Good quality protein, minerals, dietary fiber, phytochemicals, and vitamins are all abundant in millet grain, which is also extremely nutrient-dense. When compared to wheat and rice, millets have a lower glycemic index. When compared to wheat, the protein level of foxtail millet, proso millet, and pearl millet is greater. Kodo, tiny, foxtail, and barnyard millet have greater fiber contents. Modern as well as marginal farmers should be recommended to grow millets as it needs much less water and caring than its counterpart grains. Keeping this in mind a review of all the millets that can be grown in India has been included in this paper, pointing out millets from farmers perspective to include millets in his/her farming scheme as well from consumers perspective for its medical and health benefits.*

Keywords**— *Millets, Barnyard millet, Finger millet, Proso millet, Pearlmillet, Medical benefits.***

I. INTRODUCTION

1.1 Recognition of Millets on International level:

In 2023, the International Year of Millets was observed. The United Nations General Assembly declared 2023 the International Year of Millets in order to promote millet cultivation, consumption, and conservation. Millets are a type of grass with small seeds that is highly nutritious, drought resistant, and grows well in a variety of conditions. For thousands of years, they have been an important source of food for many communities all over the world. The International Year of Millets is predicted to have a number of positive effects, including enhanced food and nutrition security, higher income for smallholder farmers, and more sustainable use of natural resources. It is also intended to help achieve numerous SDGs, including SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), and SDG 13. (Climate Action). The International Year of Millets seeks to increase awareness of the importance of millets as a staple food, promote millet production and consumption, and encourage research and innovation in millet-based food systems.



Source: APEDA

1.2 Bring back Millets in farming again:

One of the first crops to be domesticated was millets. They were farmed in India for more than 5,000 years and were a staple meal in many ancient civilizations. From 3,300 to 1300 BCE, the Indus- Sarasvati civilisation ate millets. In 3,000 BC, the inhabitants of the Indus valley also ate them. They are also climate change resistant. They are an excellent alternative for dryland crops because of their innate endurance. More than rice output, millets accounted about 40% of all produced grains prior to the Green Revolution. With the effects of agriculture and the environment, millet output throughout time decreased from 40% of the grain production share to merely 10%. Wheat and rice are becoming common foods in India. During the last 60 years, our agricultural strategy has prioritised rice and wheat while ignoring millets, particularly small ones such as foxtail millet, tiny millet, browntop millet, and others. The availability of subsidised rice and wheat through the public distribution system and governmental nutrition programmes has also had a significant effect in shifting people's dietary choices from millets to rice in rainfed regions. Millets have vanished from our plates and fields as a result of systematic neglect. Millets are abundant in nutrients and include a lot of carbs, fibre, protein, and minerals including iron, magnesium, phosphorus, and zinc. They are also low in fat and have a low glycemic index, making them an excellent choice for diabetics.

II. TYPES OF MILLET

2.1 Sorghum Millet (Jowar) “Sorghum bicolor”:

Also known as great millet, broomcorn, guinea corn, durra, imphee, jowar, or milo.

2.1.1 Introduction:

Jowar, along with wheat, oats, maize and barley, is one of the world's top five grain products. Its origins are in Africa, which remains the biggest cultivator of this product. The produce has expanded to the south over time. Asia and the Americas are also included.

2.1.2 Expected medical and health benefits:

Sorghum has certain properties which makes it suitable for the patients suffered from chronic disorders, celiac disease, diabetes, obesity, celiac disease, oxidative stress and cancer. Sorghum's protein is not very easily digested. People with diabetes and obesity can benefit from sorghum as a food source due to its poor protein digestibility. Da Silva et al. (2011). Sorghum contains

a significant amount of dietary fiber (9.7–14.3 g), which is helpful for binding cholesterol, lengthening transit time, and delaying the absorption of carbs (Narasinga Rao, 2003). Sorghum lipid has the capacity to lower cholesterol. According to another research, sorghum grain includes nutrients that could be used as food additives or dietary supplements to lower cholesterol levels in adults (Carr et al., 2005). A good source of nutrients and minerals is sorghum. It typically resides in the sorghum grain's aleurone layer and germ. The main vitamins in sorghum include the vitamin B complex (pyridoxine, riboflavin, and thiamin) and a few fat-soluble vitamins (vitamins A, D, E, and K). (2012) MartinoI et al. For those with celiac disease, sorghum can be a good diet option because it is gluten-free thanks to gliadin-like peptides, according to Ciacci et al. Items made of sorghum could not reduce anti-transglutaminase antibodies after extended ingestion. In India, obesity is a growing problem that has been positively linked to many chronic diseases.

Coronary artery disease, stroke, insulin resistance, type 2 diabetes, hypertension, and metabolic condition are just a few of the well-known clinical co-morbidities associated with excessive body weight. According to experimental evidence (Alfieri et al., 1995), consuming foods high in dietary fiber helps to reduce the likelihood of becoming overweight. Sorghum is a rich source of dietary fiber and has unique physical properties including viscosity, the ability to hold onto water, and an upper limit on how much can be absorbed. These characteristics help to create the subsequent physiological conduct. It promotes fullness, aids in satisfying hunger, and has subsequent benefits. Sorghum lowers the chance of developing coronary heart disease. Sorghum has anti-carcinogenic chemicals that lessen the risk of oesophageal cancer. (1981, Van Rensburg). Antioxidant substances significantly contribute to halting the oxidation process and minimizing cellular damage. Antioxidant properties in sorghum can protect against reactive oxidative species. (Dayakar Rao and others, 2017).

Indian states suitable for cultivation: Maharashtra, Karnataka, MP, Tamil Nadu, Rajasthan, & Andhra Pradesh

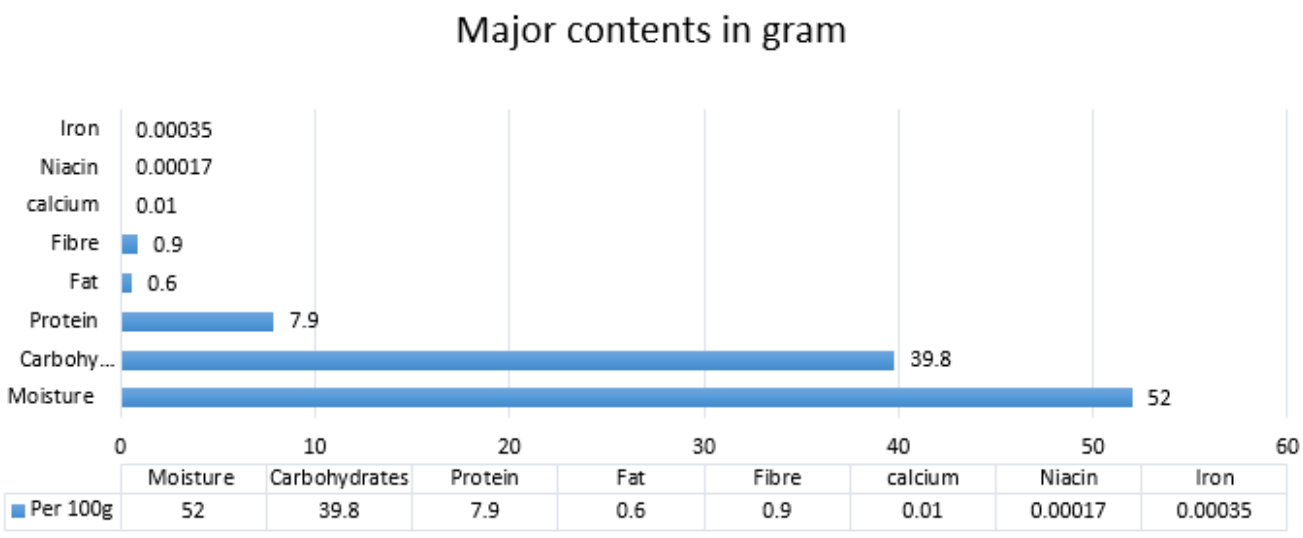
Cultivation months: Kharif season

Number of days: On average 115- 140 days

Total cost of production: On average 5557 rupees per hectare.

Cost per quintal in market sale: On average ₹3622.11./Quintal “variation between state markets”.

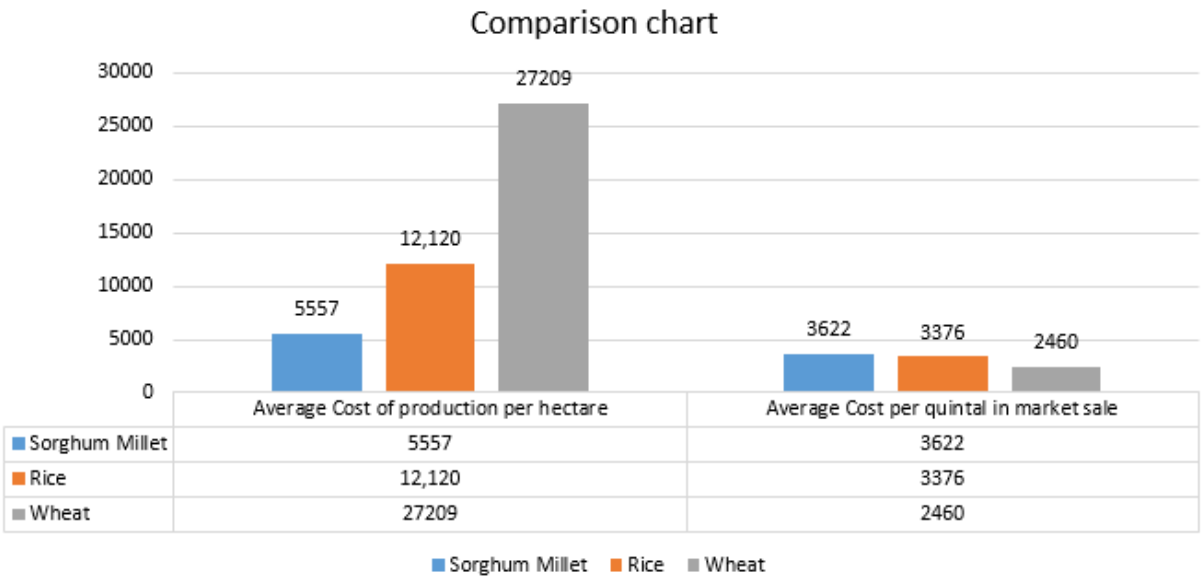
Major nutritional composition:



The nutritional composition of Sorghum bicolor grain includes energy (193 cal), moisture content (52 g), protein (7.1 g), fat (0.6 g), carbohydrates (39.8 g), fiber (0.9 g), calcium (10 mg), iron (3.5 mg), and niacin (1.7 mg). Phytochemical constituents include phenolics, polyflavonols, thiols, anthocyanins, tannins, 3-deoxyanthocyanidin, flavone, and flavanone (Dykes et al. 2009)

Expected Farmer income from one acre land: Net profit from 1 acre Sorghum farming,the farmer can get net profit of Rs.18, 995 – 20,000 by cultivating Sorghum in one acre land.

