PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol x(x): xx–xx
https://doi.org/10.14719/pst.1882

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RESEARCH ARTICLE

Traditional knowledge-based agricultural practices in tribal dominated district Anuppur, Madhya Pradesh

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OPEN ACCESS

ARTICLE HISTORY
Received: 10 May 2022
Accepted: 06 October 2022
Available online
Version 1.0 : 05 November 2022

Check for updates

Additional information
Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

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Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS etc.
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CITE THIS ARTICLE
Kurmi A, Kaushik S, Pandey S K, Nagre S, Shweta S, Thomas M. Traditional knowledge-based agricultural practices in tribal dominated district Anuppur, Madhya Pradesh. Plant Science Today (Early Access). https://doi.org/10.14719/pst.1882

Abstract

Traditional knowledge is the backbone of the agricultural system of any country. These traditional knowledge-based agricultural practices were phased out and replaced with modern agricultural practices. However, in the present scenario, these time tested traditional practices again have made a comeback due to their ability to sustain and overcome the obstacles posed by anthropogenic activities, land degradation, excessive and rampant usage of fertilizers, insecticides and pesticides, etc. In spite of this traditional knowledge has been confined to some secluded areas in particular among the indigenous, tribal, forest-dwelling communities. The present study has been aimed to document the Traditional knowledge-based agricultural practices in Tribal dominated District Anuppur, Madhya Pradesh. More than thirty agricultural practices have been documented during our study which has revealed the potential of this area which can be a model for natural, organic, sustainable farming, paving the way toward resilient agricultural systems.

Keywords

Traditional farming, indigenous knowledge, resilient agriculture, sustainable farming

Introduction

Traditional knowledge (TK) may be defined as an assemblage of unique beliefs and knowledge acquired, summarized and tested with changing generations, and continues to be in existence (1). It can be summed up as the innovative practices developed by the wisdom of human endeavor by monitoring and experimentation (2). Interestingly, since time immemorial several scientific experiments have been taken by the farmers on a trial and error basis in agriculture and allied activities to overcome the prevailing adverse social, economic and environmental adversaries of that time (3). Thus, over time indigenous people have developed and preserved distinct understandings, rooted in a cultural experience that guide relations between human and nature and influences the social, cultural and economic status of a community (4). Interestingly, Traditional Agricultural Knowledge (TAK) has evolved over centuries to support livelihood. Agriculture the practice of cultivating plants and livestock is itself a tradition and is one of ever-evolving practice utilizing ancient to modern technologies. Traditional Agricultural Knowledge, TAK thus involves the usage of indigenous knowledge, traditional tools, natural resources and the cultural beliefs of the farmer (5). Traditional knowledge-based food production system may offer a possible so-

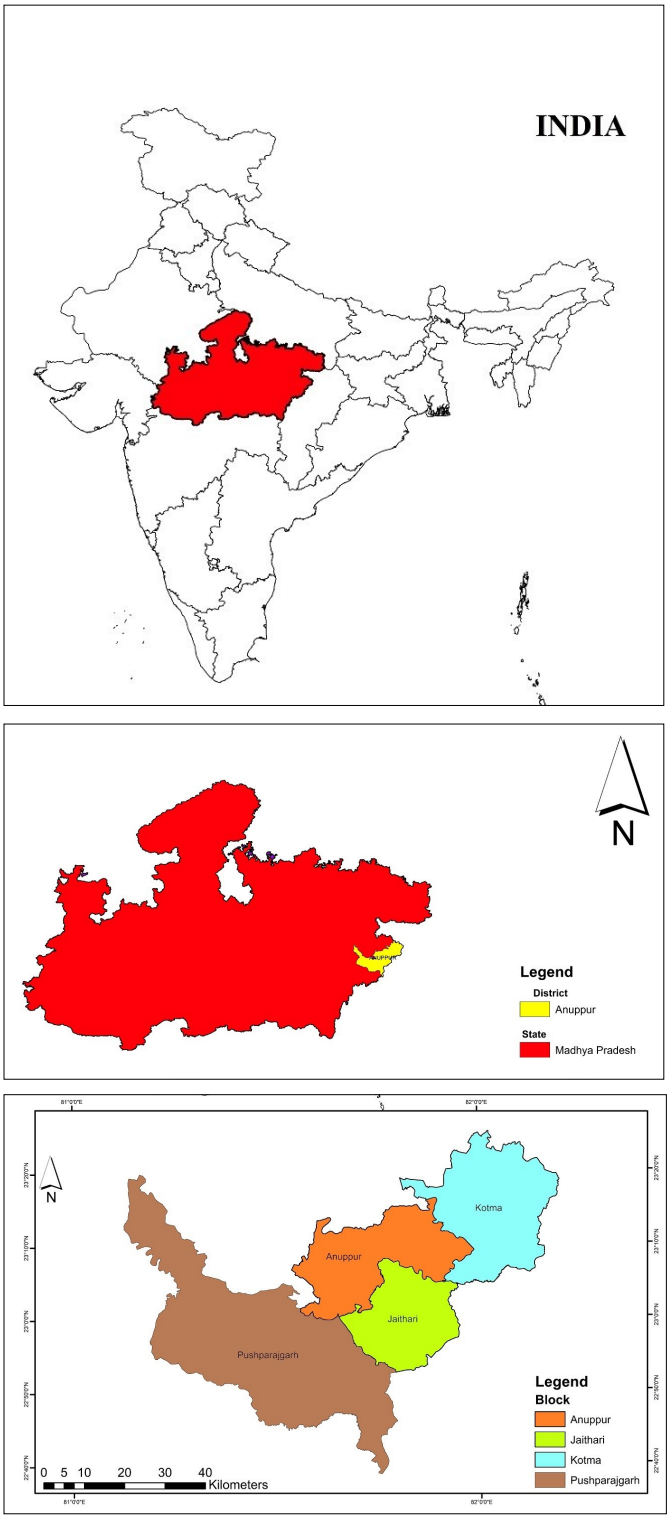
lution for food security and sovereignty (6) as it offers a cost-effective, nature-based, sustainable and environment -friendly strategy. Thus, validation, revival and dissemination of Indigenous Traditional Knowledge (ITK) become important for the sustainable development of agriculture which once fed into the current research system can develop low-cost and effective technologies for the benefit of the farming community (7-8).

