

A GUIDE TO PROSO MILLET CULTIVATION IN NEPAL



Raksha Sharma, Kiran P. Bhatta, Binod Bohora, Devraj Rajbanshi & Ramesh Karki

Authors

Raksha Sharma, Kiran Prasad Bhatta, Binod Bohora, Devraj Rajbanshi and Ramesh Karki

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Preface

This book has been prepared to sensitize all types of institutions working in the agriculture and allied sub-sector in Nepal. Though we had recently celebrated the International Year of Millet in the year 2023, the focus on several such so-called minor crops named as "Neglected and Underutilized Crop Species (viz. NUS)" in Nepal has been low. There are very few organizations, if any in Nepal, working on these crops, may it be for the development of variety suited to current context of changing climate as well as variety that may yield better so that the farmers are interested in cultivating it, developing the best package of practices for realizing the potential yield of these crops at par with neighbouring countries having similar geospatial conditions, or any other aspect for scaling-out of the acreage under these crops. There are numerous crops that are categorized under NUS like Chino (Proso millet), Kaguno (Foxtail millet), Kodo (Finger millet), Latte (Amaranthus), etc. but in this book, we are only considering to explore the intricacies of Proso millet. Writing of this book has been influenced by the first author's visit to Bajura district during field implementation of one of the research projects conducted by Faculty of Agriculture, Far Western University under ICIMOD-GRAPE project. The long discussion with the local farmers gave an idea to initiate this writing-project. The author also got engaged in several of the cultivation and post-production process during the field visit and with some seeds borrowed from the local farmers, the close observation of each of the growth stages, morphological characteristics, etc. also took place in the farm of the Faculty of Agriculture located in Kailali district. Thereafter, author(s) also interacted with some other farmers to gain insight into some of the interesting facts about the social aspects, challenges and opportunities, and other such information about the crop. The long experience of the first-author in the field of Agronomy was also useful to give a proper shape to the book. Finally, the journey has been beautiful and we hope that this book will help students, field workers and other interested in this field, as well as sensitize government and other development partners to shift their focus on such an important and hardy crop that can combat the ill-effect of changing global climate, is easy to cultivate, have highly nutritious value, is trending in urban population.

Thank you.

Authors

Message from Dean

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Glossaries

Introduction

Overview of the Proso Millet

Proso millet (*Panicum miliaceum*), known as ‘Chino’ in Nepal is often called ‘chari anna’, meaning ‘bird’s cereal’, as it is loved by birds. The panicle of this crop is similar to paddy, but has larger seed than commonly grown finger millet, so it is called ‘Dhan kodo’ (Joshi and Ghimire, 2022). It is a warm season cereal crop, having hairy leaves arranged alternatively in the light green erect stem. This crop is self-pollinated, which grows well in marginal lands and have low water requirements, and hence is well adapted in the mid hills and hills of Nepal. Mostly grown in Karnali and Far Western hills of Nepal, this crop is also found in some villages of Lamjung, Ramechhap, Udaypur and Dhading districts (Joshi et al., 2023). In Karnali province, prosomillet is grown in all districts except Salyan, Surkhet and Jajarkot, covering 1830 ha and producing nearly 1743 metric tons. But there are other districts which have larger area under this 1743 mt crop viz. Mugu (709 ha), Dolpa (500 ha), Humla (346 ha) and Jumla (200 ha), which produced 700, 480, 260 and 240 tons respectively (MoLMAC, 2024). But in far western province, Jilli, Rajatoli, Dhamkane and Dhim villages of Bajura have greater number of prosomillet growers as compared to other villages. This crop is grown during April/May as a fodder crop, due to its heavy biomass during the summer months but is cultivated as a major cereal crop, during the month of June-July in Bajura. This crop is grown from March-April in the hilly regions of Karnali province and harvested during September-October. The aerial part of Proso millet contains 10.1% crude protein, 7.9% ash, 4.5% lignin, 73.7 % NDF, 36.0% ADF, 3.6 g/kg Ca, 1.6 g/kg P, 58.5 % DOM (Tran, 2017), and leaves decompose easily, hence can also be used as green manuring crop. This crop is grown as cover crop and catch crop due to its profuse tillering habit and short growing cycle.