Comparison between rice and wheat on ground of cost and benefit:



2.2 Proso Millet (Chena / Barri) "Panicum miliaceum L."

Also known as common names, including proso millet, broomcorn millet, common millet, hog millet, Kashfi millet, red millet, and white millet.

2.2.1 Introduction:

An annual grain crop called proso millet (Panicum miliaceum L.) was cultivated in semiarid China around 10,000 years ago. India, Nigeria, Niger, and China are the main growing countries for it. Despite being extremely nutritious and healthy, proso millet is utilized as bird feed and fodder throughout Europe and North America.

2.2.2 Expected medical and health benefits:

Compared to rice, wheat, and barley, Proso millet has a lower glycemic index (GI), making it a better choice of diet for those with type-2 diabetes and cardiovascular disease (CVD) goods made with 100% it had GI (%/g) values between 50 and 65, as opposed to 70 to 80 for goods made with refined maize and wheat Comparison between rice and wheat on ground of cost and benefit. Proso Millet protein (PMP) plays a crucial function in the metabolism of cholesterol because it can raise levels of adiponectin and high-density lipoprotein (HDL) cholesterol, particularly the isomer HDL2, without changing levels of LDL cholesterol. In addition to promoting lipid metabolism, adiponectin plays a critical role in enhancing insulin sensitivity The process of atherosclerosis, which causes heart attacks and strokes, is thought to start with damage to the blood vessel's inner walls. As a result, feeding PMP can actively lower blood sugar and insulin levels after eating a high-fat meal by increasing HDL and adiponectin levels. Additionally, because TNF and insulin sensitivity have a negative correlation, PMP also down regulates TNF .The only nutritional therapy available for a person with celiac disease is diet improvement and avoiding gluten. People who have this condition also have an allergy to gluten, a protein that is present in grains such wheat, rye, barley, and oats. Lecithin, which is abundant in PM and plays a significant function in the neurological health system by repairing and renewing myelin fiber and accelerating brain cell metabolism, is present in high concentrations. Niacin, folic acid, and vitamin B-complex are also present in large amounts in PM .Compared to main cereal grains, PM has a substantially greater mineral content. PM's high fiber and antioxidant content is also beneficial in preventing cancer and cardiovascular disease. Zhang et

al.'s (2014) study revealed that PM had antiproliferative characteristics against HepG2 human liver cancer cells and MDA human breast cancer cells, which were both originally identified as parts of the MD Anderson line of breast cancer cells.

Indian states suitable for cultivation: Tamil nadu, Andhra Pradesh, central and eastern Uttar Pradesh, western Bihar, North Eastern states.

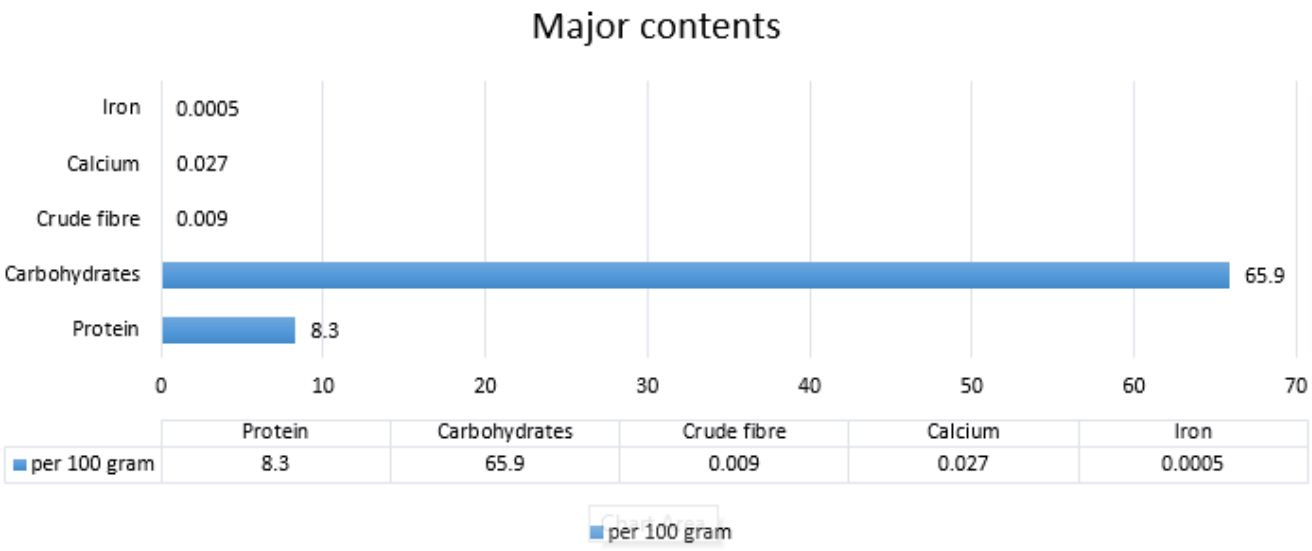
Cultivation months: The rainy season crop is sown in onset of monsoon preferable in July. September – October in Tamil nadu and Andhra Pradesh, Mid March-mid May in Bihar and Uttar Pradesh as irrigated catch crop.

Number of days: On average 60 to 100 days

Total cost of production: On average 5804 rupees per hectare.

Cost per quintal in market sale: On average 5500.00 INR/Quintal variation between state markets.

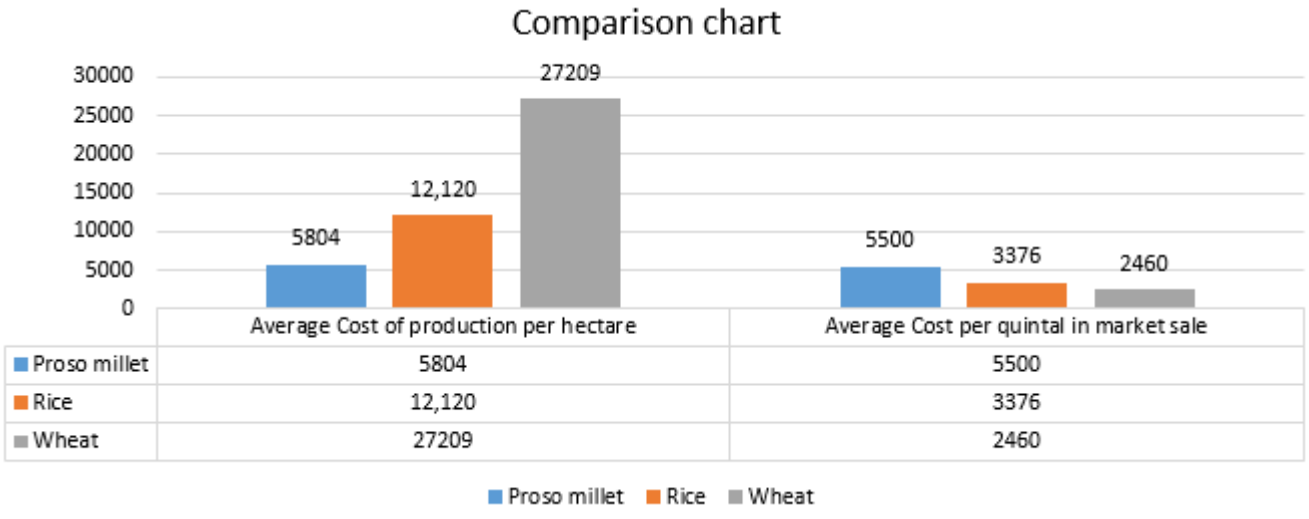
Major nutritional composition:



Niacin, B-complex vitamins, folic acid, PCa, Zn, Fe, essential amino acids (methionine and cysteine), starch, and phenolic compounds like antioxidants and beta-glucan are all abundant in proso millet grains.

Expected Farmer income from one acre land: Net profit from 1 acre Sorghum farming,the farmer can get net profit of Rs.43000-44800 per acre by cultivating proso in one acre land.

Comparison between rice and wheat on ground of cost and benefit:



2.3 Pearl Millet (Bajra) "Pennisetum glaucum (L.) R. Br.)":

This crop is also known as Pearl millet, candle millet, dark millet, bajra, indian millet, horse millet.

2.3.1 Introduction:

Pearl millet grain is considered as a staple food in Africa and India where it is used to make flour, bread, porridge and "couscous" (Ecoport et.al., 2009). As a feedstuff it is mainly grown to produce hay, silage, green-chop, pasture and standover feed grazed directly (FAO, 2009). but contain less lignin, more crude protein, have higher DM degradability and digestibility, and their overall quality does not drop as quickly as they mature, as occurs with normal mid-rib types (Hassanat et al.,2007).

2.3.2 Expected medical and health benefits:

Prevents Type 2 Diabetes, Pearl millet has a special composition that includes healthy carbs and dietary fiber that lower blood sugar levels. Slowly digesting starch: By regularly putting Pearl millet in your diet, you can reduce your chance of acquiring diabetes. Low glycemic index: When compared to foods with a high glycemic index, pearl millet raises blood sugar levels more gradually. Alternative without gluten: If you are gluten intolerant, try Bajra roti with methi, which is made from pearl millet. As one of the most significant Pearl millet Benefits, include Bajra, or Pearl Millet, in your diet might be helpful if you're trying to reduce weight. The protein in this millet aids in tissue repair and muscular growth. For vegetarians aiming to limit carbohydrates, it is a viable substitute due to its high protein content. Another advantage of pearl millet is that it lessens the risk of polycystic ovarian syndrome (PCOS). Women of all ages, including teens and those going through menopause, are susceptible to PCOS, a common hormonal condition. This disorder affects mood, causes tiredness, and unwelcome hair growth in addition to producing health problems.

Including Bajra (Pearl Millet) in the diet can be advantageous in addition to taking medicine, losing weight, and following strict dietary guidelines. Iron and fiber, both of which are abundant in pearl millet, aid in the reduction of visceral fat, especially in the abdominal area. In turn, this controls the menstrual cycle and shields against related lifestyle diseases. Magnesium and potassium, which are abundant in pearl millet and are essential for widening blood vessels and enhancing blood circulation, are present in high concentrations. This miracle millet can prevent artery blockages by lowering LDL cholesterol when consumed regularly. Furthermore, Omega-3 fatty acids and plant lignans found in Pearl Millet types contribute to heart health and general wellbeing. Bajra promotes healthy digestion and avoids constipation, which is crucial for your overall wellbeing. It's excellent for Celiacs as a gluten-free cereal. When consumed consistently, bajra's high insoluble fiber content may help ease constipation. By giving the stool more volume, this fiber encourages regular bowel motions and guards against digestive problems.