The agriculture system in India began as early as 9000 BC (9). Agriculture is not only for fulfilling the present and future demands of food but it is a way life of Indian people. Conceptually, even the present Indian agriculture system can be categorized as a partially traditional agriculture system as the majority of the farmers still follow traditional agriculture practices in one way or another. However, with the inception of new technologies in agriculture, the traditional practices are disappearing at a faster rate. Although the majority of tribal and indigenous communities in India still follow these traditional practices and play a pivotal role in preserving traditional agricultural knowledge. In this way, in addition to the conservation of natural resources, TK plays important role in better livelihood and improvement in the socio-economic status of tribal communities involved in farming operations (10). Indigenous and Tribal farmers are known to have acquired rich traditional agricultural knowledge in due course of time to overcome various obstacles due to their geographical remote and extreme living habitations adverse biotic and abiotic factors, landforms, etc. and have been successful in overcoming these effects with their innovative and spontaneous evolving traditional practices (11).

The present work has been designed to assess and document the traditional knowledge-based agricultural practices used by the tribal farmers of District Anuppur, Madhya Pradesh to understand the importance of these practices in augmenting sustainable, natural, organic farming. Madhya Pradesh has the largest tribal population in India and inhabits 46 recognized tribes contributing nearly 21.1 % of the total population of Madhya Pradesh (12). Anuppur comprise of four blocks viz Anuppur, Kotma, Jaithari and Pushprajgarh is one of the tribal-dominated districts of Madhya Pradesh and tribal communities contribute about 47.8 % of the total population. Interestingly, Pushparajgarh block which is the largest block of district Anuppur comprises nearly 76.8 % of the tribal population and is traversed by river Narmada and is a part of the Achanakmar-Amarkantak Biosphere Reserve. The livelihood of these tribal farmers depends on agriculture and minor forest production. These tribal farmers are still traditionally practising agriculture right from the preparation of land to harvesting and have their own unique indigenous traditional knowledge, experience and strategies in the field of agriculture to grow crops successfully.

Materials and Methods

The study is based on a survey to document Traditional Knowledge-based agricultural practices in 4 tribal-dominated blocks of district Anuppur, Madhya Pradesh. District Anuppur is situated in the south-eastern part of Madhya Pradesh. Encompassing an area of 3746.71 sq. Km. and is 1.2 % of the state and is located between 23.10 north latitude 35.36 north latitude and 41.40 to 82.10 east longitude. According to the 2011 Census of India, majority of the people speak hindi and the rest speak bagheli and gondi as their first language. A questionnaire in hindi was developed to survey the existing agricultural practices followed by local inhabitants in 10 tribal-dominated villages representing four blocks viz. Anuppur, Kotma, Jaithari and Pushprajgarh of district Anuppur (Fig 1; Table 1). As per the Census India 2011, the % of tribal population in block Anuppur, Kotma, Jaithari and Pushprajgarh is



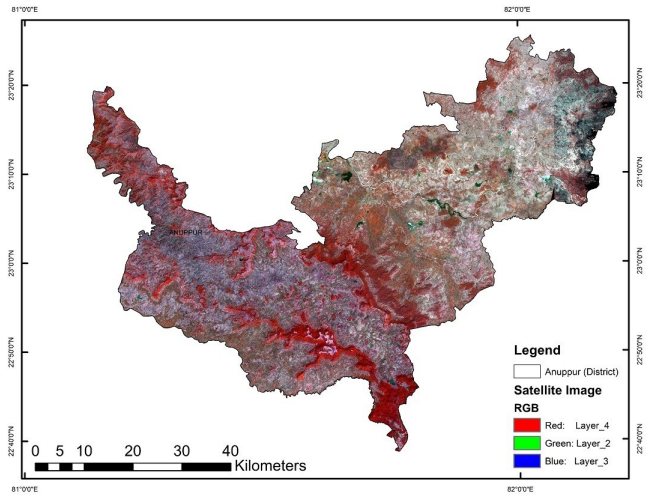


Fig. 1. Outline of the study area depicting four blocks in District Anuppur, Madhya Pradesh.

