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A technical review report on Millets as nutri-cereals of India

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ABSTRACT: Millets are small grained, annual, warm-weather cereals belonging to the grass family. These are widely grown worldwide as cereal crops or grains for fodder and human food. There are various millets which are grown in India such as sorghum, pearl millet, finger millet, foxtail millet, kodo millet, barnyard millet and proso millet. Millets are also called as nutricereals as they provide most of the nutrients in higher quantity in comparison to conventional food grain crops like paddy and wheat. Proso millets and foxtail millets have higher percentage of protein 12.5% and 12.3% respectively than wheat (11.8%) and rice (6.8%). Calcium is higher in finger millets (344 mg) than wheat (41 mg) and rice (10 mg). Crude fiber contents are higher in barnyard millet (9.8g) than wheat (1.2 g) and rice (0.2 g). Various anti-nutrients are also found in millets such as phytic acid, polyphenol, cyanogenic glucoside, tannins, oxalates, amylase inhibitor etc. These anti-nutrients can be removed by soaking, fermentation and popping. Millets are climate smart crops as they require less water and are adapted to different climatic conditions. National Food Security Mission (NFSM) was launched in October, 2007 by Govt. of India for millets. There are various techniques adopted by NFSM such as implementation of cropping system, agro-climatic zone wise planning, promotion of improved technologies, value addition at farm level and creating awareness about the nutritional benefits of millets. According to the report of the National Rainfed Area Authority (NRAA), there is a lesser possibility of increasing the production of major staple cereals to fulfill the food demand of the world's population as the world is already facing the challenges of increase in dry lands and depletion of ground water. Millet cultivation can be a solution to this problem as these can grow on shallow, low fertile soils with a pH ranging from acidic 4.5 to basic soils with pH of 8.0. Thus, millets can fulfill the nutrient demand of increasing population without creating additional pressure on existing land resources.

Key words: Millets, Nutricereals, Nutrients, Anti-nutrients, Phytic acid, etc.

I. INTRODUCTION

Millets are considered as the traditional staple foods in dry land regions of the country. Millets are believed to be originated in Africa.Millets are the nutri-cereals, having high nutrient content, gluten free, widely grown around the world as cereal crops or grains for fodder and human food.According to FAO in 2018, India ranks first in the millet production followed by Niger and China. In world, India contributes 32% of the total millet production. Rajasthan is the leading producer of millets in India. Millets were originated in Southern Asia. Major Millet crops include sorghum (Jowar), pearl millet (Bajra). Minor millet crops include kodo millet, barnyard millet, foxtail millet, finger millet and proso millet. Millets contributes only 10% to the country's food grain production.However, they are especially valued for filling specific niches as they often succeed under stressful situations, where other crops fail to produce an acceptable harvest. They are known for their resilience by adjusting to diverse ecological situations (Seetharam, 1998). Apart from food grain production, millet can also be cultivated for grazing, green fodder or silage. Millet crop residues contribute significantly to fodder supplies which can be used as a food for the livestock animals. The ability of millets to grow well on poorly fertilized soils, has led millet to be labeled as a food for the poor. Millets are adapted to dry, infertile soils than other crops, due to which millets are often cultivated under extremely harsh conditions like high temperatures, low and erratic precipitation, short growing seasons and acidic and infertile soils with poor water-holding capacity. Millets have a strong, deep rooting systems and short life cycles and requires less water as compared to other cereal crops. Therefore, these

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crops are generally cultivated where few options exist for crop diversification (Shadang changmeietal., 2017).

II. MILLETS

Millets are small grained, annual, warm-weather cereals belonging to the grass family. According to traditional growing techniques, millets do not require pesticides and the land used for growing millets is totally pest free. Millets like foxtail millet also act as anti-pest agents in storage conditions for pulses like green gram. Millets do not require any fumigants. Millets have relatively a lower position in India, among feed crops in agriculture, but they are very important from food security point at regional and farm level, (Stanley Joseph, et al., 2013).

From nutritional point of view, millets are way ahead of wheat and rice. Each one of the millets has more fibre than rice and wheat. Finger millet is having thirty times more calcium than rice while all other millets have at least double the amount of calcium compared to rice (Amir Gull, et al, 2014).