Indian states suitable for cultivation: Bajra in India and is mostly farmed in the states of Gujarat, Rajasthan, Maharashtra, Uttar Pradesh, and Haryana.

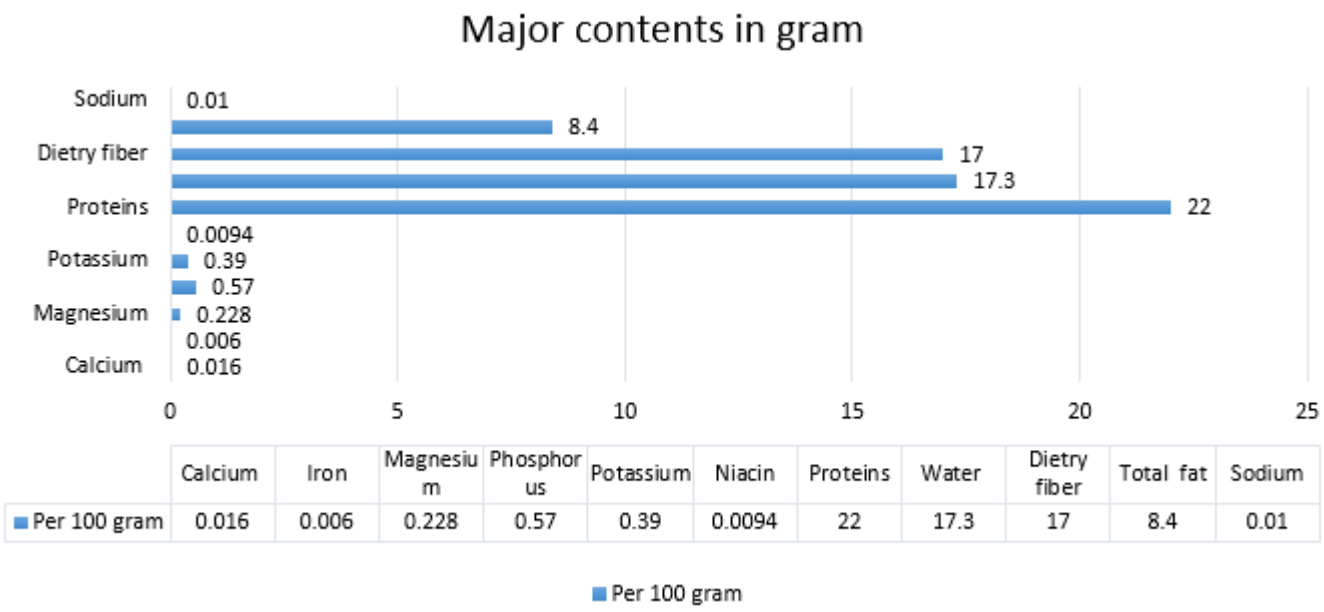
Cultivation months: In the north and center of the nation, kharif pearl millet should be sown during the first two weeks of July, just before the monsoon season begins. In Tamil Nadu, rabi season is appropriate during the first two weeks of October. Prior to the first monsoon rains, dry sowing is advised in the Maharashtra region of Marathwada. Summer pearl millet should be sown last week of January to 1st week of February to obtain higher production of summer pearl millet.

Number of days: On average 80 to 90 days.

Total cost of production: Approximately the cost of production per hectare is around Rs. 27020.70/ha.

Cost per quintal in market sale: On average ₹2200 /Quintal on average

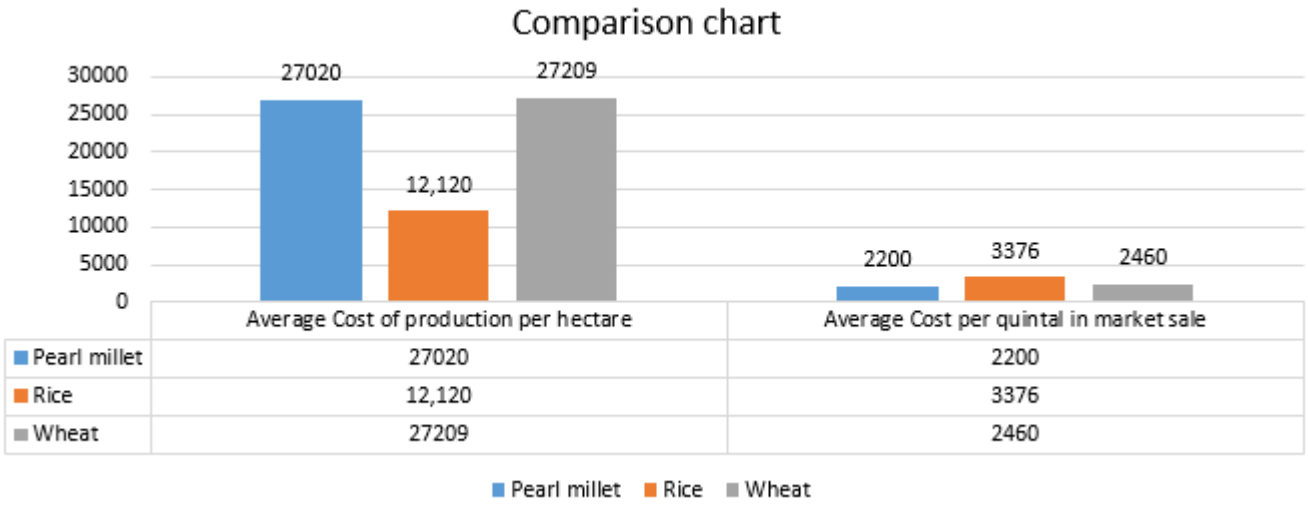
Major nutritional composition:



	Calcium	Iron	Magnesium	Phosphorus	Potassium	Niacin	Proteins	Water	Dietry fiber	Total fat	Sodium
Per 100 gram	0.016	0.006	0.228	0.57	0.39	0.0094	22	17.3	17	8.4	0.01

Expected Farmer income from one acre land: Net profit from 1 acre Sorghum farming under irrigated condition,the farmer can get net profit of Rs.50000-52000 per acre and in rainfed condition 31000 rupees per acre.

Comparison between rice and wheat on ground of cost and benefit:



	Average Cost of production per hectare	Average Cost per quintal in market sale
Pearl millet	27020	2200
Rice	12,120	3376
Wheat	27209	2460

2.4 Foxtail Millet (Kakum / Kangni) “Setaria italic”:

Second most widely grown millet in India is foxtail millet, also called as Kangni or Kakum in Hindi. Foxtail millet, also as Italian millet.

2.4.1 Introduction:

One of the first cereal grains to be domesticated, foxtail millet (Setaria italica (L.) P. Beauv.) is also the most economically significant species in the Setaria genus. However, it is also planted as a fodder plant. Foxtail millet is often grown for its grain (see the Foxtail millet grain datasheet). Setaria italica comes in a variety of cultivated and wild varieties and is interfertile. In temperate regions, annual weeds known as green foxtail millet are the wild forms. Height, habit, inflorescence form, quantity, and grain color vary among cultivars. The foxtail millet plant produces useful hay and silage.

2.4.2 Expected medical and health benefits:

According to an in vitro research conducted in 2003 by Chen et al., foxtail millets have a low glycemic index and may stimulate the pancreatic cells to create insulin, a hormone that controls blood sugar levels. These activities may lessen the blood sugar increase. Foxtail millets were found in 2003 by Choi et al. to improve the body cells' receptivity to insulin, a hormone that regulates blood sugar and has anti-diabetic properties. This suggests that eating foxtail millet may aid in controlling diabetes. The lower end of the digestive system's colon and rectum are both affected by colorectal cancer. According to published research, eating whole grains or cereals may help reduce the incidence of colorectal cancer. Foxtail millets were shown to have a new antifungal protein molecule in an experiment conducted by Wentao et al. in 2011. This protein molecule is known to have action against fungus like Botrytis cinerea and Alternaria alternative, which cause allergies and asthma. Foxtail millets may prevent the development of certain fungus, acting as an antifungal agent against them. This shows that foxtail millets may be able to treat fungus infections. A lack of nutritional intake is the primary cause of undernutrition. According to a meta-analysis by Seetha et al. from 2022, adding millets to the diet may assist with undernutrition since they include nutrients including methionine (an important amino acid), calcium, protein, zinc, and others. The results of this study lend credence to the usage of foxtail millets as an undernutrition remedy. Since foxtail millets are a great source of iron, which is necessary for the production of hemoglobin, increasing your iron intake may help you manage your anemia from iron deficiency. By lowering bile acid generation and bile cholesterol levels, foxtail millets' insoluble fiber content lowers the incidence of gallstones.

Indian states suitable for cultivation: Andhra Pradesh, Karnataka, Tamil Nadu, Rajasthan, Uttar Pradesh, Uttarakhand.

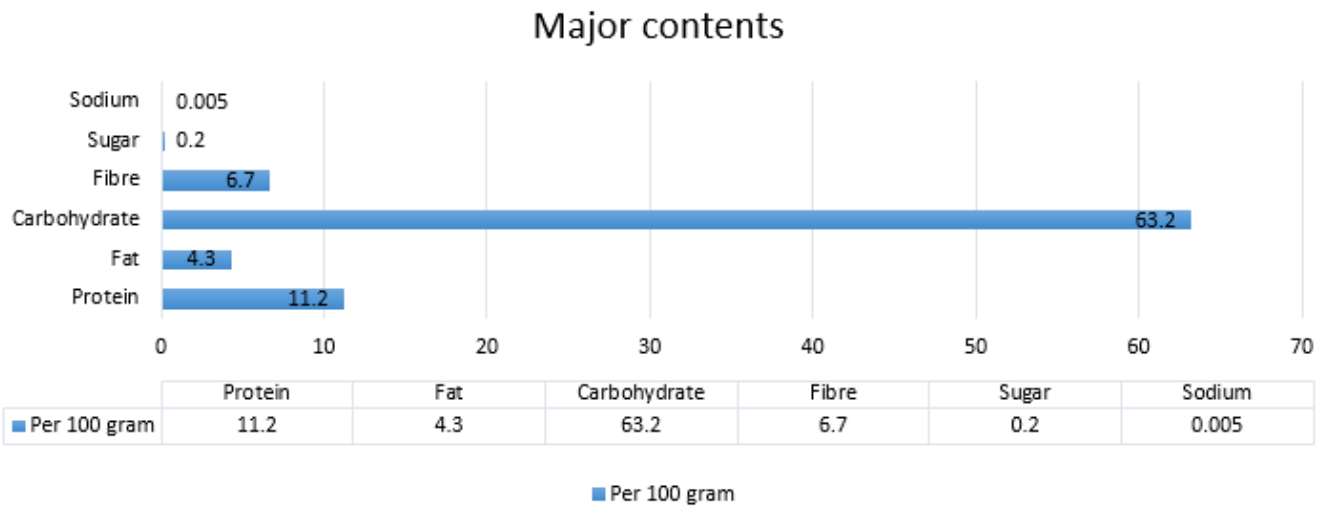
Cultivation months: August–September in Tamil Nadu., July-August in Karnataka. First fortnight of July in Andhra Pradesh, Second and third week of July in Maharashtra. In Tamil Nadu, Kharif irrigated crop is planted from the beginning of June to end of July and summer irrigated crop in January, Plains of Uttar Pradesh and Bihar, middle of June.