History of Proso Millet

Millets were the primary grains in Asia before the rice. Proso millet is the oldest among all the domesticated millets and hence is considered as true millet. According to many archaeological theorists the domestication of proso millet occurred around the beginning of the Holocene as global temperatures warmed and hunter-gatherers were exposed to new plants and environments (Bettinger et al., 2010; Habiyaemye et al., 2017). Archaeological evidence indicates that millets, Proso millet and foxtail millet were first domesticated millets around 8000–10,000 years ago in the Yellow River region of northern China (Hunt et al., 2014; Okemo et al., 2024).

Importance of the Proso Millet

Nutritional value: Grains are rich in proteins (12.5%) and carbohydrates (70.4%) (Joshi and Ghimire, 2016), which also contains 2-3% minerals, 1.1% crude fat, 2.2% crude fibers (Gavit et al., 2018). A report revealed that 100 gm of Proso millet contains 8 mg of calcium, 10 mg of

iron, 206 mg of phosphorus, and 4.5 mg of niacin (Saha et al., 2016). Similarly, these grains contain high amount of thiamin, copper, phosphorous, magnesium, zinc, selenium, riboflavin, niacin, pantothenic acid and vitamin B6 (FAO, 2023). This nutrient packed food provides strengths to the people living in mountains to beat the cold during winter. It also helps in strengthening muscle flexibility and overcoming respiratory problems, if consumed daily by the people living in hills. Das et al. (2019) has also reported higher amount of fibre and antioxidants, which prevents cardio vascular diseases and cancer. In villages of Nepal people often consume the mixture of hulled grains with 5% unhulled grains with half fermented curd for overcoming the problem of excessive bleeding and anaemia in women. They even consume the starch water (maad) after boiling the rice as a source of nutrient to gain strengths. Palchetti et al. (2023) also cited this cereal to be good alternatives to celiac disease due to gluten free protein, rich in antioxidants and low glycemic index. Due to its nutraceutical properties (Himanshu et al., 2018) proso millet can also be a good food for gluten allergic diabetic patients.

Economic value: Proso millet never received priority in the market, and remained undervalued crop for the past two decades in Nepal, which were grown and consumed within the farming households only. Any dishes of proso millet were never served to guests, as this crop was considered ‘Ku-anna’, meaning ‘bad cereal’ or ‘inauspicious’. The young generation have rarely tasted this crop, and farmers dropped this crop from their cropping system prioritizing the improved variety of other crops like maize, rice, beans and vegetables. Currently, proso millet is receiving recognition as special crop or super food, and hence is costlier than paddy and wheat, in the far western mid hills. As per the farmers, the farmgate price of threshed proso millet is Nrs. 50 per kilogram. This crop is also an insurance crop. In case of crop failures, proso millet could also be suggested as alternative crop in the hot and dry areas of mid hills (400-1200 masl), as it can be grown without supplemental irrigation during the summer, and matures earlier. Proso millet is low input and low maintenance catch crop, and hence benefit cost ratio is higher than other cereal crops.

Ecological value: This crop has been reported to improve the soil productivity making it loose and friable, unlike finger millet which make the soil dry and nutrient impoverished. Proso millet is a nutrient dense food which makes the soil loose and porous, adds nutrient to the soil through its leaves, and is a good companion crop in the mid hill. This crop can be grown in the drought prone areas, and fits well in the cropping system of hills, mid hills and terai region of Nepal due to its wider adaptability, low nutrient requirement and short growing period (Ventura et al., 2022). Tillers from each nodes make it good fodder crop, whereas the biproducts of proso millet grains are used to feed the cattles and livestock to the quantity of milk from milching animals. Some local landraces like malchino can also be grown in terai region, after the harvest of

rapeseed and mustard, which otherwise remains fallow during the summer months, thus adds to diversity of cereal crops. Despite its significant contribution to soil, human and sustainable agriculture, this crop has received limited attention.

Cultural value: This crop brings in all aged group together in the neighborhood during the harvest and post-harvest operations. “Neighbors are invited for threshing of this crop together with feet for a day or two depending upon the quantity harvested. Children, elderly people and women work together for threshing, who are served with fresh popped proso millet and freshly cut larger cucumber with spices. People grow chiono at small scale these days, and I miss the celebration”, says Karna Buda (66 years old farmer of Dhim village, Himali-6, Bajura).