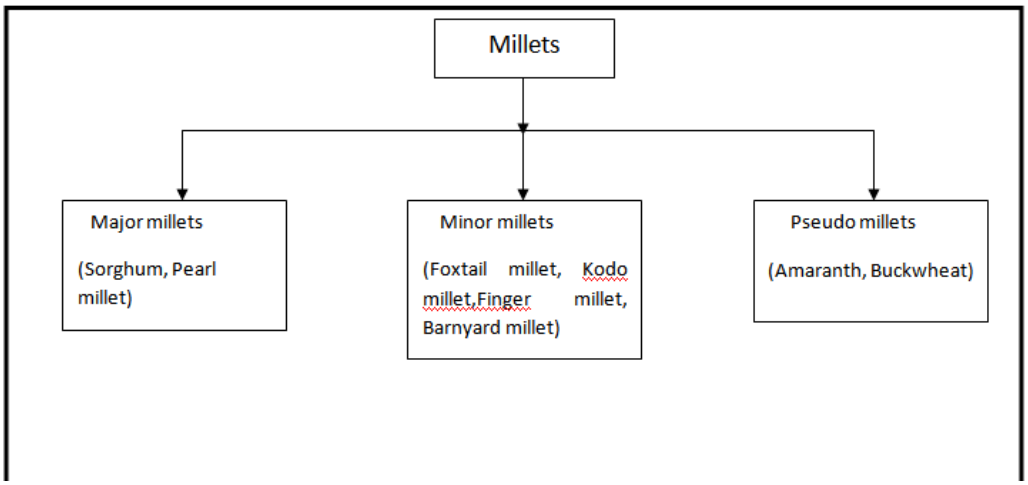
III. CHARACTERISTICS OF MILLETS

Millets can be nearly pale yellow, white, brown, grey, slate blue or purple. The height of millet plant may vary from 0.5 to 4m. Millets are highly tolerant to drought and other weather conditions. The seed weight of millets may vary from 2.5 to 14 grams.Millets are considered as smart foods as they are beneficial in many ways such as- good for the consumer as it helps in weight loss and curing various diseases, good for the planet as millets can be grown under organic farm conditions, they do not harm the environment, good for the farmer because millets do not require special care and can be grown in poor soils with less inputs, (Fereidoon Shahidi, et al, 2018).Each individual millet species acquires some unique characters for adaptation to adverse conditions like tolerance or resistance to drought, high temperature, low soil fertility and infestation by stored grain pests.

Table 3.1 Special characteristics of small millets

Millet	**Special characteristics**
Finger millet	Wider adaptability, rich source of calcium (Seetharam, 1998)
Foxtail millet	Short duration, tolerant to low soil fertility and drought (Jijau, 1989)
Kodo millet	Long duration, grown well in shallow and deep soil (Hegde and Gowda, 1989)
Little millet	Short duration, withstand both drought and waterlogging (Doggett, 1989)
Proso millet	Short duration, tolerant to heat and drought (Sahib, 1997)
Barnyard millet	Fastest growing, voluminous fodder (Gupta et al., 2009)

IV. CLASSIFICATION OF MILLETS



Source: Singh, 2018

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Table 4.1 The families, origin, common and scientific names of various millets are given below in the following table.

S.No.	Millets	Family	Common Name	Scientific Name	Origin
1	Sorghum	Poaceae	Jowar, durra, Egyptian millet	Sorghum bicolor	Africa
2	Pearl millet	Poaceae	Bajra, candlestick	Pennisetum glaucum	West Africa
3	Finger millet	Poaceae	Ragi, kurakkan	Eleusine coracana	East Africa
4	Foxtail millet	Poaceae	Italian millet, kangani	Setaria italica	China
5	Barnyard millet	Poaceae	Sanwa, Japanese millet	Echinochloa esculenta	Japan
6	Kodo millet	Poaceae	Kodra, water couch	Paspalum scrobiculatum	India
7	Amaranth	Amaranthaceae	Ramdana, Rajgira	Amaranthus virdis	America
8	Buckwheat	Polygonaceae	Kuttu,	Fagopyrum esculentum	Southwest China

Source: Singh, 2018

V. AREA, PRODUCTION AND PRODUCTIVITY

The area under millets has been continuously declining, with a decline of more than 72.7% from 7.7 million hectare in 1949-50 to 2.10 million hectare in 2009-10. However, there has been a significant improvement in the productivity of finger millet (0.7 t/ha to 1.49 t/ha) during this period because of development of high-yielding varieties. The productivity of other small millets is less than 1 t/ha (Padulosi et al., 2009).