Number of days: On average 80 to 90 days.

Total cost of production: Approximately the cost of production per hectare around Rs.11607.2

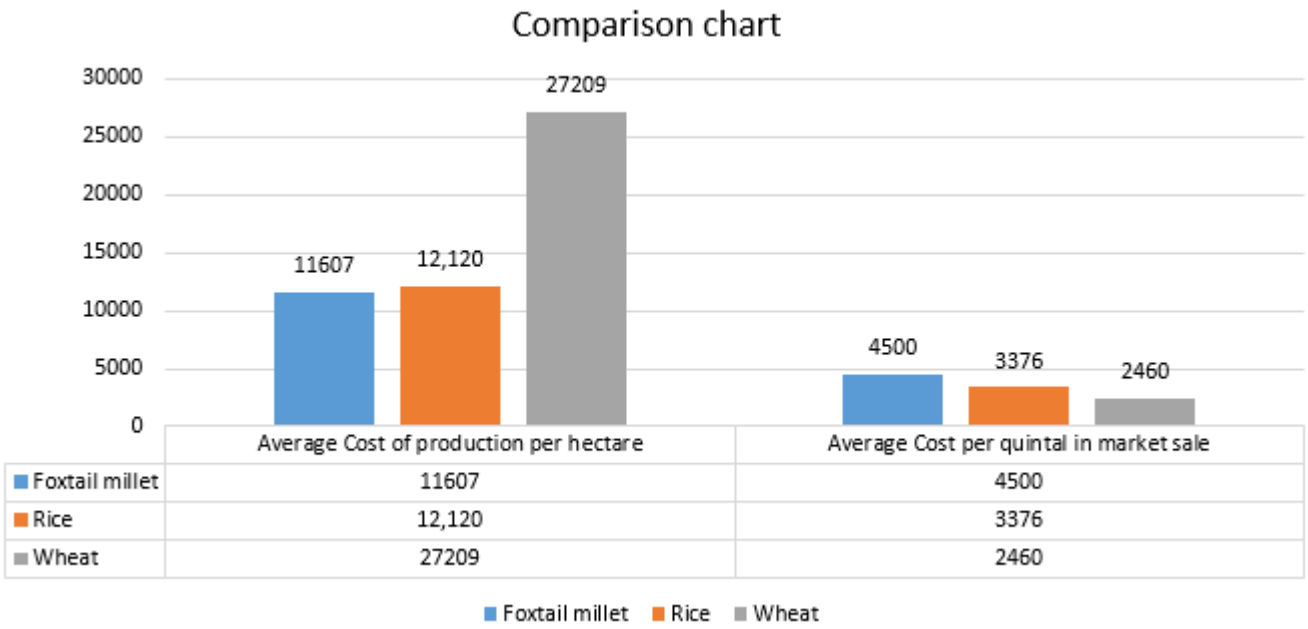
Cost per quintal in market sale: On average 4500 rupees per quintal.

Major nutritional composition:



Expected Farmer income from one acre land: Net profit from 1 acre foxtail millet farming is around 40000 rupees to 50000 rupees per acre.

Comparison between rice and wheat on ground of cost and benefit:



2.5 Finger Millet (Ragi) "Eleusine coracana"

Numerous names, including ragi (in Kannada, Telugu, and Hindi), Mandua/Mangal in Hindi, Kodra (in Himachal Pradesh), Mandia (in Oriya), Taidalu (in the Telangana area), Kezhvaragu in Tamil, etc., are also used to refer to finger millet in India.

2.5.1 Introduction:

The resilient crop finger millet thrives in arid highland regions of Asia and Africa. In times of drought and crop failure, its little, tough grain may be easily stored and is a dependable food supply.

The biggest yearly production on the continent is produced in Uganda, but finger millet is planted across the savannah and highlands of Eastern and Southern Africa.

2.5.2 Expected medical and health benefits:

Consuming finger millet, which is a very rich source of natural iron, aids in anemia recovery. Due to their high calcium and iron content, meals made from ragi are particularly well suited for older people and pregnant moms. For asthma, liver diseases, high blood pressure, and weak hearts, green ragi (finger millet) is advised. When a mother is nursing and her milk supply is low, green ragi is also advised. Regular consumption of finger millet may help stave off malnutrition, degenerative illnesses, and early aging. The phytochemicals in finger millet aid in slowing down the digestive process. This aids in the management of diabetes-related blood sugar levels. It has been discovered that a diet heavy in finger millet—which has more fiber than rice and wheat—helps diabetics. Additionally, the study discovered that a diet consisting mostly of whole finger millet has a

decreased glycemic response, or a capacity to raise blood sugar levels. This is because finger millet flour contains ingredients that reduce the digestion and absorption of carbohydrate. Regular consumption of finger millet promotes bone health, wards off conditions like osteoporosis, and may lower the chance of fracture. It is now well-established that phytates, polyphenols, and tannins can help millet foods' antioxidant activity, which is a crucial component in maintaining good health, slowing the aging process, and preventing metabolic illnesses FAO (1991).

Indian states suitable for cultivation: Ragi (finger millet) is mostly farmed and eaten in Karnataka in India, with smaller amounts also being produced and consumed in Andhra Pradesh, Tamil Nadu, Odisha, Maharashtra, Uttarakhand, and Goa.

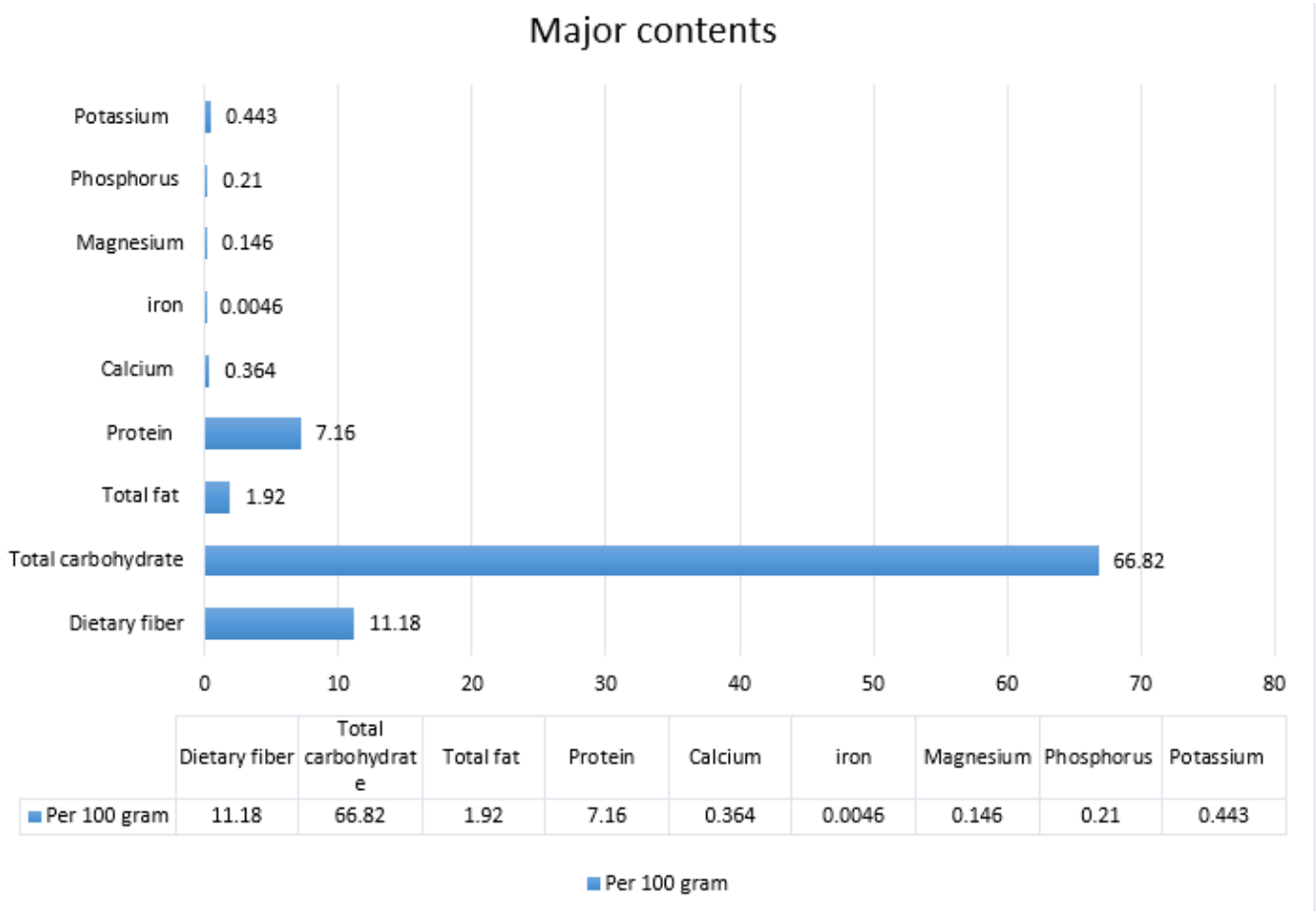
Cultivation months: In various regions of the nation, finger millet is farmed during all of the harvest seasons. The Kharif season is when more than 90% of the area is planted and cultivated.

Number of days: Depending on the tract and the type, the crop takes between 120 and 135 days to reach maturity.

Total cost of production: Ragi cultivation cost an average of Rs. 43,706 per hectare under rainfed conditions and Rs. 57,874 under irrigation conditions, respectively. Due to additional labor, FYM, fertilizer consumption, and irrigation costs, it was discovered that irrigated farming was more expensive than rainfed farming. Taking average cost of Rs. 36,900.