The culture of sending this nutrient packed food in muslin cloth, to sisters while sending them to their in-law’s place, still exists remote villages. “*Muri badhera didi bahini lai koseli pathaune chalan ahile pani gaughar tira chha*”, says Umesh Neupane, Jumla. He added, herdsmen and women generally carried freshly hulled prosomillet mixed with walnuts and perilla, during their travels or when they are away for collection of woods, fodder and forages for the livestock.



Proso millet (Mal chiono) at flowering stage

Morphology of Proso millet

Proso millet “*Panicum miliaceum* L.” belongs to the largest tribe ‘Paniceae’ of the family Poaceae (Graminae) with sub family Panicoideae. It is a tetraploid species with chromosome

number $2n=4x=36$ (Rajasekaran et al., 2023). Roots are fibrous and shallow depending upon variety. Nodal roots are mostly observed in one or two nodes above the ground. Stem is round, hollow with filled nodes and each node can develop nodal roots, leaves and tillers. Each tiller can bear secondary tillers and tertiary tiller in most the wild type of proso millet. Leaves are borne on alternate side of the stem. Leaf sheath and leaf blades are hairy. Many panicles can be observed in single plants from both the lower and the upper nodes, unlike the basal tillers (from the basal node) in rice and wheat. It takes almost 60-90 days for the plants to reach maturity depending upon varieties.

Types of Proso millet

Farmers use different types of proso millet in Nepal, the most common are dudhe chino, which derived its name from white colored grains, haade chino harder than dudhe chino with brown and yellowish-brown color and malchino named especially for small grained bushy types. Grains may be pointed or round, small, medium and larger; color vary from white, creamy, light yellow, brownish black and reddish. Depending upon these, farmers at different geographical locations have adapted the varieties like Rato chino, dudhe chino, hade chino, varvare chino, kalo chino, Sanwa chino, Samai chino, bhumaro chino, and is being grown differently at various time period.

Varieties common in Karnali province

The common varieties are Rato chino, dudhe chino and hade chino. Plant height of rato chino has been reported to be 155-160cm, which flowers in 45 to 50 days and matures in 80 days. The panicle is long with shiny light red grains. The yields of rato chino ranges from 0.8-0.85 kg per ropani.

Dudhe chino has been reported to have 145-150cm plant height, flowers early i.e., 45-60 days after sowing and matures in 85 days yielding 2.1 t/ha. Dudhe chino has larger panicles with greater number of grains, the seed is milky in color, nature and taste and is susceptible to insects and pests at storage. But hade chino has all the similar features as rato chino but is hard with larger seeds which are yellowish in color. The other types of chinios are blackish, brownish or mixed yellow in color (MoALMC, Karnali Province).

Varieties common in Far western province

But the commonly cultivated varieties are 'dudhe chino' and 'mal chino' with the yield ranging from 1 t/ha to 2.8 t/ha. Dudhe chino is often called the king of chino, as it is taller, tastier and gives higher yield than all other chino, in the midhills of Nepal. It has stout panicle which is dense enough to grasp with hand i.e., it has compact panicle. It is highly nutritious and hence could not



Leaves of Dudhe chino (flat) on the left and Malchino (narrow) on the right

be digested by all. A study was done in Kailali district, which is at 156.04 masl, to study the morphology, yield and yield attributing traits of both these varieties. The differences between roots, stems and leaves at 55 DAS for the commonly grown varieties i.e., Dudhe chino and Mal chino, in the Far western province are described in Table 1.

Table 1. Observations on root, stem and leaves of Dudhe chino and Mal chino

Parts	Dudhe chino	Mal chino
Roots	Primary roots are thicker and longer. Secondary roots are also thicker with root hairs. Root length varied from 15-18cm in terai at 55 days after sowing.	Have shallow rooted Thin adventitious roots with many root hairs. Root length varied from 8-12cm in terai region, when measured at 55 days after sowing.
Stem	Thick and soft stem ranging from 2.7 to 4.5 mm in diameter with an average of 3.42 mm. Light in color, with long stem. The plant height ranged from 80 to 95cm having long internodal lengths, with 88 cm in average.	Stem is thin and stiff ranging from 1.5 to 1.8mm in diameter with an average of 1.63 mm. Dark and short stem. The plant height ranged from 60 to70 cm having nodes at closer distance, with 66 cm in average
Leaf	Are long, flat and light green, with dense stiff hairs. The lengths of leaf ranged were larger than the plant height. Mid rib is broad and distinct.	Are narrow and short having dark green color and hairs not as dense as dudhe chino. Leaf lengths were shorter. Mid ribs can be seen when observed closer.



