

Millet based cropping systems for higher water use efficiency and farm income of tribal farmers in Odisha

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Millet-based cropping systems play a vital role in improving the water use efficiency, climate resilience, and farm income of tribal farmers in Odisha. Different crop growth habits and maturity periods make the millets suitable under different cropping systems. Traditional and improved cropping systems such as sequential cropping, intercropping, mixed cropping, and agroforestry are instrumental to utilise available rainfall, residual soil moisture, land, and solar energy more efficiently. Indigenous multi-tier cropping systems involving millets, pulses, oilseeds, maize, and vegetables support nutritional security and climate adaptation under rainfed upland and hilly ecology.

Keywords: Agroforestry, Indigenous multiple cropping system, Land use efficiency, Short duration pulses, Water productivity

MILLETS are small grained food crops rich in nutrients and considered as miracle grains to achieve food and nutritional security of rainfed farming. Low input requirement and high adaptability of millets have the potentiality to achieve the several sustainable development goals (FAO 2023). On the basis of grain size, crops are grouped as large and small millets. Sorghum (*Sorghum bicolor*) and Bajra (*Pennisetum glaucum*) comes under large millets, whereas finger millet (*Eleusine coracana*), little millet (*Panicum sumatrense*), foxtail millet (*Setaria italica*), proso millet (*Panicum miliaceum*), barnyard millet (*Echinochloa frumentacea*), kodo millet (*Paspalum scrobiculatum*), and brown-top millet (*Brachiaria ramosa* and *Panicum ramosum*) are categorised as small millets. In India, millets are grown in 15.48 mha area with annual production of 18.01 mt of grains accounting to about 6% of total food grain basket of the country.

Production, productivity and consumption of millets have significantly increased across the

all agro-climatic regions of Odisha after the implementation of 'Odisha Millet Mission'. Growth of the millet cultivation is most prominent in tribal dominant districts like Koraput, Rayagada, Gajapati, Ganjam, Sunadrgarh, Kalahandi and Nuapada. In Odisha during 2023-24, millets were cultivated in 3.18 lakh hectare with annual production of 3.18 lakh tonnes of grains. Among the millets, finger millet contributes 77.2% of total millet area followed by little millet whereas other millets like sorghum, bajra, foxtail millet, barnyard millet and kodo millets are cultivated under specific

ecosystems.

Millet based cropping systems

Millets are short duration and low water requirement crops and grown as sole crop, inter crops, mixed cropping, multiple cropping and under agro forestry in rainfed ecology. Available land and water in the millet growing regions can be efficiently utilised by simple adjustment of sowing windows, harvesting time, selection of appropriate crops and varieties for different cropping systems. Some of the traditional and modern millet based cropping systems

Table 1. Existing millet based cropping systems in rainfed condition of Odisha

Sequential cropping	Finger millet-Horse gram, Finger millet-Green gram, Finger millet-Black gram, Finger millet-Cowpea, Finger millet-Sesame, Finger millet-Chickpea, Finger millet-Niger, Finger millet-fallow, Little millet-Horse gram, Little millet-Green gram, Little millet-fallow, Sorghum-fallow, Foxtail millet-fallow, Kodo millet-fallow
Intercropping	Finger millet + Red gram, Finger millet + Sorghum, Finger millet + Cowpea, Finger millet + Black gram, Finger millet + Castor, Maize + Finger millet, Maize + Sorghum, Sorghum + Red gram, Sorghum + Finger millet
Mixed cropping	Paddy + Finger millet + Fox tail millet + Maize + Sorghum, Foxtail millet + Sorghum + Red gram, Foxtail millet + Cowpea + Sesame + Red gram + Sorghum, Foxtail millet + Red gram Finger millet + Little millet
Agroforestry	Cashew + Finger millet, Mango + Finger millet, Kendu + Finger millet, Silver Oak + Finger millet



Intercropping of jowar in maize

practiced by the farmers in the tribal dominant rainfed regions of Odisha are highlighted in the article.

Millet based sequential cropping: North-eastern ghat (Kandhamal, Rayagada, Gajapati, Ganjam), eastern ghat highland (Nabarangpur, part of Koraput) and south-eastern ghat (Malkangiri, part of Koraput) of Odisha receives a very good amount of south-west monsoon and winter rainfall. The availability of favourable soil moisture and temperature allows the farmers to grow more than one crop in sequence and several cropping systems are practiced by the farmers for sustainable crop production. Finger millet-horse gram/ green gram /black gram/ chickpea/ cowpea are some of the promising cropping sequences practiced in several districts. Intensification of finger millet by inclusion of horse gram as *rabi* crop in light textured soils helped in efficiently utilising the residual soil moisture, winter rainfall and dew. Similarly, green gram and black gram performed well in heavy textured soils.

From the surveyed data, it showed that cropping systems and establishment methods significantly influenced the water productivity and yield of finger millet. Evidently, the finger millet-fallow system showed the lowest physical water productivity (PWP) of 0.17 kg/m³ (0.14 kg/m³) and economic water productivity (EWP) of 6.37 ₹/m³ (6.08 ₹/m³) in 2023 (2024). Intensification of finger millet with horse gram in sequence in light soils enhanced system yield by 99.1 and 99.5% in 2023 and 2024, respectively. Similarly, finger millet-green gram sequence in heavy soil recorded 146.4 and 140.4% higher system yield in 2023 and 2024, respectively. The PWP under the finger millet-horsegram system was 0.31 kg/m³

and 0.25 kg/m³ in 2023 and 2024, respectively. Similarly, the finger millet-green gram cropping system showed PWP of 0.39 kg/m³ and 0.31 kg/m³, respectively in 2023 and 2024. Finger millet-fallow system consumed 588–714 L of water to produce 1 kg of finger millet, whereas 1 kg of finger millet equivalent yield consumed only 323–400 L of water in finger millet-horse gram sequence. Availability of short duration (65–80 days) little millet varieties in Nuapada and Kalahandi districts of Odisha allow the farmers to take horse gram or green gram as second crop by efficiently utilising the residual soil moisture and winter precipitation.