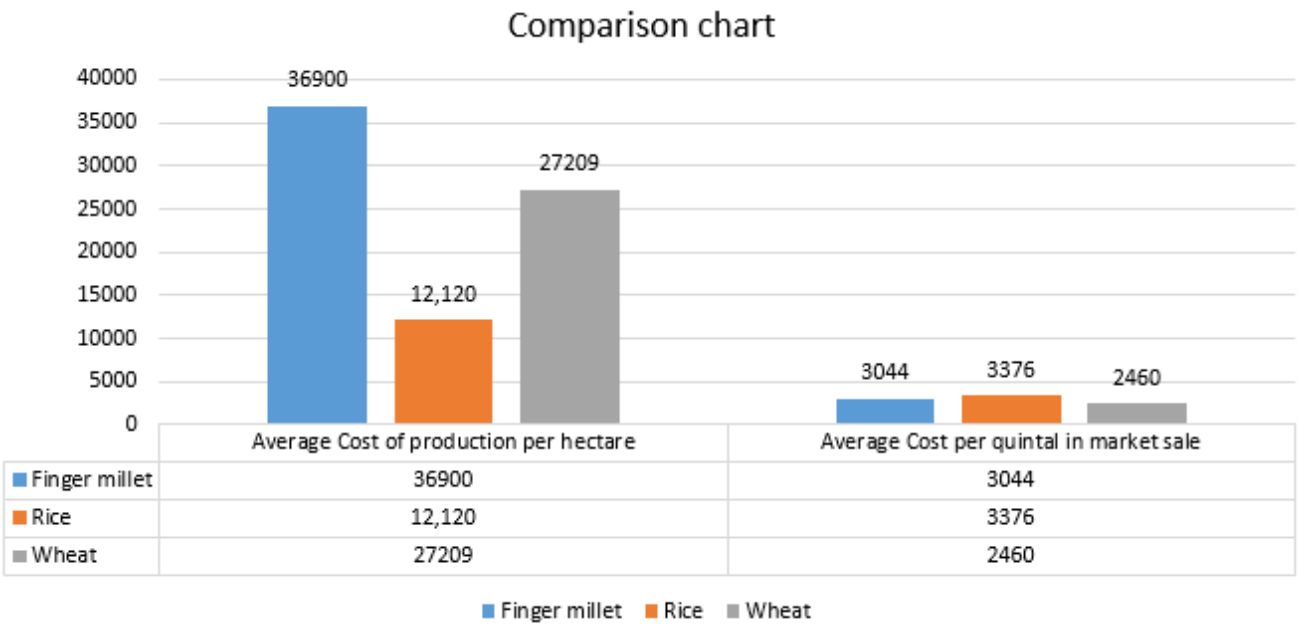
Cost per quintal in market sale: The average price of Ragi (Finger Millet), according to current market pricing, is Rs. 3044.45/Quintal.

Major nutritional composition:



Expected Farmer income from one acre land: Average net profit from 1 acre finger millet farming is around 30440 rupees per acre.

Comparison between rice and wheat on ground of cost and benefit:



	Average Cost of production per hectare	Average Cost per quintal in market sale
Finger millet	36900	3044
Rice	12,120	3376
Wheat	27209	2460

2.6 Browntop Millet (Korle) "Urochloa ramose":

Brown Top millet, also known as pala pul in Tamil, Kannada (Korale), and Telugu (Andakorra).

2.6.1 Introduction:

One of the rarest millet species is browntop millet, often known as signalgrass. It is indigenous to India and thrives in dryland areas. Browntop millet may be grown in low, often flooded locations and is heat and drought resistant. Its ability to tolerate shadows sets Korale apart from other crops. Even under tamarind trees, the crop that thrives in shade, grows well.

2.6.2 Expected medical and health benefits:

One of the greatest advantages of Brown top millet is this. Protein, fiber, and B vitamins including niacin, thiamin, and riboflavin are all included in brown top millet. Iron, phosphorus, and magnesium are also present. These substances benefit health. Finally, Brown Top Millet helps our body produce energy, red blood cells, and promotes immune system, cognitive, and physical health. This beneficial grain can help you manage diabetes by stabilizing blood sugar levels, lowering HbA1C, and improving insulin sensitivity. For better overall health, don't be afraid to incorporate this little powerhouse in your meals. Brown top millet is a fantastic option for anyone with Celiac disease or IBS because it is gluten-free. Bloating, cramping, and starch digestion are reduced. Brown top millet also relieves constipation and supports a healthy digestive tract by regulating bowel motions. Like any other millet, brown top millet is well known for enhancing heart health and reducing the risk of cardiovascular disease. Due to their high protein, fiber, and low carbohydrate content, these grains help to lower LDL cholesterol, prevent arterial clogs, and enhance heart function. Magnesium, calcium, and phosphorus are all vital nutrients for healthy bones and muscles, and brown top millet is an exceptional supplier of these nutrients.

Indian states suitable for cultivation: border territories between Karnataka and Andhra Pradesh, which include parts of the Karnataka districts of Tumkur, Chitradurga, and Chikkaballapura and the Andhra Pradesh district of Ananthpur.

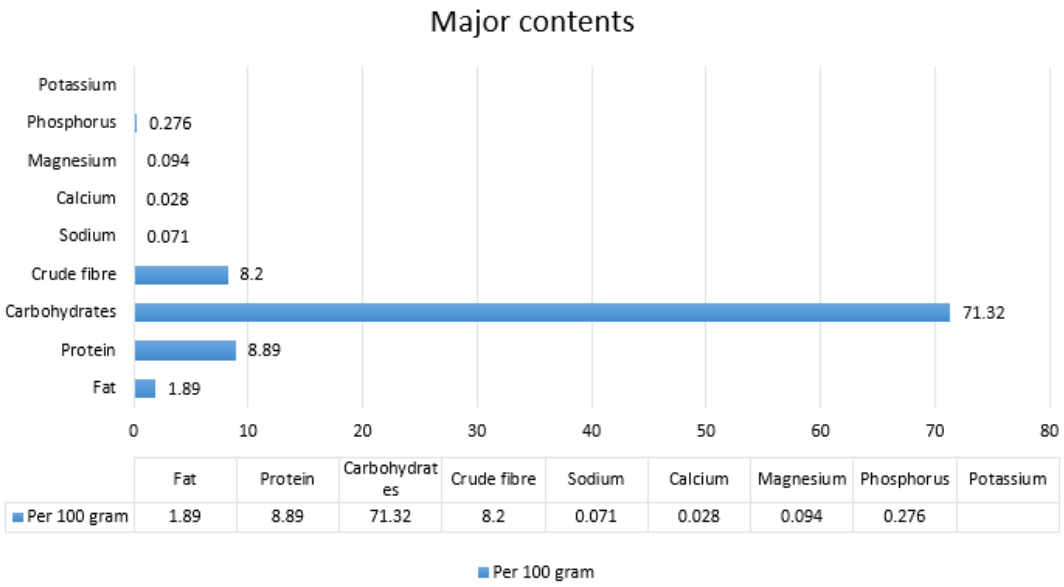
Cultivation months: Most places grow it from mid-April to mid-August, however later plantings will produce lesser yields. It may be grown either as a seasonal crop alone or in conjunction with other crops. Additionally, it is a great option when coupled with other millets. Redgram is really planted as part of a mixed crop, with 12 rows of browntop millet.

Number of days: On average needs 75 to 80days to mature.

Total cost of production: On average Browntop millet cost around 3334 rupees per hectare for cultivation in India.

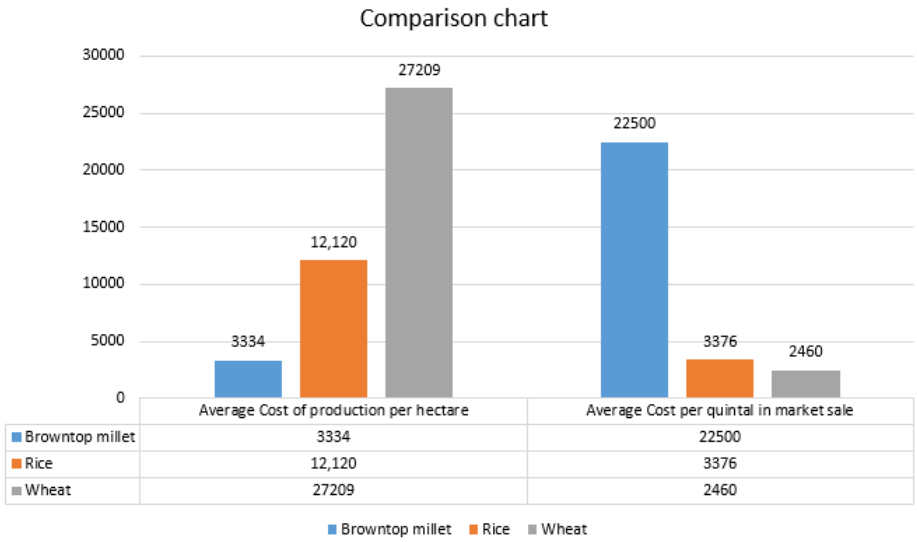
Cost per quintal in market sale: The average price of Browntop millet according to current market pricing, is Rs. 22500 per quintal.

Major nutritional composition:



Expected Farmer income from one acre land: Approximate net profit from well irrigated 1 acre browntop millet farming is around 130000 -140000 rupees per acre.

Comparison between rice and wheat on ground of cost and benefit:



2.7 Barnyard Millet (Sanwa) "Echinochloa esculenta":

Also Commonly named as Sanwa (Hindi), oodalu (Kannada), Kavadapullu (Malayalam), Kuthiravali (Tamil), Udalu (Telugu), Kira (Oriya).

2.7.1 Introduction:

A less significant grain crop is barnyard millet. It can survive water logging situations in addition to being particularly drought resistant. Typically, it is farmed as a rainfed crop. Like rice, kudiraivali grains are eaten. They are also employed in the creation of kheer, or rice pudding. Protein has a 40% digestibility rate.

2.7.2 Expected medical and health benefits:

Barnyard millet contains a high level of amylase retrogradation, which promotes the development of more resistant starches in increasing concentrations. Therefore, it could be suggested to those who have diabetes and cardiovascular disease. Due to its magnesium content, it lowers blood pressure. Increased dietary fiber helps to raise good cholesterol and reduce bad cholesterol. Barnyard millet is a great food to treat anemia because of its high iron level. Barnyard millet provides the necessary elements for a healthy metabolism when consumed in moderation. Barnyard millet can aid with symptoms like these, especially in anaemia situations when the body feels perpetually low on energy and exhausted. Barnyard millet is an excellent source of antioxidants that are beneficial for preserving skin health since it is packed with phenols and flavonoids. Additionally, the inclusion of iron and zinc aids in the promotion of robust hair growth. Barnyard millet prevents constipation, bloating, stomach pains, and acid reflux while promoting regular bowel motions.

Indian states suitable for cultivation: In Malaysia, the East Indies, China, Japan, and India, barnyard millet is cultivated. When the rice harvest fails, it is rumored that it is produced as a replacement crop in China and Japan. Africa and the United States of America are somewhat affected by it as well. Madhya Pradesh, Uttar Pradesh, Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, and Bihar are among the Indian states where it is cultivated.