Roots of Malchino on the left and Dude chino on the right

Both varieties were similar in few traits like nodal roots were observed up to two upper nodes in the main stem, showed up panicles from each of the two to three nodes and posed grains in smooth hulls. In the field condition, Malchino was able to withstand water logging condition as compared to dudhe chino, due to stiffness of the stem. Dudhe chino plant completely decayed, whereas malchino survived showing only 5% filled grains. This might be due to stiff stem and quick maturing nature of the later and succulent, soft stem at early growth stage of dudhe chino. The difference in yield and yield attributing traits are shown in Table 2.



Dudhe chino (left) and mal chino (right)

Table 2. Observation on yield attributes and yield of two common varieties at Kailali, 2024

Yield and Yield attributes	Dudhe chino	Mal chino
Days to flowering	50-70	45-55
Days to maturity	68-90	60-70
Panicle	Drooping and compact	Scattered and Open
Panicle number per square meter	160-200	200-250
Panicle length	30 -37 cm	20 - 25 cm
Filled grains per panicle (count)	120-150	180-220
1000 grain weight	4.5-4.8 g	3.3-3.5 g
Seed shape	Oval to spherical	Flat with pointed on both side
Seed color with hulls	Creamy white to soft beige	Shiny grey or umber with creamy lined
Seed diameter (mm)	1.4-1.5	1.2-1.3
Seed length (mm)	2.1-2.2	1.6-1.8
Sterility %	50-70%	30-40%
Grain yield (t/ha)	0.5-0.7	1.4-1.8
Straw yield (t/ha) at harvest	7 -8	4-5



Malchino on the left and Dudhe Chino on the right

Climatic and soil requirements

Climate: Proso millet is cultivated in the altitude ranging from 1500-3500 masl but also performs well in altitude of 156 masl at Tikapur, Kailali. Proso millet is sensitive to frost and requires high temperature for seedling development and growth (Habivaremve et al., 2017). Ideal temperature for growing this crop is 20-30⁰C. This crop is also suitable for growing in dry land areas, as the water requirement of this crop is several folds lower than major cereal crops like rice, wheat and maize. This crop has reportedly performed better under 250-300mm water throughout its growth period (Yang and Feng, 2020). Bright sunshine with relative humidity of more than 65% is best for producing higher yields. It is day neutral crop but grows well in areas with high temperature and humidity, but the vegetative growth is restricted at higher temperatures. Rainfall during flowering time increases spikelet sterility and drastically reduces the yield of proso millet but humid climate during grain filling increases the yield.

Soil: Proso millet can be grown in any type of soil including troubled soil and low fertility soil but performs best under well drained sandy loam or loamy soil with pH of 5.5-6.5 (slightly acidic). It can also be grown wide range of soil with pH of 4.4 to 10. Clay soil leads to restriction in the growth of roots leading to lean plants with lesser number of tillers, and hence is not good for proper yield. This crop can also be grown in saline soil and alkaline soil. Proso millet's ability to tolerate deleterious alkaline conditions has also been reported in a study (Islam et al., 2011). Soils containing high potassium content is considered ideal for obtaining healthy seedlings in dry land areas, due to their ability to withstand initial drought. Dry soil is better than

moist and/ compact soil for proper germination. White soil with high calcium content has been reported to be good for proper growth of prosomillet in Mugu district of Karnali province.

Cropping system

The most common cropping system in midhills are: Maize-potato-chino; Maize-wheat-chino; vegetable-chino-rajma. Some have reported Chino-wheat-buckwheat in Jumla (Joshi and Adhikari, 2016). Monoculture of chino is being practiced in drier areas with spatial mixed cropping of grain amaranth, finger millet and foxtail millet (Ghimire et al., 2018). In high hills, prosomillet is cultivated during March-April as mixed cropping with foxtail millets or as sole crop with amaranthus in the bunds. The most common cropping system in high hills of Karnali provinces are: potato+prosomillet, wheat-prosomillet and barley-prosomillet is common in Mugu district whereas prosomillet+ricebeans, prosomillet+blackgrams are common in Jumla district. Prosomillet is also grown in bunds around the fingermillet fields in Mugu. Chino can be grown together with other crops as chino+ rajma; chino+rajma+choto at around 1500-2000 masl as commonly followed by the farmers of Dhim village, Bajura. But in far western terai region of Nepal, chino is not grown but Rice-wheat-chino; Rice-Rapeseed-Wheat-Chino; Rice-rapeseed-Lentil-Chino can be suggested for improving food security, as it performed well in Kailali district, when sown during the month of March. This crop is known to reduce weed build up during spring, when grown in residual moisture after harvest of wheat crop (Habiyaremye et al., 2017). Farmers growing proso millet in Nepal have reported dramatic increase in the yield of wheat crop, when grown after Proso millet.