Table 1. Representation of study area of Annupur District

Name of the Blocks (4)	Name of the villages (10-as mentioned)	Geographical coordinates of the villages	
		Latitude	Longitude
Block-Anuppur	Bhad	23° 7'51.19"N	82° 1'19.34"E
	Badikhar	23° 5'31.41"N	82° 1'28.37"E
Block-Kotma	Changeri	23°13'5.48"N	82° 0'58.64"E
	Godaru	23°21'44.20"N	81°56'23.83"E
Block-Jaithari	Chilhari	23° 6'36.77"N	81°38'1.77"E
	Badhar	23°11'23.22"N	81°55'45.08"E
Block-Pushprajgarh	Dondiya	22°57'35.84"N	81°35'42.94"E
	Lalpur	22°48'17.62"N	81°44'25.31"E
	Ferri Semar	22°46'3.57"N	81°42'27.28"E
	Umargohan	22°46'10.81"N	81°46'28.59"E

33.8%, 28.2%, 47.8% and 76.8% respectively. The selection of villages was carried out based on village domination by tribal farmers, age of the population involved and cultivation practices followed. Twenty-respondents from each village actively practicing agriculture were selected and in total 200 respondents were selected for the survey. Focus Group Discussion, observation and key informant interview methods were used for documentation and validation of TK. Documented TK-based practices were supported by scientific discussion. Random sampling was done to collect the data from farmers, elderly tribal farmers, headmen and qualitative data were recorded systematically (13-14).

Results

The response from the farmers practicing the indigenous way of agriculture in district Anuppur were classified and documented in eleven major agricultural practice heads such as ploughing, puddling of field, manuring, cropping and sowing patterns, plant and weed management practices, harvesting, threshing etc. Field preparation is the first step in growing crops.

Ploughing

Ploughing is the foremost and primary practice used by the farmers for preparation of land using *deshi hal* and *bakhar* and used by all the respondents in field preparation.

Deshi hal (Country plough)

Deshi hal is a major and very common wooden implement used for ploughing of land. It is locally called *Nagar* in this region and made from wood of *Shorea rubusta* Gaertn. f. (Shal tree) and drawn by a pair of indigenous bullock. It is used in all kind of soils and in all seasons in this area. Normally, 3-4 ploughing is done for making soil suitable for sowing (Fig. 2A).

Bakhar

Bakhar also a wooden implement, made from Sal tree (*Shorea robusta* Gaertn. f.) is drawn by a pair of bullock. It is used for ploughing and levelling of field, preferably in dry field unlike *Deshi hal* which is used for moist land. It is used by the farmers after 2-3 ploughing of field by hal to remove freshly germinated weeds (Fig. 2B).

Puddling of field

Puddling is a very common and important operation used by more than eighty percent of the farmers for wet land transplanting of rice seedlings. In first step ploughing of wet or flooded land is done with the help of *Deshi hal* followed by puddling the soil and water in the field by using bullock drawn *datari* (Local wooden implement) (Fig. 2C).

Manuring

Farm yard manure (cow dung, remains of cattle feed and kitchen waste) is used as manure for all crops by majority of the tribal farmers. Cow dung, remains of cattle feed, ash, kitchen waste collected daily is dumped in a fixed place in the backyard locally called *Lawadra.* This dumped material is left in open for over a period of one year in open space which when turns dark black in colour is dug out from *Lawadra* and broadcasted in crop field before ploughing and in between cropping tenures (Fig. 2D).

Cropping Pattern

Utera cropping (Relay cropping)

Utera although a very popular practice and known to all the respondents however nearly twenty percent of the

Fig. 2. (**A**) Farmer carrying *desi hal* for ploughing (**B**) Farmer carrying bakhar an agriculture implement (**C**) Farmer with *datari* (**D**) *Lawadra*- FYM (**E**) *Utera* cropping pattern (**F**) Mixed cropping pattern (**G-1,2**) Manual uprooting of paddy seedlings and transplanting (**H**) Manual weeding (*I*) *Biasi*-method of weed control (**J**) Dusting of ash on vegetable (**K**) Early sown Rai crop (**L**) Early mature *Cajanus cajan* crop (**M**) Late sown Niger crop (**N**) Harvesting with sickle (**O-P**) Threshing (**Q 1-2**) Winnowing (**R**) Hanging of Maize cob (**S**) *Kothi*- Storage structure.

farmers are following this practice even they are facing limited irrigation facilities. In this cropping pattern the seed of the next crop (usually of *rabi* season) are broadcasted in standing rice crop before 2-3 week of harvesting to utilize residual field moisture efficiently for germination under rainfed situation. This practice is only performed in *rabi* season**.** Lentil (*Lens esculenta*), linseed (*Linum usitatissimum* L.), pea (*Lathyrus)* etc are grown by the farmers in this area in utera cultivation as these crops require no land preparation. Thus, this technique helps the farmers in sustainable and efficient utilization of resources (Fig. 2E).