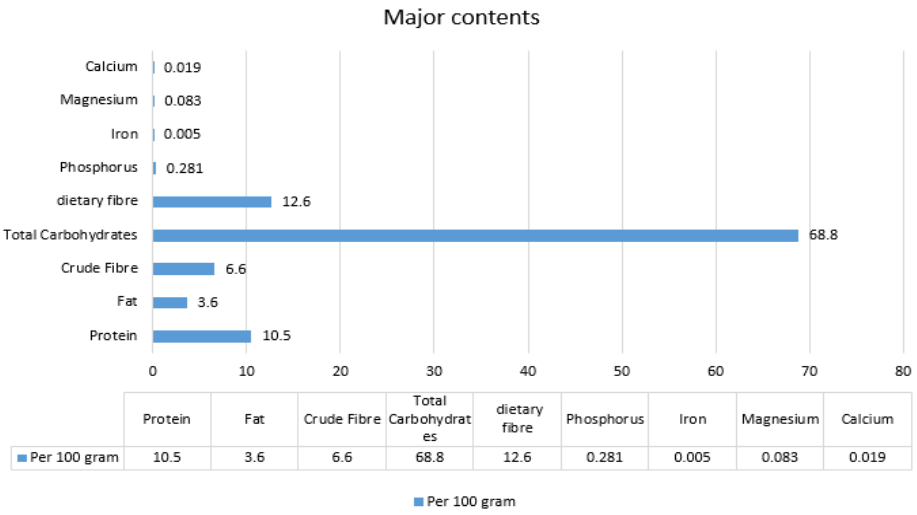
Cultivation months: A crop with a brief growing season, barnyard millet may be produced all year round. Early October to November is the ideal time to grow barnyard millet. The ideal soil temperature is roughly 18°C. Early May or April is when the rainfed early crop is seeded. The primary crop for the Kharif season is seeded in June or May.

Number of days: Millets grow quickly from planted seeds to mature, harvest-ready plants, taking just around 65 days.

Total cost of production: Barnyard millet cost around 13,585 rupees per hectare for cultivation in India.

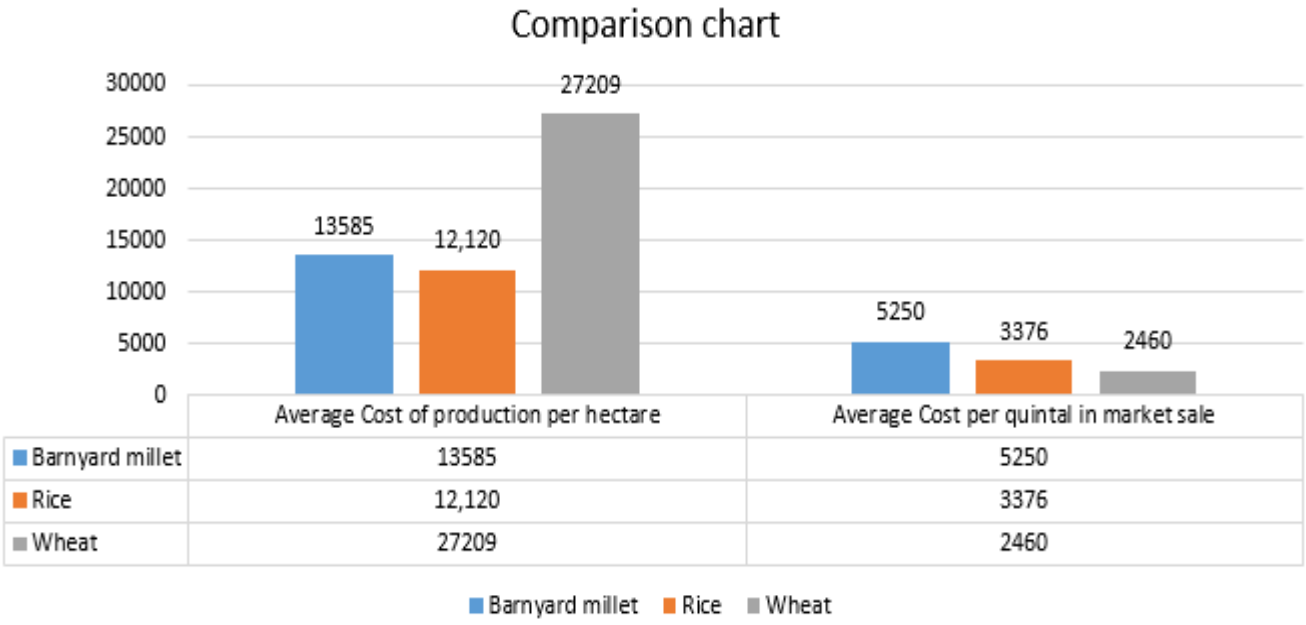
Cost per quintal in market sale: The average price of Barnyard millet according to current market pricing, is Rs. 5250 per quintal.

Major nutritional composition:



Expected Farmer income from one acre land: Approximate net profit from well farmed 1 acre farming is around 125000 rupees per acre.

Comparison between rice and wheat on ground of cost and benefit:



	Average Cost of production per hectare	Average Cost per quintal in market sale
Barnyard millet	13585	5250
Rice	12,120	3376
Wheat	27209	2460

2.8 Little Millet (Moraiyo) "Panicum sumatrense":

The regional names include Kutki in Hindi, Chama in Malayalam, Same in Kannada, Samai in Tamil, and Sama in Telugu.

2.8.1 Introduction:

Panicum sumatrense, sometimes known as little millet, is a cereal that grows quickly and only lasts a brief time and is resistant to both drought and water logging. It is a significant crop raised for food and for livestock.

2.8.2 Expected medical and health benefits:

The glycemic index of little millet is low. Its low GI causes a gradual increase of blood sugar. This makes it a fantastic option for managing blood sugar in diabetics. Foods with low GI levels provide continuous energy and help minimize blood sugar increases by being digested and absorbed more slowly. Little millet is a good option for preserving stable blood sugar levels because of its low GI. Little millet's fiber aids in maintaining regular bowel motions and guards against constipation. By adding weight and facilitating the easy transit of waste through the digestive tract, it also promotes a healthy gut. A small amount of millet in your diet can help your digestion work properly and lower your risk of gastrointestinal diseases. Little millet can be safely included in gluten-free diets. Gluten-intolerant persons may now enjoy a wider variety of dishes thanks to this grain, which provides a healthy alternative to wheat and other grains containing gluten. Little millet is inherently gluten-free, in contrast to wheat, barley, and rye. When someone has a problem connected to gluten, it might cause negative effects. If you want to eliminate gluten in your diet, Little Millet is a safe and wholesome alternative.

Indian states suitable for cultivation: Karnataka, Tamil Nadu, Odisha, Madhya Pradesh, Chattisgarh, Jharkhand, Andhra Pradesh, Uttarakhand, Maharashtra, and Gujarat are the Indian states that cultivate small millet.

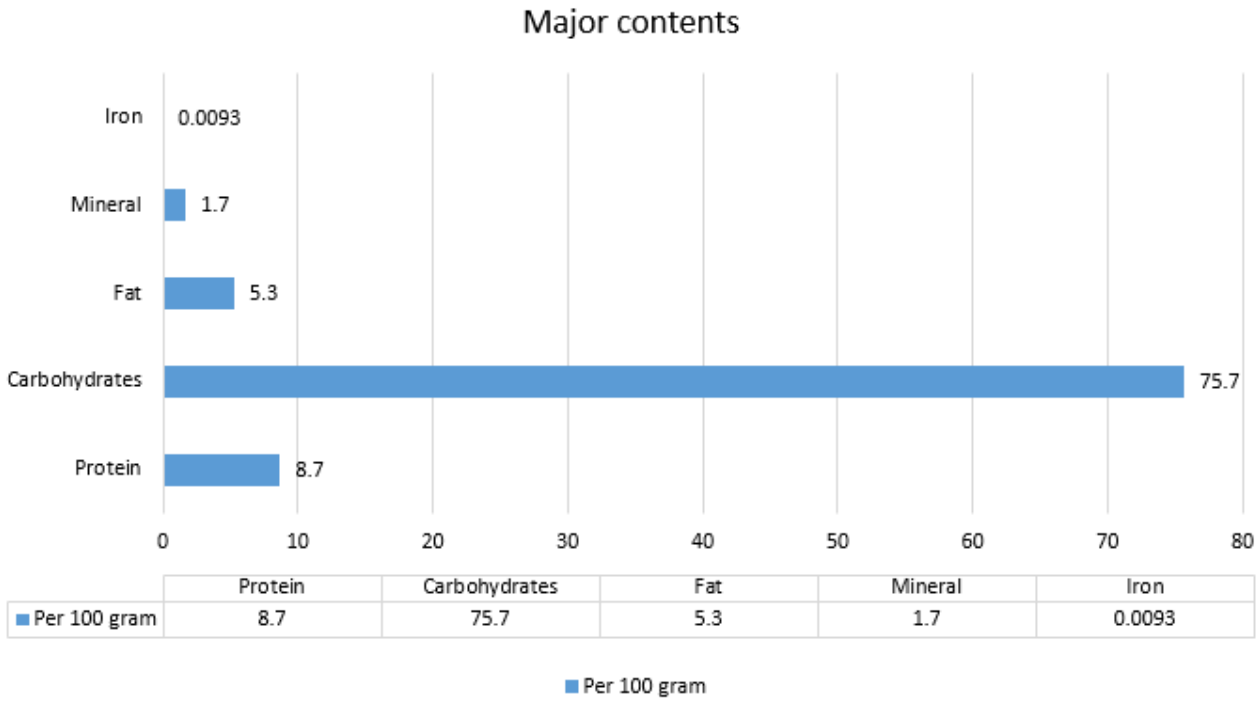
Cultivation months: Little millet is mostly grown in the kharif season. While the crop is planted in June in Tamil Nadu and the middle of June in Odisha, Madhya Pradesh and Karnataka, the seeding season is from the end of June to the first week of July.

Number of days: After seeding, the crop is ready for harvest 65 to 75 days later.

Total cost of production: Around 15,031 rupees per acre.