Cultivation practices

Land preparation: Burning of residues is done to disinfect the field and ensure robust crop. Addition of biochar or organic manures @6 t/ha should be incorporated at the time of land preparation. One deep ploughing followed by 2-3 harrowing and planking ensures proper tilth for sowing Proso millet. Tight and moist soil delays or reduces germination due to formation of crust and hence soil should be made loose and porous through residue burning and frequent harrowing. Farmers of dry land areas especially around 1900 masl in Far western province have reported higher yield from the field, where the crop residues and agriculture trashes are collected and burnt, due to stout bluish stem (as big as thumb), greater leaf area of first two leaves, higher number of tillers and heavy panicles.

Seed and sowing: Seed rate varies from 5-10 kg seed per hectare, depending upon the variety and should not be sown deeper. Seed should be covered lightly after sowing. Deep sowing leads to weaker seedlings. Good germination and seedling vigor is obtained, when sown under dry

condition as compared to moist one at soil temperature between 20-30⁰C. But soil temperature of more than 30⁰C damages the growing seedlings, and hence care should be taken. Broadcasting 8-10 kg/ha seed is highly recommended over line sowing (5-6 kg/ha), as it yielded more than 2t/ha in broadcasting as compared to 0.5 t/ha in line sowing at Kailali district of Nepal for the dudhe chino variety. Ideal time for sowing proso millet is 3rd week of May to 1st week of June (Jestha) in high hills; 1st fortnight of July (Ashadh 12th onwards) in dry mid hills whereas in the areas with high rainfall it is sown during last week of July (till shrawan 15th). But for terai, it could be sown on **March-April** during summer or 1st week of August (Shrawan 2nd week).

Weeding & thinning: Removing excessive plants and weeds from the field allows good aeration between the plants for proper yield. Weeding and thinning is done together 15-20 days after sowing to ensure one seedling per hill and to maintain the distance between the plant at 15-20cm. While thinning, appropriate space should be maintained between the plants, so that during the grain filling period the panicle of a plant will not touch another panicle and sufficient air flow is ensured within the plant foliage at maximum growth stage. This allows maximum number of grains per panicle. This is followed by bending operations. Weeding can be done manually as well as wheel hoe. During early growth stage, weed free condition should be maintained for the first 25 days after sowing. But to obtain better yield, 2nd weeding is recommended in the mid hills where the growing period is longer, which takes 4.5 months (like in Mugu).

Bending: It is a traditional practice of exposing 70 percent root towards the sun with the hoe, removing all the weeds and bending the plants at an angle of 30 to 45⁰ with the ground. While bending, the growing tip should not touch the soil, as it facilitates decay of the plant. Bending operation ensures good aeration for the growth of roots and shoots. Bending is recommended to be done 15-20 days after sowing or when the plant reaches 20-30 cm height, leaving all the uprooted plants and weeds between the plants for decay. This operation improves the tillering ability of plant and hence should be done before the nodes are visible. This practice increases grain yield by 25 percent (personal communication with Proso millet growers of Bajura, Nepal).

Water management: Proso millet can be cultivated in drylands without supplemental irrigation, hence could be grown in areas with less than 500mm average rainfall (**Changmei and Dorothy, 2014**). It can be grown as rainfed crop. Pre-sowing irrigation is recommended 2-3 days before the land preparation, if the soil is too hard to plough. Soil should be loose and friable, not moist during sowing. Flood irrigation should be avoided as it makes the soil compact. In terai region, sprinkler irrigation is suggested in proso millet just before the flowering stage and during grain filling when grown in dry season. In Nepal, the rainfall time coincides with these growth stages in the mid hills and hence farmers receive better yield of proso millet. But during dry seasons in

terai, irrigation should be given during tillering, panicle initiation and grain filling stages for higher yields, depending upon the soil condition. In terai during dry periods, sprinkle irrigation is suggested over flood irrigation.