Table 5.1 Area, production and productivity of millets in India

Millet	Area (million hectare)			Production (million tonnes)			Productivity (tonnes/hectare)	
	1949-50	2009-10	Difference	1949-50	2009-10	Difference	1949-50	2009-10
Finger millet	2.3	1.27	-0.92	1.6	1.89	0.43	0.7	1.49
Other small millets (Foxtail, Kodo, Little, Proso and Barnyard)	5.4	0.83	-4.5	2.3	0.32	-1.86	0.45	0.48
Total	7.7	2.10	-5.42	3.9	2.21	-1.43		

Source: Seetharam (1998); Source: FAI, (2011)

Table 5.2 Total area, production and productivity of small millets in different states (2008)

State	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg/ha)
Madhya Pradesh	268.4	73.5	274
Chhattisgarh	153.4	28.0	183
Uttarakhand	72	70	972
Maharashtra	59	23	390
Gujarat	58	57	983
Karnataka	27	11	407
Tamil Nadu	33.1	31.1	940

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Andhra Pradesh	25	13	520
Jharkhand	24.9	11.9	478
Arunachal Pradesh	21.4	18.4	860
Odisha	17.8	10.1	567
Bihar	4.0	3.0	750
India	830.5	381.9	460

Source: FAI (2011)

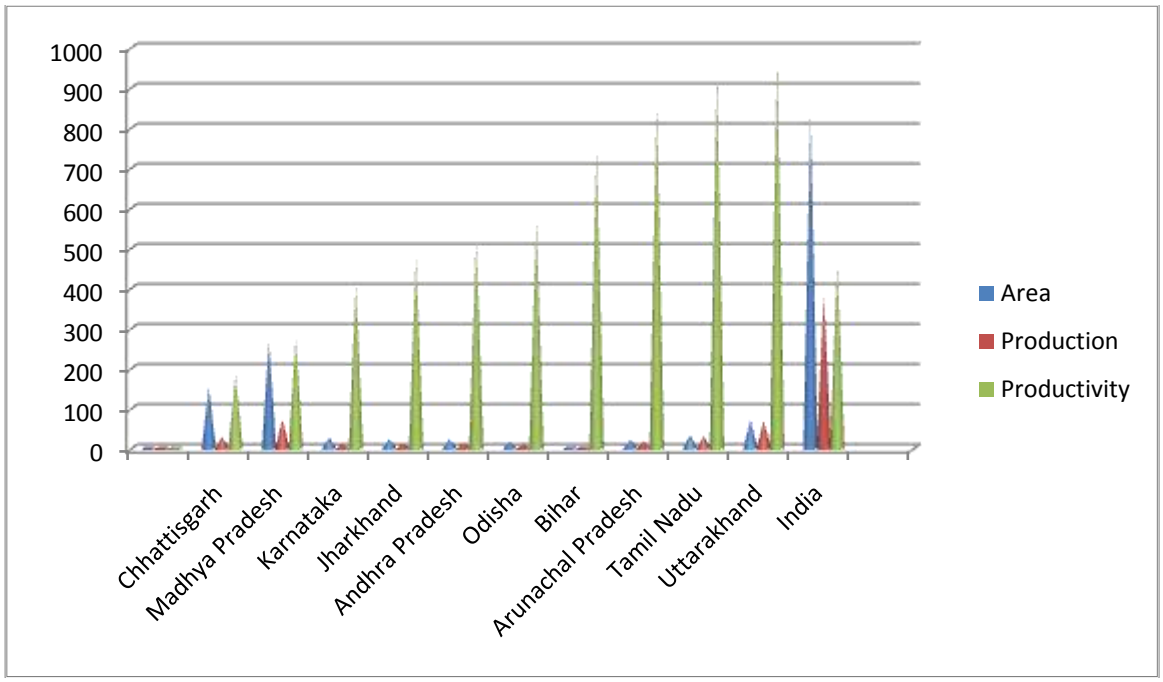

Fig.5.3. Graphical representation of total area, production and productivity of small millets in different states

VI. MILLETS AS PROBIOTIC AND PREBIOTIC

6.1 Millets as probiotic: Probiotics are"living microorganisms" which when administered in adequate amounts give a health benefit to the host (Abd El-Salam et al., 2012). A fermented millet product serves as a natural probiotic treatment for diarrhea in young children (Lei et al., 2006). In Africa, millet Koko is prepared in the form of fermented millet porridge and drink (Lei and Jacobsen M. 2004).