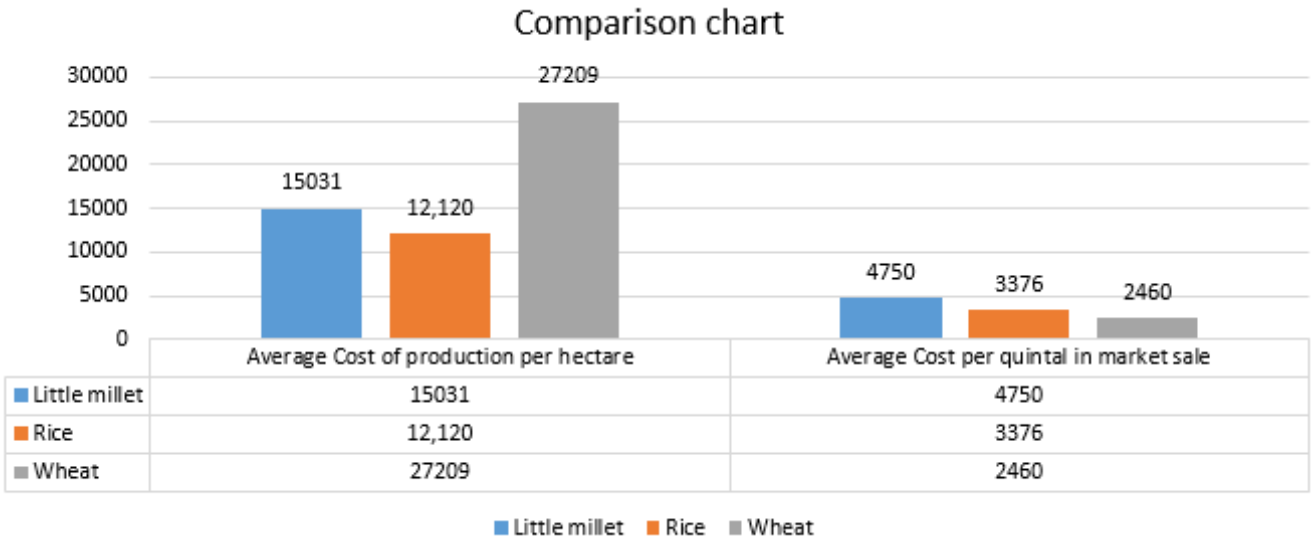
Cost per quintal in market sale: 4750 rupees per quintal.

Major nutritional composition:



Expected Farmer income from one acre land: Approximate net profit from well farmed 1 acre farming is around 20250 rupees per acre.

Comparison between rice and wheat on ground of cost and benefit:



2.9 Buckwheat Millet (Kuttu) "Fagopyrum esculentum":

Also known as kuttu in Indian states.

2.9.1 Introduction:

Buckwheat is a member of the food category known as pseudocereals. Pseudocereals are seeds that grow on grasses yet are used as cereal grains. The pseudocereals quinoa and amaranth are also popular. Buckwheat is gluten-free because, in spite of its name, it is not linked to wheat. It may be converted into groats, flour, and noodles or used in buckwheat tea.

2.9.2 Expected medical and health benefits:

Niacin and fiber are two elements found in whole grain diets that are crucial for heart health. Buckwheat has a lot of fiber. A form of plant-based carbohydrate known as dietary fiber is one that the body cannot digest. Fiber aids in the proper digestion of food by the intestines and facilitates the passage of food through the digestive system. Additionally, it could promote weight loss and shield against cardiovascular disease. Foods that prolong satiety can stave off hunger for longer periods of time and may lower the daily caloric intake of a person. Buckwheat has a lot of protein. High-protein meals are crucial for weight management, according to research, since they increase satiety while containing less calories than other food categories. FAO (2009). A healthy diet that includes buckwheat may increase satiety and aid with weight control. A source of complex carbohydrates is buckwheat. People who consume this type of carbohydrate can better control their blood sugar levels. Complex carbs are digested by the body more slowly than simple carbohydrates. As a result, digestion is slowed and blood sugar levels are kept steady for longer. An illustration of a simple carbohydrate is white bread.

Indian states suitable for cultivation: In India, Buckwheat is grown majorly in hill areas of Jammu and Kashmir ,Uttarakhand, Himachal Pradesh , Chattisgarh ,Uttar Pradesh , West Bengal , Upper Assam region, Sikkim , Meghalaya, Manipur, Arunachal Pradesh , Nilgiris and Palani hills of Tamil Nadu, and Kerala

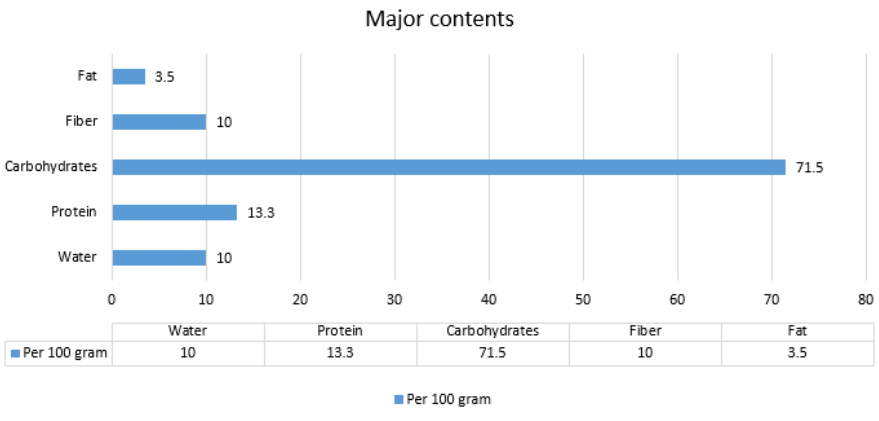
Cultivation months: Buckwheat seeds should be sown in the months of October and November. It can also be grown from February to October in controlled conditions.

Number of days: It takes about on average 80 to 90 days to mature.

Total cost of production: On average the cost of production per hectare is Rs.3,087

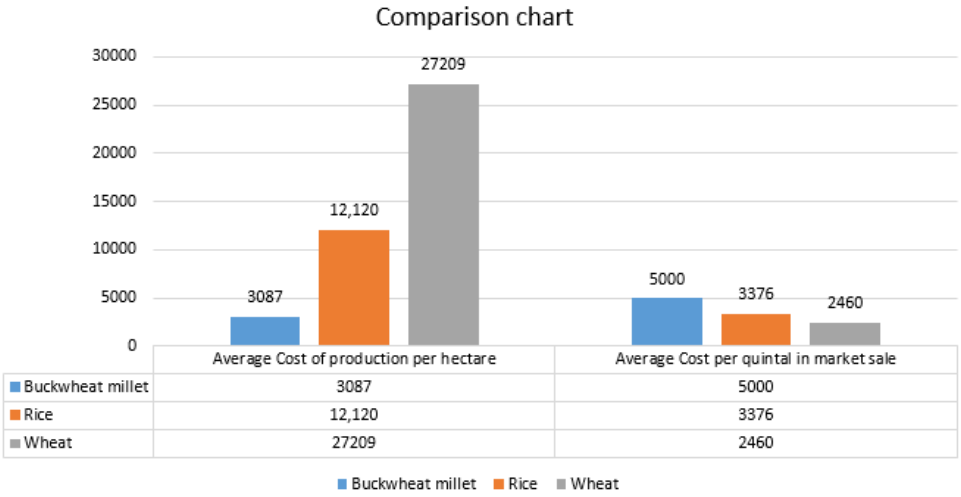
Cost per quintal in market sale: On average 5000 rupees per quintal.

Major nutritional composition:



Expected Farmer income from one acre land: Approximate net profit from well farmed 1 acre farming is around 20250 rupees per acre.

Comparison between rice and wheat on ground of cost and benefit:



2.10 Amaranth Millet (Rajgira) "Amaranthus caudatus L":

It is known as rajgira (king of seeds) in Gujarati, ramdana (seed provided by god) in Bihar, Odisha, and Uttar Pradesh, chuka in Bengal, kalaghesa, chumera, and ganhar in Central India, and bathu in Himachal Pradesh, among other names in Indian languages.

2.10.1 Introduction:

High concentration of micronutrients and higher concentration of higher-quality protein, GRAIN amaranth, an edible pseudocereal, is currently a crop of attention. The C4 pathway in grain amaranth provides the physiological benefit of a high rate of photosynthesis.

2.10.2 Expected medical health benefits:

For thickening soups, stews, sauces, and other meals, amaranth flour provides a gluten-free substitute for wheat flour. Additionally, it may be cooked using gluten-free flours and gums. decreases cholesterol levels Both LDL and triglyceride cholesterol levels are reduced by the oils and phytosterols. Amaranth contains peptides and oils that have anti-inflammatory effects that can aid with pain relief and swelling reduction. Blood pressure can be lowered using amaranth. This seed is generally a healthy meal for the heart since it reduces blood pressure, inflammation, and cholesterol. Compared to the protein in other seeds and grains, the protein in amaranth is simpler to digest. Its digestion has been contrasted with milk protein's. A food with a lot of fiber is amaranth. This increases its filling capacity, aids in digestion, lowers blood pressure and cholesterol, and delays the absorption of sugar so the body can continue to produce energy. Lack of fiber may cause constipation, flatulence, or even increased fat storage. It's a good idea to include dietary fiber-rich foods like amaranth.

Indian states suitable for cultivation: This crop is grown as a minor crop in the Asia-Pacific areas, which include Israel, India, China, Manchuria, Nepal, Bhutan, Afghanistan, Indonesia, Japan, Thailand, and Nepal.There was grain amaranth in India. largely in hilly areas, although as of the late 1990s, its cultivation accelerated in Central and areas of the western Plateau. However, According to estimates, the crop is grown. in an area of 40–50 thousand acres India.

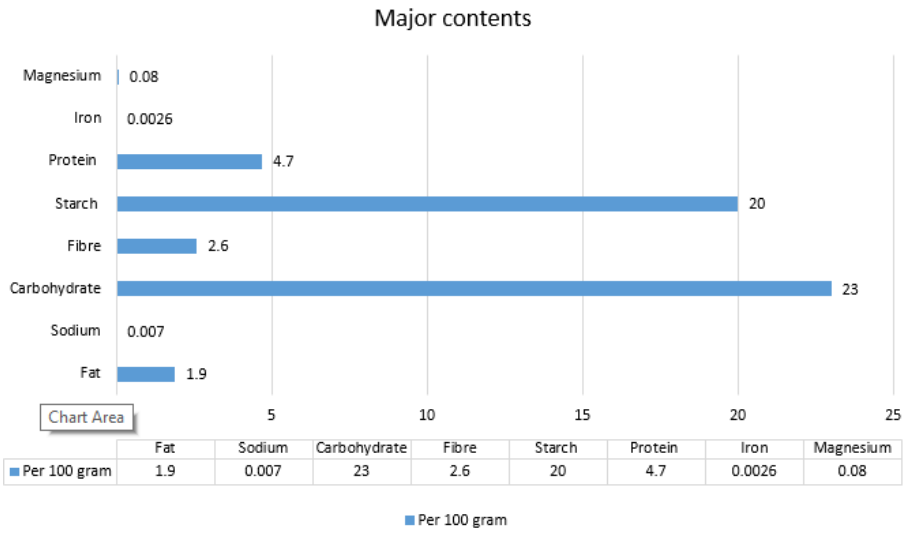
Cultivation months: In hills, the crop is generally sown in the months of May–June soon after onset of monsoon. However, in plains it can be sown either in rabi (winter) or kharif (summer) season. But, generally it is cultivated in rabi season and is sown in months of October–November.

