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Review Article

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Production Trend, Constraints, and Strategies for Millet Cultivation in Nepal: A Study from Review Perspective

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ABSTRACT
Millet cultivation is making a quick comeback in the Nepalese agrarian landscape after years of institutional neglect. Agricultural agencies and farmers ignored these cereals while giving precedence over rice, wheat, and other crops such as oilseeds and pulses. Millets can foster well in poor soil conditions with less water, fertilizer, and pesticides. The main objectives of the study were to assess prospects and potentiality of millet, constraints during farming, and the possible strategies to overcome problems by analyzing the data and secondary literature. Districts in the eastern part of Nepal show dominance in millet production. Millet contains a comparative advantage over other cereals in terms of soil climatic adaptability, drought resistance, insect pest tolerance, and management factors. Further, the health-promoting factors play an important role in tackling food security and malnutrition problems, particularly in mid and high hills. The preference of tourists towards "dhido" has further increased its demand at present. However, lack of domain-specific high-yielding varieties, high preference towards major cereals, and poor marketing infrastructure particularly in marginal areas are the constraints mainly considered for unexpected production of millet. Millet features a high possibility of improving the production which can be supported with subsidy, improving tourism, promoting the millet products with agro-based industries, and motivating the growing farmers. Proper local and national strategies to cope with the limitation will help to uplift millet farming from minor cereals to exportable standards.
Keywords: Food security, Dhido, Tourism, Agro-based industries.

INTRODUCTION

While a large portion of the world population relies heavily upon cereals as their staple food, optimum production has been a challenge of concern. Paddy, maize, and wheat have been the preferred cereals, however, conversely, millets have considerably been undervalued in many countries, including Nepal. Millets comprise a diverse variety of small-seeded grasses grown for food, feed, or forage (Lata et al., 2013; Lata, 2015). Millets have high nutritional qualities and produce well under marginal conditions but they are not used to the extent that is possible. Nepal has been harvesting different varieties of millet such as finger millet *(Eleusine coracana L.* Gaertn.), Proso millet (*Panicum miliaceum L.),* foxtail millet *(Setaria italics* L. P. Beauvois*),* barnyard millet (*Echinochloa frumentacea* Link*),* Sorghum (*Sorghum bicolor L.* Moench*),* Pearl millet (*Pennisetum typhoides* (Burm. f) Stapf and C.E. Hubb.) and little millet (*Panicum miliare* Lam.) over many years (Ghimire et al., 2017). Millets are important crops for dryland farmers suitable for growing in marginal lands with low fertility targeting sustainable agriculture and food security of the nation. They are highly nutritious and climate complaint's crops. Millet belongs to a group of secondary crops that provide another minor portion of the country's food energy. It has wide adaptability to varied agro-ecological conditions, has beneficial nutrients properties, and outstanding agronomic attributes as a subsistence food crop; therefore, it holds promise for the future of food and nutrition security. Millet can be thriven well on low fertility soils and does not depend on the use of chemical fertilizers (Gupta et al., 2017), has high drought tolerant capacity, and can be thriven well in adverse environmental conditions, some in acidic soil and saline soil (Habiyaremye et al., 2017). Among the different varieties of millet grown in Nepal, finger millet has been a big choice for farmers and has been listed as the fourth most grown cereals in Nepal (Khadka, Shrestha and Rai, 2016). The crop contains an incredibly nutrient-rich composition. Enriched with the goodness of nature, millet is a rich source of nutrients such as fiber, minerals like magnesium, phosphorous, iron, calcium, zinc, potassium, phenolic compounds, and phytochemicals that aids in the health-promoting property of millet (Hassan, Sebola and Mabelebele, 2021). Millet is not

only used by humans for food but also used as fodder for animals. Finger millet is crucial for the diets of pregnant and lactating mothers, and children as well for the economy of marginal farmers. Its grains are rich in protein, vitamins, minerals, fiber content, and energy as compared to other cereals (Vadivoo et al., 1998).

Nepal has been facing the challenge to feed a projected 28 million people. Just a few of the "mega-crops" like rice, wheat, and maize constitutes a major portion of the total population's intake. The global millet production is estimated to be 27.8 million tons, with a declination rate of 0.9% every year (FAOSTAT, 2019). Millet is consumed as a staple food in most countries like India, Korea, China, Greece, Egypt, and many other African nations. India stands at the top position in producing millet with 41.04% of global market share and African counties like Niger, Mali, Nigeria, Burkina, and Sudan with the highest consumption rate of more than 40% of total global millet consumption (FAOSTAT, 2019). Millet is generally grown as a subsistence crop in Nepal. This is due to lack of market, transport, labor-intensive agronomic cultivation practice, negative socio-cultural beliefs (Khadka et al., 2016). The Nepalese market is ruled by polished rice and secondly by maize. Millet has long been the staple crop but, polished rice, processed sugar, and other refined food products have occupied the space and have become part of our existence.