Nutrient management: Proso millet requires relatively lesser amount of nutrients compared to other cereals. A general recommendation of 6 t/ha organic manures and 50:20:20 NPK kg/ha chemical fertilizers is recommended by government for all the millet crops in Nepal. Half of nitrogen and full dose of phosphorus and potash as a basal dose at the time of sowing should be given while the remaining nitrogen should be applied at 30 DAS.

Insect-pest management: The most common insects found in prosomillet fields are shoot flies (*Antherigona spp*), which feed on the growing tips of young seedlings and cause withering of central shoots and hence reduce the plant stand. The yield loss can be minimized by increasing the seed rate. Seed treatment with Imidacloprid @10 ml/kg of seed can minimize the damage. Application of Cypermethrin 10EC@ 2.5ml per litre of water or Bullet, when the damage threshold reaches 10%, can reduce the shoot fly infestation. Similarly, rice ear bugs (*Leptocorisa oratoria*) feed on developing ear of the millet, and increase the damage to millets. The infestation of these bugs could be reduced by capturing rice bugs either in the early morning or late evening. Sometimes rice ear head eating caterpillar (*Mythimna separata*) could also be observed in prosomillets, for which Emamectin Benzoate is recommended.

Diseases: Blast, leaf blight (Daduwa) and head smut (kalo poke) are the common disease of prosomillet. Blast is commonly observed in prosomillet grown in areas with high humidity and low temperatures. Head smut in millets was first recorded in Humla district (Manandhar et al., 2016). All these fungal diseases could be controlled by treating these seeds with fungicides like Bavistin @2g/kg seed and using the high-quality disease resistance varieties. If the problem is observed at later growth stages, 0.05% carbendazim at flowering stage can control further infestation. If the infestation is severe, carbendazim+ mancozeb (1:1) @ 1g/litre can be sprayed to control the blast disease.

Maturity indices: The crop is considered fit for harvest when the stem and panicles turned yellow but peduncle are still green. Breaking of panicle tips and shattering loss occurs at ripened stage, so it should be harvested when the plants are still green. Proso millet sown in terai region during spring should be harvested when the spikelets at the upper portion of the panicle ripen to minimize loss. Generally, it is recommended to harvest the crop, when two thirds of the seeds in a panicle are ripe or when the panicle browning is 80% from the tip.



Mal Chino (left) and Dudhe Chino (right) during grain filling stage

Harvesting: It is done by cutting below the base by holding the panicle with hand. After cutting 5-6 panicles, the largest panicle is used to bind them into one bundle, which are stacked in the basket.



Heaping: The bundle of panicles are heaped together in the dry place under shade for 1-2 days. While heaping, tip of the panicles should face outside and the stalks should be at the center or the inner side to facilitate ripening of the grains. This allows proper aeration in the spikelets which releases excessive moisture from the panicle, before threshing. If heaped for greater number of days, the grains will dry soon and is floured. In Karnali, the panicles are heaped in doko (bamboo basket) tightly and then covered with muslin cloth to facilitate ripening of the grains, which were otherwise green. Such practice aids removal of grains from the panicles.

Threshing: It is usually done manually by rubbing between the feet. The grains could easily be separated by rubbing 2-4 bunch of panicles between the feet. The remaining grains in the panicle are then removed by hitting with stick or beating on the hard surface. One person can thresh 1-1.5 quintals of Proso millet in 2 hours with feet, and hence threshing is not a problem unlike finger millet. Threshed grains are winnowed before storing.

Parboiling: Is practiced in Jumla district of Karnali province to ensure long term storage and bright shiny colors of the grains. It is done in copper utensil (Taulo-round bottom flask) with small opening to ensure golden yellow shiny color of the grains. These grains containing husks are then stored in mud bins.

Dehusking: Proso millet grains are taken out from the storage and dried in the required quantity before hulling. It is generally dehulled using mortar and pestle (Okhal) in different batches at small scale. The hulls are smooth, which can scatter easily when greater pressure is applied. Light pressure should be applied at first till the hulls are separated from grains. Manual dehulling is tedious requiring 1 hour to dehull around 2 kg seed, and hence is usually done just before

cooking. Currently dehulling machine has been designed especially for dudhe chino, which can dehull 200 kg per day. Lime water or hot water treated Proso millet can be dehulled easily in the machine (Bhandari et al., 2020). The golden or turmeric yellow-colored grains obtained after dehulling, is called ‘chamal’ or ‘chino rice’ in Bajura whereas ‘muri’ in Jumla. Again, winnowing is done to remove the hulls and obtain clean yellow ‘chamal’. Fresh chamal is delicious over stored ones and hence are dehulled on the same day before cooking/boiling.