6.2 Millets as prebiotic: Prebiotics are non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and activity of one or a limited number of bacteria in the colon (Laminu etal., 2011). Millets whole grain also shows prebiotic activity, which helps to increase the population of bacteria's that plays a key role to promote digestion.

VII. WHY MILLETS ARE CALLED AS NUTRI-CEREALS?

Millets are termed as Nutri-cereals, since they are highly nutritious cereals and contribute substantially for food and nutritional security of the consumers. Millets are powerhouse of nutrition as they are natural source of iron, zinc, calcium and other nutrients that are essential for curbing the problem of malnutrition in India.Millets are not only superior in nutritional quality as compared to traditional cereal crops (wheat and rice) but they are also very good sources of carbohydrates, micronutrients and phytochemicals with nutraceutical properties. The millets contain 7-12% protein, 2-5%fat, 65-75% carbohydrates and 15-20% dietary fibre. Around 40% of preschool-age children are suffering from the anaemia disease due to deficiency of iron in their body. It is also estimated that 250 to 500 thousand children go blind from Vitamin A deficiency every year. The consumption of millets can effectively solve the problem of anaemia from the world, (NIN, 2019).

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Table 7.1.Nutritive value of millets

Millets	Protein (g)	Carbohydrates (g)	Total fibre (g)	Calcium (g)	Iron (mg)	Magnesium (mg)	Zinc (mg)
Finger millet	7.16	66.8	11	36.4	4.6	146	2.53
Foxtail millet	8.92	66.1	6.3	15.2	2.3	122	1.65
Barnyard millet	6.20	65.5	9.8	14.0	5.0	-	-
Proso millet	12.5	70.4	2.2	14.0	0.8	-	-
Pearl millet	12.0	67.0	1.9	42.0	8.0	114	1.56
Amaranth	13.2	61.4	7.4	16.2	8.0	270	2.52
Buckwheat	13.0	72.9	10	12.0	15	10.19	-

Source: NIN, 2019

VIII. BENEFITS OF CULTIVATION OF MILLETS

The cultivation of millets requires less maintenance. It is less susceptible to pests and diseases as compared to traditional crops like wheat and rice.The cultivation of millets requires less irrigation water. The market demand of millets are increasing as people are becoming health conscious and are getting aware of the nutritional benefits from millets.Millets can withstand higher temperatures. Thus, millets can be grown in dryland areas where other high yielding crops like wheat and rice cannot be grown.Millets are short duration crops, (Shweta Malik, 2015).