In spite of the fact that they are stapled in the diets of the majority of the population residing in the semi-arid and arid regions of the world, millets are often called “Orphan Crops,” or even “Lost Crops.” These crops are not really lost but the term signifies their abundance by the developed nations and also their global production statistics indicate significantly low quantity compared to the other more popular food crops. Nevertheless, these neglected crops are significant in view of their contribution to biodiversity and the means of livelihood of the poor in various parts of the world (Belton and Taylor, 2004). Keeping these in consideration, there is a need for solid strategies that can develop the millet cultivation programs in Nepal.

Types of millet and distribution in Nepal

Kodo millet

Kodo millet (*Paspalum scrobiculatum)* is grown as an annual crop in Nepal and also in the India, Philippines, Indonesia, Vietnam, Thailand, etc. Kodo millet was originated from West Africa and later carried to India (Blench, 2012). Kodo millet is a very hardy crop that is drought tolerant and can survive on marginal land (Hariprasanna, 2015). It is a good source of polyphenols, an antioxidant compound, and rich in phytochemicals.

Pearl millet

Pearl millet (*Pennisetum typhoides* (Burm.f.) Stapf and C.E. Hubb*) is* commonly grown in Africa and the Indian subcontinent. It can also grow on sandy soil (Changmei et al., 2014). It is rich in magnesium and other important nutrients. Fiber present in the Pearl millet helps in reducing the excessive bile in our system (Malik, 2015).

Barnyard

Barnyard millets are rich in nutrients. In a research, it was found that fresh cookies prepared from 30% maida (Wheat flour) and 70% barnyard millet flour (MBF70) contained, 7.64% protein, 26.81% crude fat, 6.95% crude fiber, 68.02% carbohydrates, 20.90 mg/100 g calcium, 232 mg/100g phosphorous and 4.31 mg/ 100 iron (Salunke et al., 2019). Barnyard millet contains a considerable amount of protein, carbohydrates, fiber, and most notable micronutrients like iron and zinc (Renganathan et al., 2020). Among different varieties of barnyard millet cultivated, the most popular species are *Echinochloa frumentacea* (Indian barnyard millet) and *Echinochloa esculenta* (Japanese barnyard millet*)* (Sood et al., 2015).

Sorghum

Sorghum being a C4 type cereal species that originated in Africa and Eurasia and is cultivated in the same agro-ecological zones. Sorghum is cultivated in some counted parts of Nepal, across mid-hills (Gurung, 2016), and has many nutritional values. Sorghum helps in hunger satisfaction and helps in satiety and therefore reducing the risk of development of obesity (Ambati and Sucharitha, 2019; Rao et al., 2017).

Foxtail millet

Foxtail millet (*Setaria italics (L.)* P. Beauv.) is regarded as native to China, one of the world's oldest cultivated crops. It can thrive well in dry conditions. In Nepal, it is commonly cultivated in high hills and mid-hills districts of the Karnali zone (Ghimire et al., 2017) and consumed as a food grain. Foxtail millet has healthy carbohydrates that balance blood sugar and is also rich in calcium and iron (Bhandari, 2020). It is also grown in some other parts of the nation like Kaski and Lamjung (Ghimire et al., 2017). Foxtail millet is rich in nutrients like magnesium and is a good source to reduce diabetes.

Pearl millet

Pearl millet is commonly grown in Africa and the Indian subcontinent. It can also grow on sandy soil (Changmei et al., 2014). Millet is rich in magnesium and other important nutrients. Fiber present in the Pearl millet helps in reducing the excessive bile in our system (Malik, 2015).

Little millet

Little millet (*Panicum miliare Lam*) is believed to be native to India and is commonly called Indian millet (Guha, Sreerama and Malleshi, 2015). It is an annual herbaceous plant, whose seeds are smaller, round, and smooth (1.8 to 1.9mm long) than those of other millets. This variety grows straight or with folded blades to a height of 30cm to 1m. Little millet is a good source of vitamin B, minerals like calcium, iron, zinc, potassium among others (Guha et al., 2015).

Proso millet

The origin of proso millet (*Panicum miliaceum L)* goes back to at least 10,000 years ago, growing in the semi-arid region of China (Das, Khound and Santra, 2019). Commonly grown proso millet (Chino) is an incredible climate resilience crop due to the minimum water

requirement for growth and development. Proso millet commonly requires relatively low water and less vulnerable to pest and disease attack (Arendt and Zannini, 2013). It is a good diet for those who are gluten intolerant since it is completely gluten-free. Further, contributes to nervous system health. In Nepal, the cultivation of proso millet is limited to some least developed districts like Humla, Dolpa. People there traditionally consume it as a staple food, commonly called Dhido (Ghimire et al., 2017).