Mixed cropping

Mixed cropping is the growing of two or more crops in the

Table 2. List of traditional crops grown by the farmers of district Anuppur

Sl. No.	Season	Blocks	Name of the Crops			
			Cereals	Pulses	Oilseeds	Millets
1.	Kharif	Anuppur	*Oryza sativa* (Poaceae), *Zea mays* (Poaceae)	*Cajanus cajan* (Fabaceae), *Vigna mungo* (Fabaceae)	-	*Panicum sumatrance* (Poaceae), *Paspalum scrobiculatum* (Poaceae), *Eleusine coracana* (Poaceae)
		Kotma	*Oryza sativa* (Poaceae), *Zea mays* (Poaceae)	*Cajanus cajan* (Fabaceae), *Vigna mungo* (Fabaceae)	-	*Panicum sumatrance* (Poaceae), *Paspalum scrobiculatum* (Poaceae), *Eleusine coracana* (Poaceae)
		Jaithari	*Oryza sativa* (Poaceae), *Zea mays* (Poaceae)	*Cajanus cajan* (Fabaceae), *Vigna mungo* (Fabaceae)	-	*Panicum sumatrance* (Poaceae), *Paspalum scrobiculatum* (Poaceae), *Eleusine coracana* (Poaceae)
		Pushprajgarh	*Oryza sativa* (Poaceae), *Zea mays* (Poaceae)	*Cajanus cajan* (Fabaceae), *Vigna mungo* (Fabaceae)	(*Guizotia abyssinica* (L. f.) Cass.) (Asteracea)	*Panicum sumatrance* (Poaceae), *Paspalum scrobiculatum* (Poaceae), *Eleusine coracana* (Poaceae)
2.	Rabi	Anuppur	Wheat *Triticum aestivum* (Poaceae)	*Pisum sativum* (Fabaceae),, *Cicer arietinum* (Fabaceae), *Lathyrus sativus* (Fabaceae), *Lens esculenta* (Fabaceae)	*Brassica juncea* (Brassicaceae), *Linum usitatissimum* L. (Linaceae)	-
		Kotma	Wheat *Triticum aestivum* (Poaceae)	*Pisum sativum* (Fabaceae),, *Cicer arietinum* (Fabaceae), *Lathyrus sativus* (Fabaceae), *Lens esculenta* (Fabaceae)	*Brassica juncea* (Brassicaceae), *Linum usitatissimum* L. (Linaceae)	-
		Jaithari	Wheat *Triticum aestivum* (Poaceae)	*Pisum sativum* (Fabaceae),, *Cicer arietinum* (Fabaceae), *Lathyrus sativus* (Fabaceae), *Lens esculenta* (Fabaceae)	*Brassica juncea* (Brassicaceae), *Linum usitatissimum* L. (Linaceae)	-
		Pushprajgarh	Wheat *Triticum aestivum* (Poaceae)	*Pisum sativum* (Fabaceae),, *Cicer arietinum* (Fabaceae), *Lathyrus sativus* (Fabaceae), *Lens esculenta* (Fabaceae)	*Brassica juncea* (Brassicaceae), *Linum usitatissimum* L. (Linaceae)	-

same piece of land during one growing season and is a common practice among tribal farmers. During kharif season pigeonpea (*Cajanus cajan*) + *kutki (Panicum sumatrance)*, pigeonpea (*Cajanus cajan*) + *kodo* rice (*Paspalum scrobiculatum*) + pigeonpea (*Cajanus cajan*) and maize (*Zea mays*) + okra (*Abelmoschus esculentus*) are popular. Wheat (*Triticum aestivum*) + chickpea (*Cicer arietinum*) + linseed (*Linum usitatissimum* L.), lentil (*Lens esculenta*) + linseed (*Linum usitatissimum* L.) + mustard (*Brassica nigra*), wheat (*Triticum aestivum*) + mustard (*Brassica nigra*), chickpea (*Cicer arietinum*) + lentil (*Lens esculenta*) + linseed (*Linum usitatissimum* L.) + *Lathyrus sativus* are popular combinations during rabi season. This cropping pattern is practiced by the farmers to fulfill their dietary requirements from the same piece of land, assurance of a better harvest, and recovery from the loss of any crop failure (Fig. 2F).

Traditional crops

As the area is a rain-fed thus the farmers here grow traditional crops such as maize (*Zea mays*), pigeonpea (*Cajanus cajan*), black gram (*Vigna mungo*), niger (*Guizotia abyssinica* (L. f.) Cass.), kodo (*Paspalum scrobiculatum*), kutki (*Panicum sumatrance*), mandwa (*Eleusine coracana*), sorghum (*Sorghum bicolor*), field pea (*Pisum sativum*), chickpea (*Cicer arietinum*), lentil (*Lens esculenta*), rai (*Brassica juncea*), linseed (*Linum usitatissimum* L.) etc in the *Kharif* and *Rabi* seasons (Table 2).

Methods of crop sowing

Broadcasting

Broadcasting is a very popular practice for sowing of all crops. In this practice field is ploughed 3-4 times with help of desi hal or Bakhar then seeds are scattered over the prepared field. Broadcasted seeds are covered by again ploughing of field. It is easy and convenient method of sowing and does not require technical knowhow. Majority of the farmers follow this sowing pattern.