Hulled grains ‘chamal’

Yield: Dudhe chino has been registered in Nepal in the year 2021 (B.S. 2077), which is recommended to grow in the mid hills ranging from 1500-2000 masl and in the areas around Karnali Province. This variety has been reported to yield 2.1 t/ha (Krishi Diary, 2024). Though recommended for mid hills, the yield of dudhe chino ranged from 0.5 to 2.8 t/ha, and malchino yielded 1.4- 1.8 t/ha, when grown by Faculty of Agriculture in the Kailali district of Nepal during the year 2024.

Bi-products: The hulls and the flours obtained in the process of dehulling are generally mixed with the animal roughages and given to the livestock, as these are considered healthy. Similarly, straws are used for feeding during lean period. In addition to these, even the whole grains with hulls are cooked along with the animal feed and are given to the milching animals for greater quantity of milk and to weak animals for proper diet.

Storage: The threshed grains are cleaned by winnowing. Unlike rice and wheat, it does not need strong wind or pressure for cleaning due to its light weight. The cleaned seeds (with hulls) are sun dried for 2 days before storing in sacks, drums or bins. Grains below 14% moisture contents are considered dry and can be stored for short duration. But moisture content of 12% or lesser is recommended for long term storage. Storage insects is not a problem in proso millet. But the grains should be protected from moisture and mice. The freshly harvested grains are often parboiled in some parts of midhills and high hills of Nepal for long term storage.

Dishes of Proso millet

Several dishes could be prepared from proso millet, except bread or roti, due to lack of gluten to bind the flour. Proso millet flour and dehulled grain is sweet in taste and have low glycemic index, thus has more health benefits. Some of the common dishes used in Nepal are:

- a. Raw chamal: The freshly hulled grains are taken as it is by herdsman and women during collection of forages and woods.
- b. Sweet khaja: Hulled grains are soaked in water for 2-3 hrs, mixed with jaggery, walnuts and perilla (silam), which are nutritious and healthy for all groups of people.
- c. Cooked rice: The freshly hulled golden color grains are boiled, similar to paddy rice, but with less water. It is digestible when taken with mohi (Chhai) or milk or curd. Proso millet rice is delicious when taken with blackgram thick soup (Faado) or rajma thick soup (Baklo daal). Unlike paddy rice, it is highly nutritious and could not be digested when eaten in greater amount.
- d. Freshly Popped grains: Freshly threshed Proso millet (with hulls), are made to pop using hot pan, which are called khaja (snacks). They are cleaned with light pressure and eaten.
- e. Old grains popped: The grains are taken out from storage and are kept in hot water for few minutes to remove the smell. Water is removed, the seeds are then popped in fry pan. The popped grains are eaten with pickles.
- f. Sweet dish: Flour of Proso millet is mixed with honey for binding it in round shape. The ball like sweet dish 'laddoo' is delicious as well as nutritious. Similarly, it can be stored for longer, and hence is used during long travels. If sugar is used with the Proso millet flour, it cannot be stored for more than 2-3 days, and hence people use honey.

Challenges

Despite its significant contribution towards food security and ability to grow in marginal environment of Nepal, little research has been done on this crop. Despite availability of different local landraces in various regions of Nepal, only one variety of proso millet has been registered, and no variety has been released by the government. Lack of high yielding improved varieties for different types soils and geographical locations, lack of proper equipment for weeding, poor infrastructures for marketing and lack of consumers' preferences in local markets are some of the challenges faced by Proso millet growers of Nepal. Research has been meager on development of advanced package of practices for cultivation, and technological development for easing different agronomic/intercultural practices. Education and awareness about this crop is low and every educational institutions had neglected this already neglected and underutilized crops from their teaching-learning processes. This scenario demands priority for millets in research, education and extension.