Finger millet

Finger millet is a vigorously growing, tillering annual plant belonging to a grass family with a height up to 170 cm high (de Wet, 2006). It is grown in the arid and semi-arid areas in Africa and Asia. Finger millet is commonly called Kodo in the hills of Nepal where 877 accessions have been maintained by the National Plant Genetic Resource Centre, Khumaltar, Nepal (Ghimire et al., 2017). The grain of finger millet can be grounded and cooked into cakes, pudding, or porridge. Finger millet grains are used to brew alcoholic beverages, owning their significance in the local culture of some ethnic communities. It has the potential to improve food security, health, income, livestock production, and the overall development of smallholders living in marginal land (Khadka et al., 2016). Finger millet (Commonly called "ragi" in Nepa) l is full of minerals like calcium, iron, protein, and amino acids, (Muthamilarasana et al., 2016) popularly known as the first food for babies in Hills of Nepal.

Millet statistics: Area, production, and productivity

Millet is being grown for many centuries in Nepal. If we look back in 1999/91, millet was grown in 198,570 ha of land with production 231,630 metric tons and yield 1.16 metric tons per hectare (MOALD, 2016). Then gradually production and productivity increased and the area cultivated reached maximum by 2014/15 with an area of 268,050 ha (MOALD, 2016). In 2009/10, millet was grown in 268473 ha of land and 299523 metric tons of millet was produced. By 2075/76, the cultivated area of millet was decreased by 5212 hectares; however, the production was increased by 14702 metric tons. (MOALD, 2075/76). The increased in millet productivity during the past decade (2066/67 to 2019/20) was only 0.07 metric tons per hectare.

Production status of Millet in different provinces

Out of seven provinces of Nepal, Gandaki province ranks at the highest position in millet production with the production of 99741 metric tons and a yield of 1.19 mt/ha. Province 2 is the lowest millet producer with a production of 1663 metric tons only and a yield of 0.98 Mt/ha (MOALD, 2018/19). Further, Gandaki province tops the list in millet production in terms of area with 86,610 hectares of land. Province 1 ranks second with 71,863 hectares of land under millet cultivation.

Production status of Millet in different agro-climatic region

Millets are adopted to the distinct agro-climatic region and included in various cropping patterns. However, millet is widely adopted to marginal lands of high hills (Ghimire et al., 2017). If we see the production scenario of millet in the year, 2015/16 and 2016/17, the production seems to be higher in the hilly region followed by mountain and terai (MOALD, 2015/16). The production has increased considerably with a change of about 4,848 metric tons in the year 2016/17. A total of 2,40,958 metric tons (79%) of millet was produced from the hilly region followed by the mountain region, 58,095 metric tons (19%), and the Terai region, 7,651 metric tons (2%) (MOALD, 16/17).

Table 1. Distribution of different varieties of millet in Nepal

Type	Nepali name	Scientific name	Distribution
Finger millet	Kodo	*Eleusine coracana* L. Gaertn.	Khotang, Baglung, Sindhupalchowk, Sindhuli, Kaski, Gorkha, Syangja
Foxtail millet	Kaguno	*Setaria italica* L. P. Beauv	Mugu, Kalikot, Hulmla, Jumla, Bajhang, Bahira, Dolpa, Lamjung, Gorkha, Ramechhap, Kavre
Proso millet	Chino	*Panicum miliaceum* L	Mugu, Dolpa, Humla, Jumla, Kalikot, Bahira, Jajarkot.
Sorgham	Junelo	*Sorghum bicolor* L. Moench	Across mid-hills and terai, small area.
Barnyard	Sama	*Echinochloa frumentacea* Link	Gorkha, Lamjung, far western.
Pearl millet	Bajra	*Pennisetum typhoides* (Burm.f.) Stapf and C.E. Hubb	Rarely found in Nuwakot and far western Terai.
Little millet	Kutki sama	*Panicum miliare* Lam.	Rarely found in the far western region.
Kodo	Kodo	*Paspalum scrobiculatm* L.	Gorkha, Lamjung, Tanahun, Dhading.

Recommended Varieties of millet in Nepal

It is crucial to choose the proper variety of millet to obtain the maximum yield. Being widely grown, millet has different yield capacities depending on the varieties grown, temperature, humidity, precipitation, and wind. Different recommendations have been made since long ago for increasing the production and productivity of millet in Nepal. The recommendation is based upon the altitude from the sea level along with maturity days and yield potential as shown in Table no 4.