Line sowing

Line sowing of crop is not a very common practice. It is performed by only few farmers with the help of *Nadi* a traditional implement used in line sowing of crops. It is the improved version of *Deshi hal* (*Nagar*) with minor attach-

ments. Wooden funnel fitted on hollow bamboo pipe is attached to the hal. The pipe opens in furrow which is made from cutting of soil by share of hal. Two persons and a pair of bullocks are required for sowing of crop by using *nadi*. One of them controls the bullock and another pore seeds in the funnel. Pored seeds in the funnel pass through the bamboo pipe and get placed in the furrow.

Lehi (wet seeding) method of paddy sowing

This is the traditional method of growing rice under low land condition. In this method rice (*Oryza sativa*) seeds are soaked overnight. The water soaked seeds are then kept under the shade, covered with wet jute bag or cotton cloth and allowed to incubate for 3 days. After 3 day seeds gets sprouted and are broadcasted in pre-puddled field.

Nursery preparation and transplanting

Lowland rice is cultivated by transplanting seedlings by preparing nursery beds. 25-30 days old rice seedlings are transplanted in puddled field at the rate of 4-5 plants per hill. A majority of the farmers are following this method of rice cultivation (Fig. 2G).

Weed management

Manual

Hand weeding although a labour intensive weed management practice is followed by majority of the farmers which is done by pulling out weeds along with roots. The interval between two weeding operations depends on presence of weeds (Fig. 2H).

Puddling

It is done in wet soil in the field to prevent percolation and optimum water stand for transplanting of rice seedlings and is an important practice in transplanted rice to keep weeds under check such as *Cyperus* sp., *Echinochloa* sp., *Chloris* sp., *Cynodon dactylon*, *Commelina benghalensis, Eclipta prostrata* to name a few (Fig. 2C).

Biasi

Biasi is an important intercultural operation used in directly seeded rice for weed management. In direct seeded rice condition weeds and crop grow simultaneously. This operation involves ploughing rice field in the standing water of 5-10 cm by bullock drawn *hal* at 30-40 day after sowing. This practice is practiced by a small fraction of the farmers (Fig. 2I).

Plant Protection

Use of Ash

Ash obtained from fuel wood or cow dung cake is broadcasted over the crop and at fruiting stage of various crops (eg. Mustard (*Brassica nigra*), dolichos bean (*Lablab purpureus*), cabbage (*Brassica oleracea* var. *capitata*; *Brassica oleracea* var.)) to protect from insects and diseases. It is very common and very popular zero cost practice used by majority of the farmers. Ash provides protections to plants against various insects like Red pumpkin beetle (*Aulacophora foveicollis*), flea beetle (*Phyllotreta cruciferae*), aphid (*Lipaphis erysimi*) etc. (Fig. 2J).

Early sowing of Rai

Rai is a small seed mustard crop very popular among tribals of this area and is sown in the last week of August in the standing crop of maize and is harvested in November. This early cropping and harvesting helps in escaping infestation by aphid (*Sitobion* sp.) (Fig. 2K).

Short duration Pigeon pea (Cajanus cajan)

This region is highly prone for frost as during the month of December and January temperature fall below 0 °C. Thus long duration varieties of pigeon pea are not suitable for this area. To overcome this problem, tribal farmers of this area grow short duration traditional cultivar, locally known as *Baigahi* or *Aghani* arhar. This short duration traditional variety is sown in June-July and harvested in November before temperature begins to dip and thus sowing of short duration pigeon pea escapes the frost attack (Fig. 2L).

Late sowing of Niger (Guizotia abyssinica)

This region in particular pushprajgarh receives higher average annual rainfall in comparison to plain areas of district Anuppur which promotes vegetative growth of niger crop and poor flowering. Higher rainfall is also a cause of poor pollination resulting in no seed formation. To overcome this problem, the niger here is sown in August instead of June-July and harvested in November to obtain a higher yield (Fig. 2M).

Harvesting

Harvesting is the cutting and gathering of crop. Perfect harvesting stage of crop is observed on the basis of traditional knowledge of tribal farmer. Harvesting of crop is done manually by tribal farmers using *sickle* or pulling out of crop. Crops like rice (*Oryza sativa*), wheat (*Triticum aestivum*), pigeon pea (*Cajanus cajan*) etc. are harvested by sickle, while crops like lentil and pea are harvested by direct uprooting on maturity. (Fig. 2N).

Threshing

Threshing is the loosening of the grains from chaff after harvesting of crop. Harvesting is done manually or by bullock. Crop like pigeon pea and rice is harvested manually by striking the crop against the hard surface whereas shelling of maize is done manually by picking the seeds from the cob. Crop like paddy, wheat, chickpea etc. are threshed by using bullock in which the crop is spread over a pre prepared platform and a strong wooden pole is fixed in the center of threshing area in which bullocks are tied and moved in parallel manner one after another crushing the harvested crop continuously till the grains are separated from the straw (Fig. 2O,P).

Winnowing

Winnowing is the method of separation of grains from crop straw by making use of blowing wind. It is done manually by dropping threshed crop from a height against the wind. Blowing wind separates lighter husks/chaff and heavier grains. This method work only when there is wind. It is also done by using winnowing basket which is used to toss the mixture of grain and husk into the air where the wind

sweeps away the husk. This technique works in no wind condition but applicable only for small quantity of threshed crop (Fig. 2Q).