Millet based intercropping: Inter cropping of millets with pulses and other short duration crops are common for enhancing farm income. Based on survey, it was found that intercropping of finger millet, little millet and sorghum with redgram can be encouraged in the districts like Ganjam, Gajapati, Koraput, Rayagada, Malakangiri and Sundargarh for better utilisation of available resources and higher farm income with better management of soil health. Inter cropping of line sown finger millet with redgram in 1:6 ratio recorded enhanced the system yield by 24.7% as compared to finger millet alone. The increase in system yield was due to better utilisation of available soil moisture and nutrients at different soil depth. Maize crop is the prominent commercial crop in rainfed uplands of north-eastern ghat regions (Kandhamal, Rayagada, Gajapati, Ganjam). Innovative farmers grow local varieties of sorghum (120 days and higher plant height) with maize crop (90 days duration and shorter height) as a multi-tier cropping system. Under this cropping system, 15–25% higher farm income is realised as compared to maize alone. Farmers harvest the maize cobs at maturity for selling as grains, while sorghum grains are used for family consumption.



Bagada chasa (Shifting cultivation) with mixed cropping

Intensification of little millet based system by intercropping with redgram or blackgram also enhances the farm income and soil health.

Millet based mixed cropping: Mixed cropping of millets, paddy, oil seeds, and pulses of different crop duration are common in hill tops, plateaus and uplands. Multiple cropping of upland paddy + sorghum + redgram is popular in Sundargarh districts. Mixed cropping of paddy + finger millet + fox tail millet + maize + sorghum common and popularly known as *bagada chasa* in Gajapati. In tribal dominant hilly regions of Rayagada, foxtail millet + sorghum + red gram, foxtail millet + cowpea + sesame + red gram + sorghum is most popular mixed cropping in uplands.

Millets in agro-forestry: Growing of finger millet and little millets as intercrop in mango and cashew orchards in the initial year of orchard establishments are gaining popularity in Ganjam, Gajapati, Rayagada, Koraput and Malkangiri districts. The intercropping of finger millet in the



Intercropping of finger millet in Silver oak plantation in Koraput

Table 2. System yield, gross return, physical and economical water productivity as influenced by different finger millet based cropping systems

Cropping system	2023				2024			
	SFMEGY (kg/ha)	SGR (₹/ha)	SPWP (kg/m³)	SEWP (₹/ha)	SFMEGY (kg/ha)	SGR (₹/ha)	SPWP (kg/m³)	SEWP (₹/ha)
Finger millet–fallow	937	36020	0.17	6.37	1026	44000	0.14	6.08
Finger millet–horse gram	1791	68880	0.31	11.79	2047	87820	0.25	10.91
Finger millet–green gram	2309	88800	0.39	15.20	2466	105800	0.31	13.15

SFMEGY: System finger millet equivalent yield, SGR: System gross return, SPWP: System physical water productivity, SEWP: System economic water productivity.



Inter-cropping of finger millet in mango orchard

plantation of silver oak, eucalyptus and *Diospyros melanoxylon* (*Kendu*) trees is also practiced in Rayagada, Koraput and Malkangiri district. Horizontal expansion of millets under tree plantations helped in the enhancement of millet production in Odisha.

Indigenous millet based multi-tier cropping system: Indigenous multi-cropping system comprising several crops of different duration and growth habits is common under *jhum* farming in north-eastern ghat regions (Kandhamal, Rayagada,

Gajapati, Ganjam). Farmers grow millets like foxtail millet, sorghum, little millet, finger millet mixed with other crops like maize, redgram, and paddy in uplands to maximise the rainwater use and enhancement of profits. Sowing of seeds of foxtail millet, cowpea, sesame, red gram and sorghum as mixed crop is common practice among the tribal community of Rayagada district for their livelihood. Such type of farming helps the farmers to harvest food grains over a longer period. Field survey conducted at



Indigenous multitiered cropping system in Ganjam

Dharakote of Odisha observed that tribal farmers grow about 20–30 types of crops in mixed and multitier system to get cereals, pulses, oil seeds, vegetables and fruits from same piece of upland. Such type of traditional cropping systems benefits from efficient utilisation of natural resources like rainfall, solar energy and land, soil health, spatial and temporal intensification, balanced nutrition and higher income. Promotion of indigenous cropping and farming systems is the need for mitigation and adaptation to climate change.

SUMMARY

Millets are well fitted to diversified cropping and farming system including mixed cropping, intercropping and sequential cropping. Based on sowing window, harvesting period, soil type, soil moisture holding capacity of the soil and winter rainfall beside horizontal intensification of millets with short duration pulses will ensure a better utilisation of natural resources like water, land and solar energy for enhancement of production of quality foods. Inter cropping of finger millet, little millet and sorghum with red gram can be encouraged for better utilisation of available resources and higher farm income with better management of soil health. Promotion of suitable millet based cropping system is more dependable and profit oriented than the sole cropping. Blending of traditional knowledge with modern technologies is needed for sustainable millet production in Odisha State.

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