IX. BENEFITS OF MILLETS

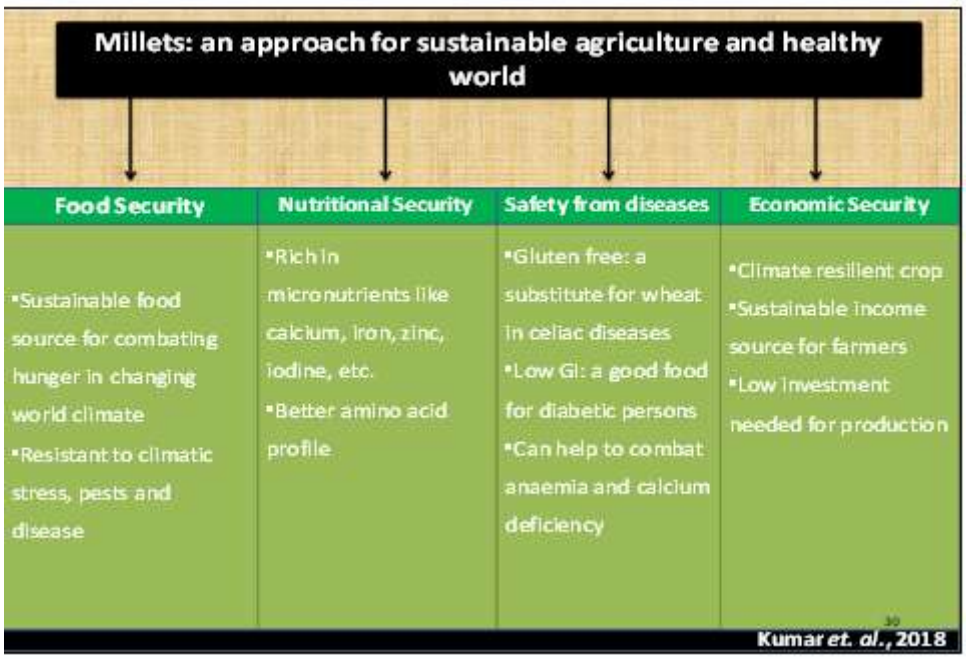

Fig.9.1. Benefits of millets in a nutshell

9.2. Nutritional importance of finger millet

Finger millet is rich in calcium (344 mg) and potassium (443 mg) which helps in strengthening bones and teeth.As finger millet does not contain gluten, it is a grain alternative for people who are gluten-sensitive. It contains an amino acid called tryptophan which lowers appetite and thus, helps in keeping weight in control. It also contains threonine amino acid which helps in bringing the cholesterol level of the body down, (Palanisamy Bruntha Devi, et al, 2014).

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Composition	Finger millet
Protein (g)	7.3
Fat (g)	1.3
Minerals (g)	2.7
Fibre (g)	3.6
Carbohydrate (g)	72.0
Calcium (mg)	344.0
Phosphorus (mg)	283.0
Thiamine (mg)	420.0
Edible matters	100.0

Fig.9.2.Nutritional composition of finger millet per 100g of serving

9.3. Nutritional benefits of Pearl millet

Due to high composition of minerals and proteins in it, pearl millet provides various health benefits to human. It consists of many essential minerals like magnesium, phosphorus, zinc, etc. It contains essential amino acids and vitamins also which contribute to it therapeutic properties.It is beneficial in treating stomach ulcers, beneficial for heart health and reducing migraine attacks, (Saleh ASM, et al., 2015).

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Pearl Millet	
Nutritional value per 100 g (3.5 oz.)	
Energy	1,470 kJ (351 kcal)
Carbohydrates	75 g
Dietary fiber	6.0 g
Fat	3.3 g
Protein	10.6 g
Minerals	2.3 g
Iron	16.9 mg
Calcium	38 mg

Fig.9.3.Nutritional composition of pearl millet in 100g of serving

9.4. Nutritional importance of foxtail millet

Foxtail millet have low glycemic index which helps in controlling blood sugar levels. It is rich in antioxidant activity. It is a good source of mineral and iron that keep one's body strong and immune, (Singh KP, et al, 2012).

The glycemic index of sorghum and wheat is shown in the table below.

FOOD	GI SORGHUM	GI WHEAT
Coarse semolina upma	23±1.34	58±6.85
Fine semolina upma	26±4.87	67±10.80
Flakes poha	50±5.85	74±4.87
Pasta	60±2.8	72±6.51
Biscuits	23±8.4	57±11.40

Source: IIMR, 2018

9.5. Nutritional benefits of Amaranth

The protein content present in amaranth is 14.5%.Amaranth protein consists of about 20% globulins, 3% prolamins and 25-30% glutelins.Minerals like calcium, magnesium, iron, potassium and zinc in amaranth seeds are approximately twice than cereals (eg. Wheat =1.8%).Amaranth includes high content of arginine and histidine, which are essential amino acids for infants, (Vandana Shiva, et al, 2014).

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9.6. Nutritional importance of proso millet

The energy and protein content present in proso millet is 356 Kcal/100 g and 12.5% respectively.It is a good source of magnesium and phosphorus. Magnesium has the ability to help reduce the effects of migraine and heart attacks whereas phosphorus is an essential component of adenosine triphosphate (ATP) a precursor to energy in the body, (The Hindu, 2014).

Proso millet

9.7.Nutritional benefits of Barnyard millet

The carbohydrate content of barnyard millet is low and thus, it is easily digestible.The grains of barnyard millet have superior nutritional quality as compared to other crop grains in terms of amino acid composition.It reduces blood glucose and lipid levels which is helpful for diabetic patients.It is an appropriate food for patients intolerant to gluten content, (O.S.K. Reddy, 2017).