Proso millet is a hardy crop but is easy to grow. However, the major challenge is in the post-production, especially deshushing process (removing the outer layer of the seed which is inedible) which decreases its charm in the eyes of farmers. The dehushing process is tedious and time consuming, which is often the role of women. Traditionally, dehushing needs two women working in synchronization using traditional form of mortar and pestle (Okhal). Two healthy women has been reported to dehusk 20-30 kg of proso millet in a day, which is inefficient and uneconomical (Bhandari et al., 2020). Although some organizations are working in this sector to develop dehushing machines, the adoption rate is low due to several constraints. Besides, increasing migration from the rural areas, especially hilly areas has also reduced the acreage since mostly these crops are cultivated in higher altitudes. There are handful of development organizations, including government organizations for the development of these types of crops and supporting the Proso millet growers, which demands priority for research, education and extension.

Social constraints: Considering Proso millet as ‘unholy grain’ or ‘in auspicious grains’ has limited its use during big feasts, occasions and celebrations, which has limited the marketability of this crop. People say, “Dhan Dhamiko, Gahu Pahunako, Kodyo Hamikana”. It means, “paddy is served to priests and respected ones”, “wheat to guests” and “millet to family members”. These sayings honors rice and wheat as precious cereals over millets, which is also linked to prestige in society. The social taboo related with this crop is one of the major hindrances in the scaling-out of this crop. Migration and resulting socio-demographic changes viz. out-migration of youth and male members of the families in the rural and hilly areas where these crops were mostly cultivated has also reduced its production due to reduction in cultivated areas. Feminization of agricultural works has also hit hard in the proper scaling-up/scaling-out of this crop since it is increasingly difficult for women members of the household to dedicate large amount of time for its production and processing.



Bug in prosomillet (left) and shoot borer damage to the prosomillet (right)

Biotic constraints: Big black ants' and bird damages (sparrow) are the major challenges to growing proso millet. Placing shining ribbons and scare crow at different places apart from shouting and making sounds for scaring the birds are the major practices for reducing the damages by the birds. Shoot flies and golden beetles are also the major constraints in Proso millet at field, when grown during summer/dry season. Weeds and insects are generally suppressed when grown with the mixed cropping system with Rajma (kidney beans).

Opportunities / Future directions

This crop has performed well during the dry season in Kailali district and hence could also be explored for performance in the altitude ranging from 500-1400 masl, where dry condition prevails before the monsoon as catch crop. There are several local landraces which has short growing period but performs well under dry condition, which need to tested in different locations for developing as a variety. Different varieties grown traditionally need to be explored for their tolerance and resistance to biotic and abiotic stresses as well as for their nutraceutical properties. This crop can be considered as climate resilient crop as this crop is superior to major cereals grown in Nepal in terms of nutrient contents in the grain and the production of which requires lesser time, water, fertilizers and is easy to thresh and store for longer period at ambient temperature with little or no insect pest infestation. This crop grows well in marginal lands and in upland condition during rainy season in the mid hills and hence could be promoted as important source of nutrition and income for smallholder farmers in dry areas receiving less precipitation.

In the era of rapid climate change and slow research and development, it is worthy to note that these hardy crops can still be cultivated with ease and low external inputs. The cost of cultivation is lower than several other cereal crops. Although there is no research to validate this statement the no/low requirement of tillage, labor and external inputs can help us safely come to this conclusion. Processing, is one of the difficult parts but slowly local organizations have come up with affordable machines which will be very helpful to increase the popularity of this crop among farmers since cultivation is already simple and easy. Government and donor organizations is gradually prioritizing this crop, as is observed from the events like celebrating the year 2023, as the "Year of Millet". This trend is sure to catch up and more focus will divert to these types of crops that have huge potential in the context of changing climate.

Due to growing consciousness among urban dwellers for nutritious and healthy foods, the demand for this food has been increasing along with prices that it can fetch. Currently, several

government officials have urged to treat the millets as “Shree anna”, meaning ‘auspicious super food’. Nowadays, in each large grocery shops, the flour of Proso millet (and other millets, etc.) can be found, and the trend is ever-increasing. Several people who had migrated in the past to the urban areas are also feeling nostalgic about their culture and food-habits and several restaurants are serving varieties of food items prepared from millets/Proso millets to cater them. Some organizations are also working on developing new recipes from these nutrition rich foods including bakes and cakes, which lure the urban youths. This trend is surely creating a favorable environment for more research and development of these types of crops.

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Faculty of Agriculture

Far Western University

Tikapur, Kailali

Phone: (+977) 091 560 265

Email: agriculture@fwu.edu.np

Website: <https://agriculture.fwu.edu.np/>

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