Table 2. Area production of millet, production, and productivity during 1990/91 to 2019/20, Nepal

Year (in A.D)	Area (in hectare)	Production (in metric tons)	Yield (metric tons per hectare)
1990/91	198,570	231,630	1.16
1991/92	198,240	228,660	1.153
1992/93	201,770	236,750	1.173
1993/94	225,207	245,957	1.092
1994/95	228,001	252,843	1.109
1995/96	260,090	282,440	1.086
1996/97	259,940	289,480	1.114
1997/98	262,440	285,120	1.086
1998/99	263,950	291,370	1.104
1999/00	263,450	295,380	1.121
2000/01	259,888	282,852	1.088
2001/02	258,120	282,860	1.095
2002/03	259,130	283,378	1.092
2003/04	258,597	289,838	1.096
2004/05	258,839	290,936	1.120
2005/06	261,673	284,813	1.112
2006/07	265,160	291,098	1.074
2007/08	265,496	292,683	1.096
2008/09	265,889	299,523	1.11
2009/10	268,473	299,523	1.12
2010/11	269,820	302,691	1.12
2011/12	278,030	315,067	1.13
2012/13	274,350	305,588	1.11
2013/14	271,183	304,105	1.12
2014/15	268,050	308,488	1.15
2015/16	266,799	302,397	1.33
2016/17	263,596	306,704	1.33
2017/18	263,596	366,704	1.16
2018/19	263,497	313,987	1.19
2019/20	263,261	314,225	1.19

Source: MOALD (2016-2019/20)

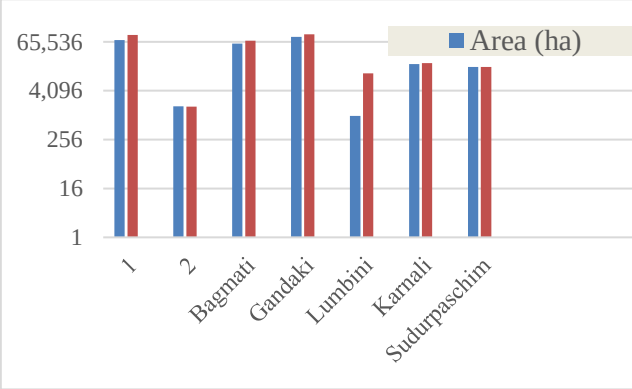

Figure 1. Production status of millet in different Provinces of Nepal (MOALD, 2018/19)

Table 3. Production status of millet in different agro-climatic region

Regions	**Area (ha)**	**Production (tons)**	**Yield (tons/ ha)**
Eastern Mountains	12,335	15,596	1.264
Eastern Hills	56,513	75,892	1.343
Eastern Terai	3,688	4,364	1.183
Central Mountain	21,040	26,793	1.273
Central Hills	36,221	39,095	1.079
Central Terai	2570	2,433	0.967
Western Mountain		-	-
Western Hills	92,932	1,03,598	1.115
Western Terai	495	489	0.988
Mid-west Mountain	10,833	9,971	0.920
Mid-west Hills	11,336	12,955	1.143
Mid-west Terai	15	15	1.00
Far-west Mountain	6,800	5,735	0.843
Far-west Hills	8,468	9,418	1.112
Far-west Terai	350	350	1.00
HIlls Total	205,470	240,958	1.1584
Mountain Total	51,008	58,095	1.075
Terai Total	7,118	7,651	1.0236

Source –MOALD, 2016/17

Cultivation System of Millet

Millet is cultivated from 600m to 2500m level of altitude in Nepal (Koirala and Subedi, 2011). It is grown as a sole crop in the terai region followed by paddy or wheat or oilseed. Similarly, it is grown as a mixed crop or intercrop in the hilly region. In most parts of the hilly region, it is grown as a relay crop with maize followed by wheat or oilseed, or fallow (Table 5). In the mountain region, millet is cultivated as a sole crop followed by barley/wheat or potato, or buckwheat.

Nutrient's content in Millet

Millets are high in their nutrient content. Millet contains three to five times more nutrients than rice and wheat in terms of protein, minerals, and vitamins (Kamatar et al., 2015). Millet imparts nutritional superiority over non-cereals due to its high level of protein, minerals, vitamins, and antioxidants, and for such reason, it is called Nutri cereals (Muthamilarasana et al., 2016)

Table 4: Recommended varieties of millet with maturity days, yield potential, and recommended area for production

Variety	Recommended year	Maturity days	Yield potential (MT/ha)	Recommended area
Ookhla 1	2037 (1980)	154-194	3.3	Mid-hills, high-hills
Dalla 1	2037 (1980)	125-151	3.3	Terai, inner terai and mid hills
Kabra millet	2047 (1990)	167	2.3	900–1900-meter area of mid-hills
Sailing millet	2072 (2015)	155	2.4	1300–2200-meter area from the western too far western area of hills and high hills.
Kabra millet	2072 (2015)	153	2.5	700–1800-meter area from the western too far western area of hills and high hills.

