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Adaptive potential of traditional millets and pest management strategies among tribal farmers in Jharkhand

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Abstract

Millets, being climate-resilient and nutrient-rich, are a critical component in the quest for food security for vulnerable tribal groups in Jharkhand. The present study analysed the climatic stresses, such as drought, moisture deficiency, and soil fertility decline, which disproportionately impact millet production, especially among the Korwa and Sauria Paharia tribes. Despite a decline in millet farm area, consistent yields presented their resilience potential and role in tribal diet and livelihoods. The pest and disease problems in millet cultivation in the Munda, Santhal, Sauria Paharia, and Korwa tribes reported that finger millet and little millet were relatively resistant to pests and diseases, but sorghum was severely damaged by black cutworm and shoot fly as pests, smut and downy mildew as diseases. Differential management practices among tribes with considerable changes favouring chemical control among Korwa farmers and restricted disease management within the Sauria Paharia community, combined with declining usage of indigenous knowledge. The results emphasised the imperative to link indigenous knowledge with contemporary pest and disease management techniques, complemented by prioritised climate adaptation and climate-resilient soil and water conservation practices, to enhance millet production, maintain agro-biodiversity, and enhance socio-economic resilience of Jharkhand's tribal farmers.

Keywords: Finger millet, little millet, sorghum, tribal community, pest and disease management, indigenous knowledge

1. Introduction

Millets commonly known as nutria-cereals have fed millions of individuals for generations, especially in the dry and semi-dry regions of Asia and Africa. These resilient, climate-tolerant crops like finger millet (*Eleusine coracana*), pearl millet (*Pennisetum glaucam*), foxtail millet (*Setaria italica*) and little millet (*Panicum sumatrense*) were possess vast adaptive capacity because they can grow in poor soils with low water supplies and in hot temperature environments when other staple foods tend to disintegrate (Patro *et al.*, 2018) [6]. Their ecological flexibility and genetic diversity make them an essential component in the event of climate change, unpredictable rainfall and rising food insecurity (Dip *et al.*, 2019) [3].

Through resilient, millets are not free from pest and disease pressures which can be species to species, location to species and culturally dependent on farming practices (Rao *et al*., 2021) [8]. Pests like shoot flies, stem borers and aphids and diseases such as fungal and viral ones like blast, downy mildew and smuts, pose serious threats to yield and quality (Reddy *et al*., 2021) [9]. These challenges have to be tackled by an integrated approach blending advanced pest management strategies with traditional indigenous methods based on indigenous knowledge system (Kumari *et al*., 2024). This method is very important for passing on important farming knowledge to tribal people in Jharkhand (Das *et al*., 2023) [2]. Improving cooperation between study centres and farmers makes it easier for extension programmes to pass on current pest management options, environment-centred farming tips and the value of heritage knowledge (Prusty *et al.*, 2020) [7]. Focusing on these communities such efforts support tribal farmers in practising sustainable farming methods that help increase millet production, preserve a wide range of crops and raise their social and economic strength (Saha *et al*., 2024) [10]. It also enables tribal communities to use their age-old knowledge together with new scientific solutions to address the particular problems they encounter (Chava *et al*., 2023) [1].

The adaptive potential of millets, determines their principal pest and disease risk and presents both contemporary scientific and local control methods (Nanda *et al*., 2025) [4]. Such integrative approaches are critical for sustainable millet cultivation, agro-biodiversity conservation and advancement of robust farming systems, particularly for small landholder and tribal farmer especially tribal people who depend on these crops for their nutrition, food and livelihood (Padhy *et al*., 2025) [5].