Storage

Soil coating for preservation of seed

After the harvesting of crop (E.g. pigeon pea, chickpea, pea etc.), tribal farmers store the seeds for growing crop next year. The seeds are preserved by coating with soil. Coating is done by mixing soil and water to form a paste in a container and then seeds are transferred into that container mixed well, so that the soil paste completely covers the seeds. Soil paste coated seeds are dried properly under shade. Dried soil coated seeds are stored in a separate container or bag for next year. This traditional practice although an effective strategy to protect agains stored pests is also diminishing at a faster rate.

Use of dry Neem leaves

Use of *Azadirachta indica* (neem) in crop protection is very cost-effective and is in practice by the majority of the farmers. Green neem leaves are collected and dried properly under shade. These dried leaves are mixed with grains and filled in the bags or storage structures.

Use of dry Vitex negundo (Nirgundi) leaves

Similarly to neem leaves, Nirgundi leaves are also used as a storage insecticide by tribal community of Anuppur. Green leaves are collected and dried well under shade and mixed with grain and stored for longer period. Nirgundi leaves reduce the infestation of various stored grain insects.

Hanging of maize (Zea mays) cobs

Hanging of harvested dried cobs is a very common practice to keep maize cobs for future use. Mature harvested maize cobs is hanged on roof of house preferably in smoke emitting areas such as kitchen with help of cobs leaves. Hanged cobs remains untouched with soil and are safe for longer period from infestation by stored grain pests (Fig. 2R).

Storage structure

Grains storage structure is used by farmers, locally called *Kothi*. The structure is made with help of baked bricks and soil. The traditional storage structure is eco-friendly, less expensive, easy to apply, need no formal training and grains can be stored for longer period (Fig. 2S).

The result showed that more than half of the 30 agricultural practices such as ploughing of the fields with desi hal, bakhar, growing of traditional crops in kharif and Rabi seasons, mixed cropping, Winnowing using basket and wind, threshing manually and by bullock, manual pulling of weeds, harvesting by sickle, late sowing of niger, early sowing of rai, manual weeding, manual broadcasting of seeds and usage of neem leaves for storage of seeds were practiced by all the respondents in their fields. A very less number of respondents followed the practice of using Nirgundi leaves, seed coating for seed storage, utera cropping etc. A moderate number of farmers were following rest of the agricultural practices such as puddling of field, manuring of the field using cattle dung (64%), use of ash for plant protection (81%), hanging of maize cobs and construction of storage kothi for storage of seeds (38%). A very few farmers were using nirgundi (*Vitex negundo*) leaves just 3% as compared to neem (*Azadirachta indica*) for storage purpose. Similarly only 4 % of the farmers under study were using coating seeds with soil for preservation of seed sowing of short duration pigeon pea (Fig. 3).

Discussion

Traditional knowledge on agricultural practices acquired by the indigenous communities has become the backbone of the today's natural and sustainable farming. These traditional farming practices have been documented or some even have remain undocumented till date. However, they are in practice right from field preparation to harvesting to storage of seeds. Similar traditional agricultural practices are employed by the farmers of district Anuppur a tribal dominated area. Here, the majority of tribal farmers still practice field preparation by using *desi hal* which is a specialized farming instrument made from wood of Sal (*Shorea robusta* Gaertn. f.) tree. However, the wood of the hal may vary from place to place depending upon the availability of hard wood. *Desi hal* commonly known as *Nagar* is known to soften the soil enough to create favorable conditions for seed placement and plant growth (13). It is a very effective implement for keeping the soil in good physical condition and is cost effective, easy to carry and a low maintenance implement. Interestingly, farmer does not require technical knowhow during working with *hal* and can be used for ploughing, puddling and even sowing of crop, where tillage depth can be adjusted by applying manual force (14) with palm. Another farming implement is *Bakhar*, this wooden implement has soil cutting blade made up from iron. It is an implement for seed bed preparation and also serves as leveler when it is drawn in inverted position and is used to cover the broadcasted seed with soil.

Another practice puddling is known to create a compact layer below puddled zone which reduces percolation rate of water and helps in increasing the yield of paddy due to increase in plant height, more number of tiller, root length density, panicle length and decrease in soil penetration resistance (15). Traditional farming practices takes in consideration the organic matter and nutrients of the soil as soil health determines the crop health, production and all. One such practice followed by the tribal farmers is using of Farm yard manure (FYM) commonly referred to as *lawadra*. This heap turnouts into an inoculum of micro-biota, laced with a pools of nutrients due to anaerobic respiration and is known to harbor various athropods, earthworms etc. helpful in providing nutrients and aeration to the field (16). In addition, it also improves physical, chemical and biological properties of soil (17). The cropping pattern do play an important role as it mainly focusses upon the land type, irrigation pattern, crop productivity etc. This region is traditionally rice growing area, although mostly rainfed as irrigation facilities are