(AITC, 2077)

The important nutrients present in millet include resistance starch, oligosaccharides, lipids, antioxidants such as phenolic acids, Avenothramides, flavonoids, lignans, phytosteroid and phytochemicals like phenolics, sterols, lignans, inulin, resistant starch, β-glucan, phytates, tocopherol, dietary fiber and carotenoids (Ambati et al., 2019) which are believed to be responsible for many health benefits.Pearl millet is an excellent source of micronutrients like iron and zinc (Krishnan and Meera, 2018). Besides this millet is rich in carbohydrates, fat, calcium, iron, and fiber. Millet contains vitamin B such as Niacin, flacon, riboflavin, and thiamine and phosphorous are present in millet that plays a key role in the energy synthesis of the body (Muthamilarasana et al., 2016). Nutrients present in millet help built our immune system stronger and proper functioning of our body organ. All different types of millet contain different quantities of protein, fibers, and minerals. Comparing to rice and wheat, other different varieties of millet contain much more amount of protein fiber, calcium, phosphorous, and iron. Finger millet is having more than thirty times more calcium than rice while all other millets have at least double the amount of calcium compared to rice (Ambati et al., 2019).

Table 5. Cropping pattern of Millet

Altitude	Cropping pattern	Time of planting
Sea level to 600m	Early ripening millet – Paddy Early ripening maize - Millet – Wheat Maize – Millet – Oilseed crop	Shrawan to the second week of Bhadra (Aug-Sep)
600m to 2000m	Millet/Maize - Wheat/Oilseed crop Millet/Maize - Fallow Millet – Wheat – Oilseed crop	Aashad to Shrawan (Jul-Aug)
2000m to 2500m	Soybean + Millet – Barley/Wheat Millet – Barley – Pseudocereals Millet – Potato –Wheat Millet - Buckwheat	Jestha to Aashad (Jun-July)

Koirala et al., 2011

Table 6. Comparison table of nutrient content in rice, wheat, and different millets per 100 grams of consumption

Types of Millet	Protein (g)	Fat (g)	Ash (g)	Crude fiber (g)	Carbohydrate (g)	Energy (kcal)	Thiamin (mg)	Riboflavin (mg)
Pearl millet	11.8	4.8	2.2	2.3	67.0	363	0.38	0.21
Finger millet	7.3	1.3	2.7	3.6	72.0	336	0.38	0.21
Foxtail millet	12.3	4.3	3.3	8.0	60.9	351	0.42	0.19
Proso millet	12.5	3.1	1.9	7.2	70.4	364	0.59	0.11
Little millet	7.7	4.7	1.5	7.6	67.0	329	0.41	0.28
Barnyard millet	6.2	2.2	4.4	9.8	65.5	300	0.30	0.09
Kodo millet	8.3	1.4	2.6	9.0	65.9	353	0.33	0.10
Rice	6.8	0.5	0.6	0.2	78.2	362	0.41	0.04
Wheat	11.8	1.5	1.5	1.2	71.2	348	0.41	0.10
Sorghum	10.4	3.1	1.6	2.0	70.7-72.6	329	0.38	0.15

Source – Muthamilarasana et al., 2016

Importance of millet

The presence of all these essential minerals makes millet one of the important cereal crops. For a developing country like Nepal, the eradication of malnutrition has been a challenge since long ago. Millet has the capacity of providing essential nutrients for the correct functioning of the body. The presence of these nutrients makes millet a natural medicine for several diseases and the prevention of diseases.

Prevention of cancer

Millet contains anti-carcinogenic properties that help the body fight, cancer-causing agents. Substances present in millet-like phenolics reduce the danger of cancer initiation and progression in vitro (Chandrasekara and Shadid, 2011). Studies even have shown the inverse relationship between dietary fiber and colorectal, small intestine, oral, larynx, and carcinoma (Park et al., 2009). Fiber supplied by the entire grains of millet offered the foremost protection against carcinoma. It's been reported that the danger of carcinoma reduced by 41% in those pre-menopausal women eating the foremost whole grain fiber (at least 13 g/day), compared to those with the bottom whole grain fiber intake (Changmei et al., 2014). Further, in post-menopausal women, dietary fiber helps in preventing carcinoma through the non-estrogenic pathway (Park et al., 2009).

Protection against diabetes

Millet is one every of the most important cereals because it prevents the danger of diabetes. Many folks in Nepal old above 40 are in danger of diabetes and lots of people are taking medicine. Millet helps in preventing type II diabetes thanks to its significant level of magnesium. Finger millet contains a sufficient amount of magnesium, 137 mg per 100g dry matter (Muthamilarasana et al., 2016). Magnesium is vital for increasing the efficiency of insulin and glucose receptors by producing many carbohydrates digesting enzymes which manages insulin action, acts as a cofactor for more than 300 enzymes in the body and also affects permeability of excitable membranes and neuromuscular transmission (Long and Romani, 2014). In every research, it's been found that the risk of type 2 diabetes was lowered by 31% in black women who frequently ate whole grains stuffed with magnesium compared to those eating the smaller amount of those magnesium-rich foods (Awasthi and Yadav, 2015) It's found that proso millet showed to boost the glycemic responses and insulin in genetically obese type 2 diabetic mice which were fed under high-fat feeding conditions (Park et al., 2009).