Number of days: It takes about 120 to 130 days to mature.

Total cost of production: The cost of cultivation per acre around 24700 rupees.

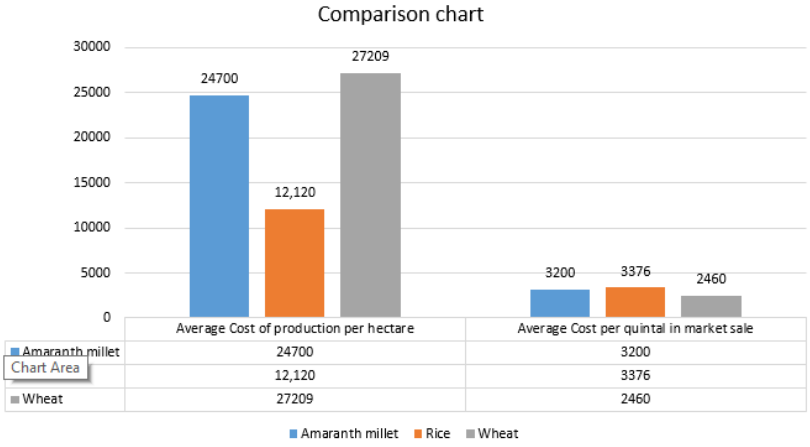
Cost per quintal in market sale: On average 3200 rupees per quintal in market mandi.

Major nutritional composition:



Expected Farmer income from one acre land: Approximate net profit from well farmed 1 acre farming is around 28,800 rupees per acre.

Comparison between rice and wheat on ground of cost and benefit -



2.11 Kodo Millet "Paspalum scrobiculatum":

Locally known as rice grass, ditch millet, cow grass in English, araka in Telugu and kodra in Marath.

2.11.1 Introduction:

It is well renowned for having the strongest drought resilience of all the millets that are available, and because it yields a high amount of grain quickly, it has significant economic significance. Kodo millets are produced in the largest quantity in the world, hence it is important economically to grow them. Kodo millets come in a variety of kinds, including Indira kodo, Jawahar kodo, TNAU, etc., and are grown during the kharif season (the monsoon season). Kodo millets are transformed into premium dishes and beverages. In addition to its economic and gastronomic advantages, kodo millets have a host of health advantages FAO (2002).

2.11.2 Expected medical and health benefits:

Because of its greater amounts of fiber, lower levels of uric acid production, and lower levels of potassium, kodo millet is beneficial for renal problems. The flavonoids and antioxidants in Kodo millet aid in blood purification and reduce the risk of kidney and gallbladder stone development. Kodo millet has phytochemicals such phytic acid, which reduces cholesterol, and phytate, which has been associated with Kodo millets contain polyphenols and little sugar. Both of these assist in lowering blood sugar levels. Kodo millets are said to aid in the management of type 2 diabetes, according to a study done in 2022 by Han et al. Additionally, a study discovered that Kodo-dependent foods, such as Kodo idly and upma, have a 60% lower glycemic index, making them a perfect replacement for cooking diabetic-friendly meals. a decreased risk of cancer. Heart attacks, atherosclerosis, and other chronic illnesses can be avoided by eating Kodo millet since it contains potassium, magnesium, and prebiotic fiber. Kodo millets have a greater polyphenol content, which reduces the risk of obesity, according to research. Additionally, it aids in lowering inflammation, adipose tissue fat synthesis, and weight gain. Antioxidants and polyphenols found in Kodo millets aid in the fight against free radicals and have cell-repair properties. A traditional method of treating cuts and wounds is to apply Kodo millet flour paste to them.

Indian states suitable for cultivation: As a food grain, it is grown throughout India, from the southern states of Kerala and Tamil Nadu to the northern states of Rajasthan and Uttar Pradesh, and the eastern state of West Bengal.

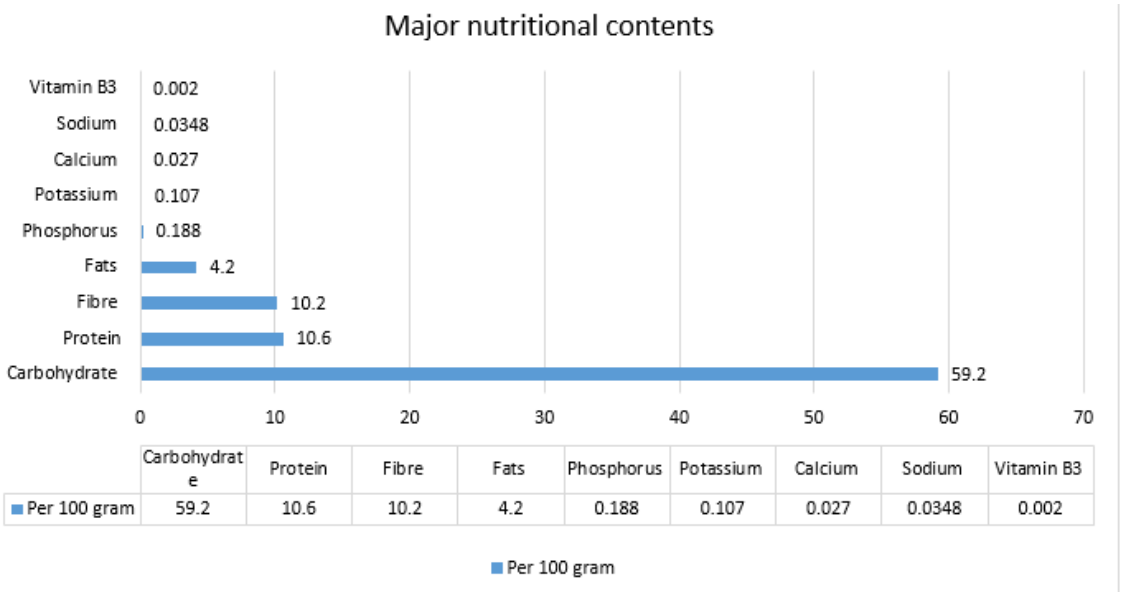
Cultivation months: Kodo millet is sown in early June and is a "kharif" or monsoon crop.

Number of days: Its growth period, which ranges from 120 to 180 days, is rather brief.

Total cost of production: Minimum 24700 rupees is cost of production for a hectare.

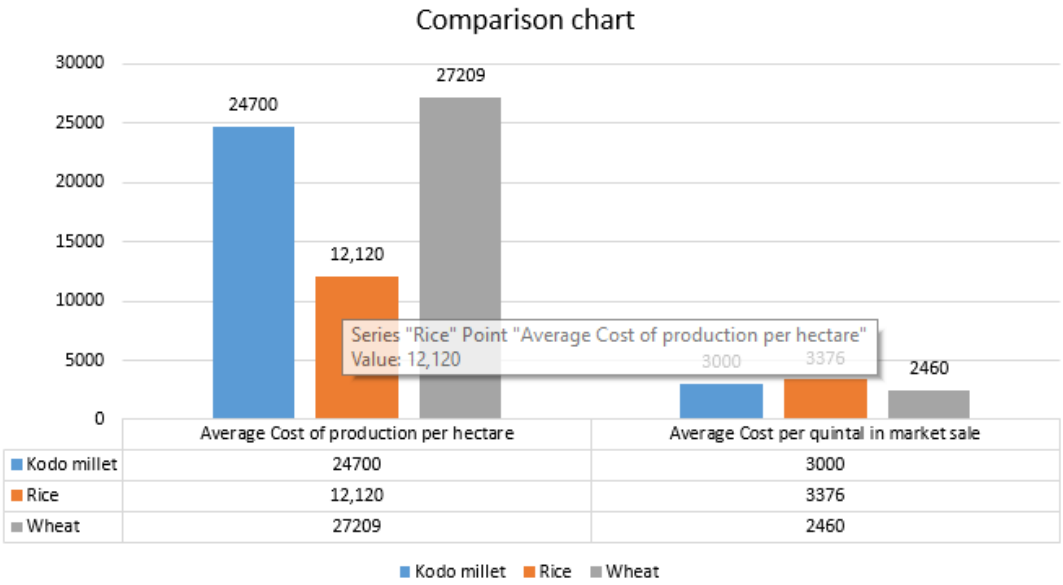
Cost per quintal in market sale: In market a farmer can get 3000 rupees per quintal.

Major nutritional composition:



Expected Farmer income from one acre land: Approximate net profit from well farmed 1 acre farming is around 27,000 – 28,000 rupees per acre.

Comparison between rice and wheat on ground of cost and benefit:



III. CURRENT SITUATION OF MILLETS IN INDIA:

One of the top five nations in the world for millets exports is India. India exported millets for $75.46 million in 2022–2023. Around 173 lakh tonnes of millets are produced in India, which accounts for 20% of world output and 80% of that in Asia. Top manufacturer of Barnyard is India (99.9%). Finger (53.3%), Kodo (100%),(100%) Little millet,(44.5%) Pearl millet. In India, millet cultivation produced an average of 1208 kg per hectare in 2021–2022. Despite India's millet farming area steadily declining since 1971–72, the production of millets rose by 7% from 1966 to 2022.

IV. FEW STARTUPS BUSINESS ON MILLETS

In India, millet production in 2021–2022 averaged 1208 kg per acre. Despite India's millet agricultural area continuously dropping since 1971–1972, millets were produced in greater quantities from 1966 to 2022, increasing by 7%. The government is providing funding for initiatives such as market and value chain development, research and development, raising consumer awareness for increased consumption, and supporting sustainable production. In 212 districts throughout 14 States, the National Food Security Mission's (NFMS) nutritious cereal component for millets is being implemented. The ministry is collaborating with other central ministries, the state governments, and other stakeholder groups to promote millet production and consumption. The Public Distribution System must now reorient its distribution programs away from providing only basic calories and toward offering a more varied food basket that includes millets in order to enhance the nutritional health of young children and women who are of childbearing age. In April 2018, the Indian government declared millet to be a wholesome cereal. The Poshan Mission program has also incorporated millet.

V. CONCLUSION

With the increasing population every year equivalently increasing pressure for higher production leads to higher consumption of water, fertilizers, pesticides etc. Rice, wheat, maize, sugarcane especially consume much water and time for giving relevant production, to counter this in present time, millets gives much higher counting benefits than any of the farming cereal. Before the rise of wheat and rice in late 1960's during green revolution, millets were playing the part of India's major cereal. Afterwards high yielding rice and wheat took over the area from millets but now after five decades it is realized that need of millets is not only for saving cultivation price but also to fulfil nutritional need.

CONFLICTS OF INTEREST

There is no conflicts of interest of any type in drafting this review paper.

AUTHOR'S CONTRIBUTION

Both author contributed equally in conceived and design the analysis, collected the data, performed the analysis and wrote the full length paper.

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