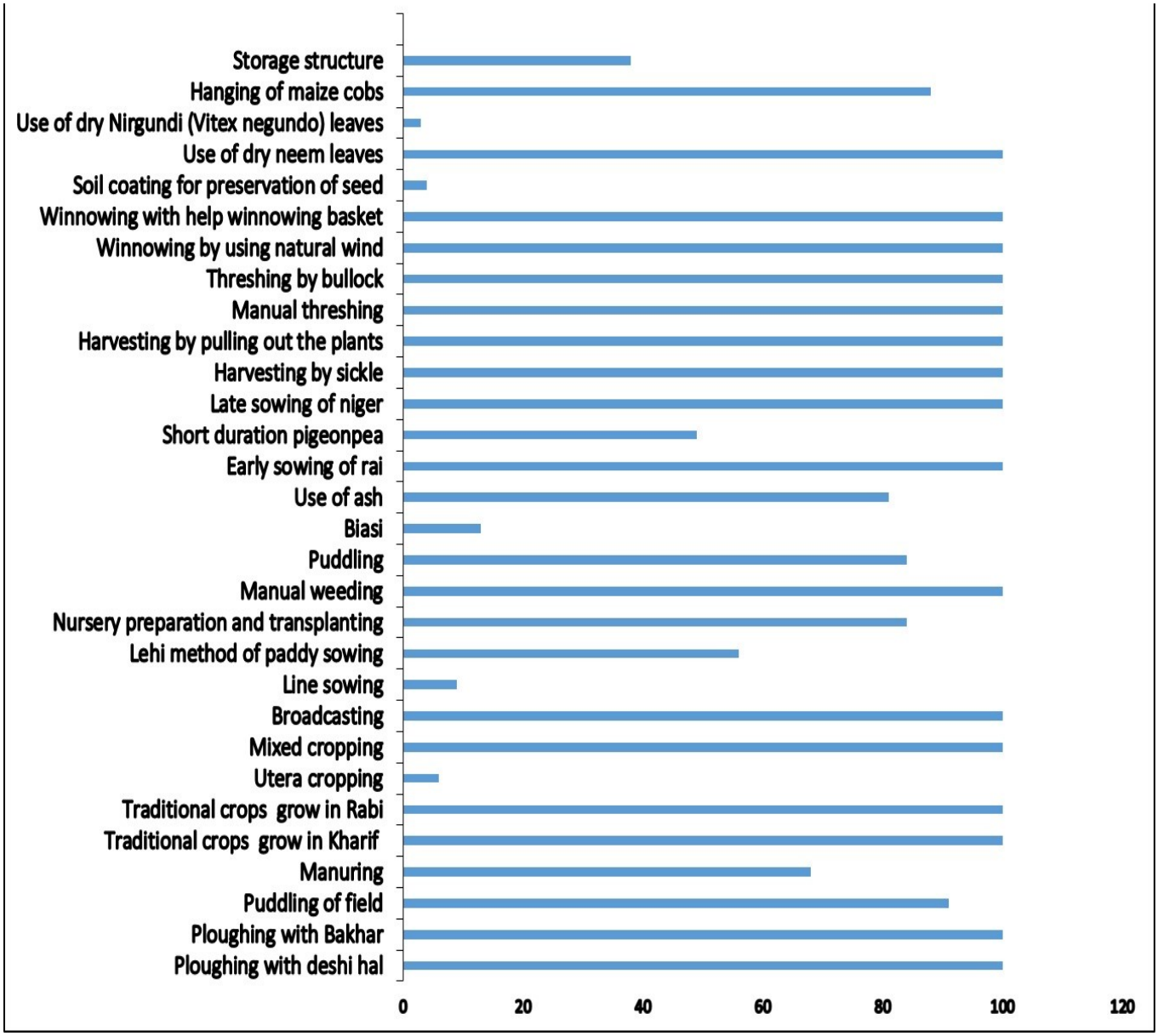


Fig. 3. Proportion of traditional agricultural practices (in percentage) followed by the farmers of District Anuppur (Number of respondent N= 200).

limited in this hill region, thus utera a type of cropping practice and mixed cropping aids in second crop cultivation and sustainable utilization of resource (18), leading to more yield in comparison to mono cropping (19) and suppression of weeds (20). In addition, diversity of vegetation interferes in movement of the insect/pests and host finding of host crop, thus acting as a natural barrier in controlling pests (21). Thus these cropping patterns reduces the financial distress of the farmers and also acts as an add on income in addition to fulfilling their dietary requirements.

Similarly, broadcasted rice matures early and this practice is suitable for sowing of small seeded crop which is otherwise difficult by other method, cost effective and large area can be sown in less time. On the other hand, line sowing method reduces the seed rate and produces more yield then broadcasting and also favors the uniform and maximum germination of seeds (22). This method performs well and gives better yield as compared to direct (dry seeding) broadcasted rice (23). In addition, *Lehi* also reduces the weed infestation and is practiced by farmers of Pushprajgarh block (24). Interestingly, transplanting leads to higher planting density, higher number of panicles, facilitates effective management of weed control and water, uniform ripening and less lodging and is mainly practiced by farmers in the plain areas of Anuppur, Kotma and Jaithari blocks (25). Weed management and plant protection strategies leads to major economic losses to the farmers, however the old weed management practices are cost effective, environment friendly although labour intensive but provides long term solution to the farmers (26). Puddling is an important practice in transplanted rice also keep weeds under check as during this process the weeds gets buried into the mud and gets decomposed under anaerobic condition (27).