Protection against obesity

The presence of fiber in diet plays a vital role to stop constipation and obesity of the intestine. Millet could be a good source of fiber thus helps prevent obesity. With high fiber content, millet helps to scale back problems like constipation, bloating, and stomach cramping (Butola, Vaaga, Gusain and Kachhwa, 2020). Recent studies even have shown the identical that intake of high dietary fiber decreases the incidence of obesity (Gao et al., 2021). Jowar (sorghum) has been used to make different types of dishes (In Nepal called "rotis") for ages in our country. It's stuffed with protein, iron, and fiber, and helps keep the bad cholesterol away (Gao et al., 2021)

Heart protecting properties

Millet contains some essential nutrients that help keep our hearts strong and healthy. Magnesium has been shown in the study to cut back the frequency of migraine attacks (Dinicolantonio et al., 2018). Magnesium is a cofactor in additional than 300 enzymatic reactions (Dinicolantonio et al., 2018). These enzymatic reactions are liable for regulating pressure level, glycaemic control, and lipid peroxidation, which is critical within the cardiovascular system (Dinicolantonio et al., 2018). Further, it has been found within the study that, the mortality risk of coronary heart disease decreased by 17-35% with every 10gram addition of dietary fiber to a diet (Streppel et al., 2008).

Detoxification

Soluble bound phenolic extracts of several varieties of millet (Kodo, finger, foxtail, proso, pearl, and little millet) show antioxidant, metal chelating, and reducing power properties (Chandrasekara et al., 2011). Further, millet contains curcumin, ellagic acid, quercetin, and catechins, which help remove foreign agents and free radicle. This antioxidant property of millet helps to get rid of the toxic substance from our body. In an experiment conducted, around 50 phenolic compounds were identified as phenolic acids and their derivatives, dehydrodiferulates and dehydrotriferulates, flavan-3-ol monomers and dimers, flavonols, flavones, and flavanonols in 4 phenolic fractions of several whole millet grains (Kodo, finger, foxtail, proso, little and pearl millet) were tentatively identified using HPLC and HPLC – tandem mass spectrometry (MS) (Chandrasekara et al., 2011).

Constraints of millet production in Nepal

Weed

Weed has been a significant factor contributing the crop loss in many of the cereal crops. One of the good problems with which a farmer must deal is the presence of weeds or plants aside from those sown, which arise without human effort and prevents from obtaining maximum yield (Winifred, 1917). It is believed that a low weed population can be advantageous to the growing crop as it provides habitat and food for a variety of beneficial organisms (Mishra, Upadhyay, Kumar and Hans, 2018). Although if weeds cross the critical threshold, utilize food and water from the soil, and they tend to shade the crop and rob it of much of the sunlight essential for better crop growth and development (Brenchley, 1917). Commonly arising weeds in millet fields belong to families Poaceae, Convolvulaceae, Asteraceae, Amaranthaceae, Commelinaceae, Compositae, Nyctaginaceae, apparridaeceae, portolacaceae, ehphorbiaceae, tiliaceae, alizoaceae, zygophyllaceae, asclepiadaceae, cyperaceae and scrophulaceae (Mishra et al., 2018). Weed competes with millet for nutrition, space, and water. Uncontrolled weed infestation significantly reduces the crop yield between and 15 to 83% in Sorghum, 16 to 94% in pearl millet, and 55 to 61% in finger millet depending on crop cultivars, nature, and intensity of weed infestation, management practices, and environmental condition (Mishra et al., 2018).

Table 7. Common weeds on Millet field with their scientific name and family

Common weeds	Scientific name	Family
Browntop millet	*Brachiaria ramose*	Poaceae
Crabgrass	*Digitaria sanguinalis*	Poaceae
Crowfoot grass	*Dactyloctenium aegyptiam*	Poaceae
Viper grass	*Dinebra retroflex*	Poaceae
Peacock plume grass	*Chloris barbata*	Poaceae
Goosegrass	*Eleusine indica*	Poaceae
Jungle rice	*Echinochoa colona*	Poaceae
Johnsongrass	*Sorghum halepense*	Poaceae
Yellow foxtail	*Setaria glauca*	Poaceae
Green foxtail	*Setaria viridis*	Poaceae
Tarpedo grass	*Panicum repens*	Poaceae
Hilo grass, sour grass	*Paspalum paspaloides*	Poaceae
Field bind weed	*Convolvulus arvensis*	Convolvulaceae
Bristly starbur	*Acanthospermum hispidum*	Asteraceae
Prickly chaff flower	*Achyranthes aspera*	Amaranthaceae
Tropical spider wort	*Commelena benghalensis*	Commelinaceae
Bill goat weed	*Ageratum conyzoides*	Compositae
Pigweed	*Amaranthus viridis*	Amaranthaceae
Palmar amaranth	*Amaranthus palmeri*	Amaranthaceae
Redroot pigweed	*Amaranthus retroflexus*	Amaranthaceae
Hog weed	*Boerhaavia diffusa*	Nyctaginaceae
White cock's comb	*Celosia argentea*	Amaranthaceae
Cleome	*Cleosia viscosa*	Capparridaeceae
False amaranth	*Digera arvensia*	Amaranthaceae
Common purslane	*Portulaca olerecea*	Portulacaceae
Pill pod spurge	*Euphorbia hirta*	Euphorbiaceae
False daisy	*Eclipta alba*	Compositae
Jew's mellow	*Corchorus acutangulus*	Tiliaceae
Morning glory	*Ipomoea haderacea*	Convolvulaceae
Horse puslang	*Trianthema portulacastrum*	Aizoaceae
Coat buttons, tridex	*Tridex procumbeans*	Compositae
Puncture vine	*Tribulus terrestris*	Zygophyllaceae
Common cocklebur	*Xanthium strumarium*	Asclepiadaceae