Barnyard millet

9.8.Nutritional importance of Buckwheat

The buckwheat flour is fat free and it contains vitamin B1 and B2 which helps in proper functioning of nervous system. It is gluten-free, a good source of fiber, rich in minerals and various plant compounds, especially rutin. As a result, buckwheat consumption is linked to several health benefits, including improved blood sugar control and heart health. It is a good source of energy, (Shweta Malik, 2015).

Buckwheat

X. ANTI-NUTRIENTS IN MILLETS

Though there are various nutrients present in millets, they also includes various anti-nutrients such as phytic acid, polyphenol, cyanogenic glucoside, tannins, oxalates and amylase inhibitor. These anti-nutrients reduce the bioavailability of nutrients in the body. The proportions of anti-nutrients present in millets can be reduced in the meals by adopting some food processing techniques like fermentation, malting, germination, etc. which improves the bioavailability of nutrients. The mostly used food processing techniques are

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soaking, germination, fermentation and popping or puffing, (Deshpande et al., 2015).

Table 10.1 Processing techniques to overcome the effect of ant-nutrients in millets based meals. (Sarita and singh, 2016)

Sr.No.	Processing Techniques	Function
1	Soaking	• Decrease the amount of phytic acid and polyphenolic compound • Improve the protein digetability
2	Germination	• Increasebio-accessibility of minerals such as calcium, iron and zinc • Decrease the level of tannins
3	Popping or puffing	• HTST (High-Temperature Short Time) method used for starch gelatinization and the endosperm bursts open giving highly desirable flavor and aroma, helpful to promote ready to eat millets based products.
4	Fermentation	• Reduces the levels of anti-nutrients and improves the protein availability, digestibility in vitro and appreciable change in chemical composition of food material • Provides many varieties of food products with different flavors and texture

XI. CAUSE OF REDUCTION IN MILLETS CULTIVATION

According to the Ministry of Agriculture and Farmer's welfare, in 2016-2017, the area under millets stood at 14.72 million hectares (60% less coverage area) down from 37 million hectares in 1965-1966, prior to the green revolution.This decline was largely due to lack of input subsidies and price incentives, difficulty in processing, low shelf life of flour, low social status attached to millets, change in consumption pattern, low yield and less demand and conversion of irrigated area for cultivation of rice and wheat.

XII. CREATION OF DEMAND FOR MILLET

The demand for millets can be increased by various methods such as creating awareness regarding their environmental sustainability, nutritional and other health benefits, value addition, inclusion of millets under feeding programmes like mid-day meal. Fine-tuning the technologies for development of millet food products, entrepreneurship and appropriate strategies to promote and popularize millets for commercialization through value-addition, branding as health foods, (Chandrasekara A, et al., 2010).

XIII. FIELD EXPERIMENTS

A field experiment was conducted at Agricultural and Horticultural Research Station, Bavikere, University of Agricultural and Horticultural Sciences, Shivamogga onnutrient management practices for organic cultivation of finger millet(Eleusine coracana L.) under southern transitional zone of Karnataka.Through this experiment, growth parameters, grain and straw yield of the finger millet crop were determined. The experiment was laid out in Randomized Complete Block Design with three replications and different treatments. Finger millet variety GPU-28 was used. Among the different treatments, application of farm yard manure (FYM) at 10 t ha^{-1} + Biodigester Liquid Manure Equivalent (BDLME with two splits) at 75 kg N ha^{-1} recorded significantly higher plant height (132.2), number of leaves per plant (20) and number of tillers per hill (5.4). The highest grain yield was observed as (18.36 q/ha), straw yield (34.88 q/ha) and harvest index (0.46) in which the treatment of farm yard manure at 10 t ha^{-1} + Biodigester Liquid Manure Equivalent (BDLME) at 75 kg N $ha^{-1}$was given, (Veeresh, 2010).