Ash works as a potent deterrent against chewing and sucking insects and is a very popular practice followed by farmers of this region. It is known to provide protection to plants against various insects like red pumpkin beetle, flea beetle, aphid etc., serves as a physical toxin to various insects and also enriches potassium level of soil (28). Severity of Aphid (*Lipaphys erisimi*) infestation increases progressively with the delay in sowing (29), to overcome this

problem sowing of *rai* is done early i.e. in the month of august and is harvested before december and the crop thus escapes aphid infestation as aphid infestation generally starts after December (30). Similarly, short duration pigeon pea locally known as *Baigahi* or *Aghani arhar* is used by the local farmers of Pushprajgarh block, a hilly terrain and part of the Achankamar-Amarkantak bioshphere reserve which experiences frost attack after December. This short duration traditional variety is sown in June-July and harvested in November before temperature begins to dip. Short duration cultivars are very much suitable in frost prone area as at low temperature (below 5 °C) intracellular water gets converted into ice. This ice causes cell dehydration and cell membrane destruction, ultimately leading to death of plant (31). Unlike early sowing of Rai, Niger is sown in month of August instead of June-July, as heavy monsoon leads to heavy vegetative growth and affects the flowering ability. Thus, crop is sown in August for higher yield and yield attributing characters such as plant height, number of branches etc (32).

Harvesting is the cutting and gathering of crop. Perfect harvesting stage of crop is observed on the basis of traditional knowledge of the farmers and is done manually by tribal farmers using sickle or pulling out of crop. Crop like pigeon pea and rice is harvested manually by striking the crop against the hard surface. Threshing is the loosening of the grains from chaff after harvesting of crop. Crop like paddy, wheat, chickpea etc. are threshed by using bullock in which the crop is spread over a pre prepared platform a traditional method involving livestock.

Storage of the harvested seeds form an important part of the agricultural practice for longer usage, food security and prevention from losses. A very conventional practice of coating seed with soil is undertaken by farmers of this area where the soil coat acts as a barrier to stored grain pests. Soil coated seeds are also known to get protection from harm causing microorganisms and avoids the spoilage (33, 34). Mixing of dry neem leaves and nirgundi leaves with stored grain is a widely used and cost effective practice as leaves mixed grains are not preferred by insects for feeding as well as egg laying (35, 36). It acts as an antifeedant, repellent, repugnant agent and induces sterility in insects this is cost efficient practice. This reduces the infestation of various stored grain insects and seeds can be stored for longer period (37, 38). Similarly, hanging of cobs in smoke emitting areas such as kitchen is considered as rational method of maize storage in which the cobs remain untouched with soil, remain safe for longer period from infestation of stored grain pests and rodents (39). Grains storage structure locally called *Kothi* is a popular practice for storage of seeds for longer duration ranging in even 5-10 years. The structure is by the local farmers with the help of baked bricks and soil and is made technically air tight due to which the grains remains unaffected by high temperature, humidity etc. Traditional storage structure is eco-friendly, less expensive, easy to apply, need no formal training (40) and thus grains can be stored for longer period (41).

In short it can be deciphered that the traditional yet scientific strategies in practice by the indigenous/tribal communities of district Anuppur is cost effective, environment friendly and thus paving a way to natural, sustainable and resilent agricultural system. These practices with scientific validation can be disseminated on a broad scale. In addition the district Anuppur, do possess immense potential in terms organic/natural farming as majority of the farmers still practice indigenous/traditional practices.

Conclusion

District Anuppur, in addition to being inhabited by a large tribal population is a part of the Aachankamar biosphere reserve is a bio diverse region in terms of flora and fauna. Fortunately, this region even though culturally and spiritually rich lacks the technical know-how in term of modern methods of agriculture and majority of the people still employs traditional agricultural practices however, with changing time and interventions by governmental agencies, NGOs, increasing monetary demands these traditional practices are slowly replaced by the modern agricultural practices which may have a dire impact on the flora, fauna and the Narmada river traversing through the district as modern agriculture has shifted the agriculture under rain fed to irrigational practices and rampant usage of insecticides, pesticides and fertilizers.

Further taking in view the shift of Indian agriculture from traditional to modern to sustainable agriculture, which takes into account the limitations of production as well as socio-economic status of the farmers while using eco-friendly natural farming practices thus minimizing the effects on environment. In addition, the ever changing climate is posing a threat to Indian scenario where a large population is based upon agriculture directly or indirectly. Thus, usage of these enriched technical traditional know-how since time immemorial can act as a boon to the Indian farming community to not only improve the quality and quantity of crop and livestock production but also in terms of mitigating the dangers posed by climate change. Taking in view of the same a lot of work needs to be carried from local to regional to global level in documentation of these traditional technical knowledge, its scientific validation and dissemination of the same to various parts of the world according to the needs and landscape requirements.

Acknowledgements

The authors highly acknowledge all the farmers who actively participated and shared their experiences with us.

Authors contributions

AK and SK designed the work. SN, AK and SK carried out field survey, drafted the manuscript and prepared herbarium. SS and SK identified the plant specimens. SKP and MT supervised entire study and critically evaluated the manuscript. All the authors have read the final manuscript and approved its submission.

Compliance with ethical standards

Conflict of interest: The authors declare no conflicts of interest.

Ethical issues: None.

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