Source: Mishra et al., 2018

Disease and pest

Stem borers and Grain midge are a common variety of regularly occurring pests in millet (Gahukar, 1989). About quite a hundred insect pests are identified to attack millet within the field and during storage. (Gahukar, 1989) Disease and pests cause a considerable loss in millet production and reduce both biological and economical yield. Common pests include shoot fly, stemborers, armyworms, leaf beetle, leaf folder, flea beetle, leaf roller, surface grasshopper, and ants (Kalaisekar et al., 2017). These insects go after shoots, leaves, and fruit part of millet causing a significant loss.

Poverty and food insecurity

Millet has long been a staple crop in hills and high hills of Nepal, but since when polished rice and sweetening took the place of millet, farmers seem to be less attracted towards millet production. The poverty rate is much lower in urban areas (15%) than rural areas (27%); seasonal poverty is higher (34%) in April- May and lowest within the October-January (17%) (National Planning Commission, 2018) Farmers cannot afford expensive hybrid new released varieties of millet and fertilizers. Low per capita income has led to traditional farming and lower returns. Tools and heavy pieces of machinery are beyond excess to them.

Lack of Research

Lack of research is one of the most constraints in the slow development of millet production in Nepal. Among all the publications made by National Agriculture Council (NARC), only 6% were on small millets; the bulk on finger millet (Khadka et al., 2016). This 6% is also based on few accessible areas of Terai and hilly districts. There's no such research carried out to enhance the genetic makeup of millet as it is done for other cereals like rice and wheat. The majority of researches are limited to central areas concentrated on major cereals only. Lack of research has been a major constraint towards the millet production of Nepal.

Labor Intensive

Compared to other major cereals, millet require high labor input during transplanting, weeding, harvesting, and grinding. The high hills of Nepal are facilitated with fragmented lands creating difficulty for mechanization. Increasing labor charges and scarcity of labor at transplanting, and intercultural operations have increased the workload of farmers. Women are the chief labor throughout the whole process of cultivation and preparation of finger millet items. Millets are widely grown within the sloped or terraces in the hills, with limited possibility of mechanization to reduce the drudgery associated with production and post-harvest operations.

Lack of Awareness

Lack of awareness on the nutrient composition and value of millets on human health; consequently, there is a low rate of consumption especially among the generation. It has received inadequate policy support for development, cultivation, and value addition. Further, information on area, cultivation, and production of small other than finger millet is scanty although they are grown and consumed by farmers in different parts of the country.

Changing Climatic Conditions

Each year Nepal faces plenty of variation within the atmospheric condition and therefore the ecosystem. The global circulation model indicated that Nepal will increase between 0.5°C and 2.0°C with a multi-model of 1.4°C by 2030s (Bhandari, 2014). The speed of rising of temperature in higher altitudes, especially within the mountains and Himalayas of Nepal was beyond that of the global average (IPCC 2012).