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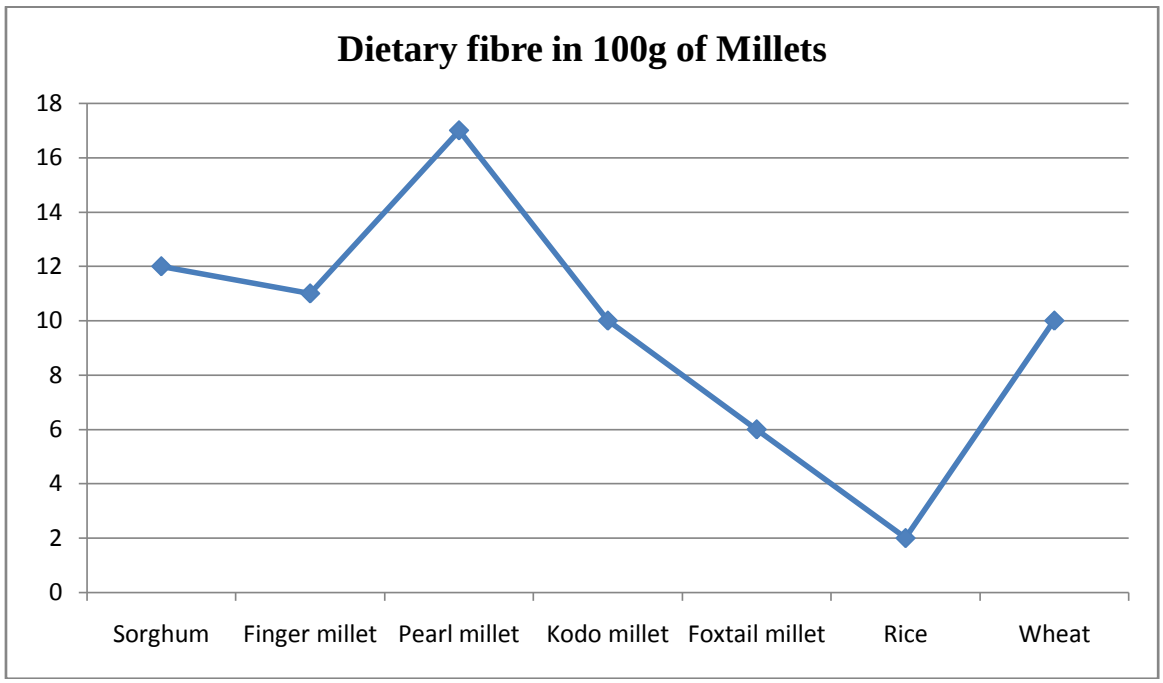

Fig.1. Dietary fibre present in 100g of millets comparing to rice and wheat.Source: Amir Gull, et al, 2014

XIV. FUTURE THRUST OF MILLETS

Now, it is a known fact that the whole world is facing various health challenges because of fiber-less foods. Therefore, there is a great need to add millets in people's diet to fulfill the nutritional requirements. Millets can withstand environmental stress being resistant to drought and warming. Thus, these are grains for future and "harbingers for green revolution".As the climate is getting unpredictable day by day, millet crops are the best choice for farmers.It has low risk of loss. Thus, it is suitable for poor farmers.The market value of millets can be increased by creating processed products that attracts customers. For eg.- Millet biscuits, millet chips, etc.Awareness regarding nutritional, health and environmental advantages may be created through known communication strategies.Millets are considered as future crops as they are adapted to different climatic conditions. Millets provide food security and fight against socio-economic issues such as malnutrition and rural poverty.It is resilient to environmental stress, gives an assured yield in both low and excess rainfall conditions while keeping input costs low. The increased costs of inputs have made it difficult for dryland farmers to meet their crop production needs and when they cannot access institutional credit, tend to fall back upon money lenders. Millets provides food security and have an eco-friendly production.

XV. CONCLUSION

Millets are major coarse cereals which have high human health benefits and are more nutritious than rice and wheat crop.Millets are rich in protein, iron and calcium than the traditional cereal crops like wheat and rice.Millets cultivation requires less water as compared to wheat and rice.Small farmers can afford the cultivation of millets, because it requires low input cost.Millets can easily thrive in extreme weather conditions like drought and flood.They can serve as an income crop for farmers. Millets are higher than rice and wheat in terms of their mineral content. Each millet is superior to rice and wheat and thus, millets are the solution for the malnutrition that affects a majority of the Indian population. For the future food security in the climate crisis conditions, India needs to recognize millets as the future food for the country.The main objective of this study is to help people recognize the importance of food and to introduce millets as a nutritious food, fulfilling the nutritional requirement of the global population.

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