Table 8. Common disease and pests in Millet

Disease	Category	Causative organisms	Survival and spread	Host
Grain mold	Fungal	*Fusarium spp., Curvularia lunata Bipolar spp., Aspergillus spp.*	Crop residues, soil; air-born	Sorghum, pearl, finger millets
Sugary disease/Ergot	Fungal	*Claviceps sorghi, C. Africans C.fusarium*	Infected panicle, sclerotia in seed and soil, collateral host; seed-, soil-, airborne	Sorghum, pearl millets
Smut	Fungal	*S. relianum S. sorghi S. cruenta*	Head smut: soil-borne; loose and covered smut: externally seed-borne; long smut: air-borne	Sorghum, pearl, small millets
Pearl millet smut	Fungal	*Tolyposporium penicillariae*	Survives as teleutospore in infected seed or soil; air-borne sporidia cause infection	Pearl millets
Small millet smut	Fungal	*Melanopsichium eleusinis Ustilago crameri U.panici-frumentacei*	Grain smut: externally seed-borne, air-borne; Head smut: seed-borne	Finger, foxtail, barnyard millets
Udbatta	Fungal	*Ephelis oryzae*	Survive in *cynodon dactylon, Pennistetum spp*	Foxtail, kodo, little millets
Blast	Fungal	*Pyricularia grisea*	Crop residue, and other cereals	Pearl, finger, barnyard, Proso and little millets
Bacterial leaf spot	Bacterial	*Pseudomonads syringae pv. syringae P. syringae*	Crop residue in soil; spread by rain-splash	Sorghum, pearl, finger millets
Bacterial leaf stripe	Bacterial	*Pseudomonas andropogoni Ps. avenae Ps. eleuinae*	Crop residue in soil; spread by rain-splash	Sorghum, pearl, finger millets
Bacterial leaf streak	Bacterial	*Xanthomonas axonopodis pv. Holcicola X.a pv. pennamericanum X.a pv. coracanae*	Crop residues in soil;spread by rain-splash	Sorgum,pearl,small millets
Bacterial stalk rot	Bacterial	*Erwinia chrysanthemi*	Crop residue in soil, spread by rain -splash	Sorghum
Maize stripe virus	Viral	*Maize stripe (MStV-S)*	Plant hopper	Sorghum, pearl, small millets
Maize mosaic			Plant hopper, peregrinus maidia	Sorghum, pearl, small millets
Red stripe	Viral	*Red stripe (*SRSI)	Mechanically by sap; Amohid	Sorghum, pearl, small millets

Source: Das, Vilas and Tonapi, 2016

In terms of climate change, Nepal is one of the most vulnerable countries in the world because of its physiography and ecology and ranks the fourth most vulnerable country due to the impact of climate change by Maplecraft in 2016 (Sapkota and Rijal, 2016). The variability of climate adversely affects agriculture, natural ecosystem, and water bodies which also contributes as a hindrance to the production and yield of millet. Rainfall showed a strongly significant decreasing trend in all elevation regions and onset on snow delayed. A negative relationship has been found between millet yield and rainfall, while both rainfall and temperature showed a strongly negative relationship on millet yield (Ojo et al., 2020). *Consideration as marginalized food*

Millet crop is not identified as a nutritious crop in Nepal. It is considered as the 'low-value food' or 'food of marginalized communities. It is consumed by the majority of households in the mid and high hill regions of the country in varying quantities, irrespective of ethnicity (Khadka et al., 2016). Millet as a crop is treated as impure by Brahmin and Chhetri caste people in someregions of our country and even hesitate to eat it in public places (Khadka et al., 2016).

Lack of Infrastructures and Proper Marketing Facilities

There are no suitable facilities of infrastructures for preventing post-harvest losses and for the storage of millets. There is a lack of good transportation facilities for the timely transport of millet in different regions of the country. In many areas of the country, water is scarce and there are no proper irrigation facilities. There are no proper marketing facilities and great fluctuation in the price due to which crop become uneconomical.

Strategies to overcome the problems

Agriculture is the backbone of the Nepalese economy. Millet production has to be focused on the potential cultivation areas. However, in Nepal, there has been no effective formulation of plans and strategies for producing safer food products, such as Millet. As a result, farmers have been deprived of the benefits of higher incomes of selling crop products; moreover, the public has been deprived of a healthy diet and a better environment as well (Khanal, 2020). Focus on future research related to the production of high-yielding varieties of millet. Development of HYV, location-specific varieties. Advertisement on the nutritional importance of millet. Changing the social perception of farmers through media, online conferences, and home – visit. Focus on integrated weed and pest management. Support from government and extension agents to perform field demonstrations, providing subsidies and other technical support. Support from local level providing basic inputs.

Development of Tourism sector as the demand for "Dhido" is higher.

CONCLUSION

Millet not only being nutritionally important, can be a powerful asset to countries like Nepal. Millet is the fourth most produced crop in Nepal mainly produced in hills and high hill regions. The Millet production trend of Nepal isn't satisfactory. Area and productivity of millet seem to be decreasing in recent years with constant productivity. Disease and pests, poverty and food insecurity, lack of research, labor-intensive work, changing climatic conditions, consideration as marginalized foods, and lack of proper infrastructure and marketing are the major constraints for millet production in Nepal. In 30 years, the overall change in production is simply 82,595 metric tons which are kind of low to cut back the food dependency and export, promotion of millet farming is important through various local and national level strategies like, subsidy, varietal development, market development, awareness campaign, technical support. Further, concerned authorities need to show their active participation in pointing problems for reducing their effects. Further emphasis is required for advertising their health-promoting characters for attracting people to its consumption. Advertisement of popular dish 'Dhido' which demand is increasing within the domestic and foreign tourists is necessary. The problems identified should be addressed as fast as possible for a sound and healthy millet production trend.

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