2. Methodology

The research used a descriptive and exploratory research design that merged qualitative and quantitative methods for evaluating the adaptive characteristics of traditional millets, determining serious pests and diseases, and recording local and modern control practices. This facilitated an overall understanding of millet-based agro-ecosystems, especially in tribal situations where conventional information feeds into modern technology. Field study was carried out in four target tribal areas of Jharkhand—Tamar block (Ranchi district), Dhalbhumgarh block (East Singhbhum), Sundarpahari block (Godda), and Dumri block (Gumla). These regions are dominated by Munda, Santhal, Sauria Paharia, and Korwa tribes, respectively. The locations were chosen as per the existence of traditional millet cultivation, agro-climatic variability, and cultural diversity in indigenous agriculture. A purposive sampling technique was employed to choose respondents who are actively engaged in millet farming. 200 respondents (50 from each of the two tribes) were selected as respondents for the study.

Used to seek out in-depth information on millet cultivation methods, pests and disease problems and indigenous control practices. Interviews also dealt with adaptive features of various millet varieties. Carried out separately with male and female farmers in each village to record common experiences, customary practices, and communal memory concerning pest management and climate coping capacity. Problem-ranking matrices were applied in ranking pest/disease threats and control options. On-farm direct observation and facilitated crop walks assisted in the identification of typical millet varieties, pests, disease symptoms, and intervention methods employed.

3. Results and Discussion

3.1 Adaptive potential of millet

Millets have emerged as climate-resilient crops because they possess a special set of morph physiological, molecular and biochemical properties that enable them to tolerate various environmental stresses, especially those due to uneven rainfall, drought and unfavorable soil. Such traits render millets a key crop for climate-affected regions and regions unstable weather where other major crops such as rice and wheat could not cope. Millets short duration, heat and drought tolerance and capability to thrive under poor soil conditions render them extremely appropriate for climate-resilient agriculture. Where there is an irregular rainfall pattern, heat-waves or low water availability, millets present a strong solution that guarantees food security with sustainability in the environment. The major reasons why millets are more appropriate for stressful conditions than large cereals such as rice and wheat were given in Table 1.

Table 1: Distribution of respondents according to their perception of tolerance capacity of millet in Jharkhand (N=200)

Climatic condition	Munda (N=50)	Santhal (N=50)	Sauria Paharia (N=50)	Korwa (N=50)	Pooled (N=200)
Moisture stress	42 (84)	5 (10)	50 (100)	37 (74)	134 (67)
Low soil fertility	37 (74)	-	3 (6)	26 (52)	66 (33)
Drought	31(62)	4 (8)	47 (94)	41 (82)	123 (62)

Table 1 indicated that substantial discoveries had been made regarding the agricultural issues of the four tribes (Munda, Santhal, Sauria Paharia, and Korwa) in Jharkhand, particularly concerning drought situations, soil health, and moisture stress during crop production. Specifically, 84 percent of the Munda tribe had indicated moisture stress, compared to 10 percent of the Santhal tribe. The Sauria Paharia tribe had reported moisture stress at a rate of 100 percent, while 74 percent of the Korwa tribe had experienced moisture stress in their crop cultivation. Moisture stress had been a serious issue for the Korwa and Munda tribes, with an extremely high percentage of respondents indicating it. The Sauria Paharia tribe had also experienced high moisture stress, which may have been a result of water deficiency, inadequate irrigation facilities, or climatic changes. In contrast, Santhal respondents had indicated comparatively low levels of moisture stress, suggesting that they might be in an area with more favorable water availability or efficient water management techniques. Pooled analysis had shown that 67 percent of the respondents in the chosen tribal groups had reported experiencing moisture stress in their crop production.

74 percent of the Munda tribe had experienced soil fertility problems, the highest among the tribes. The Korwa tribe had also faced soil fertility problems, with 52 percent of respondents reporting it. Only 6 percent of the Sauria Paharia tribe had experienced soil fertility problems, and no Santhal tribe respondents had reported soil fertility problems. Pooled analysis had indicated that 33 percent of all respondents across the different tribes had experienced soil fertility problems.

Regarding drought, 62 percent of the Santhal tribe and just 8 percent of the respondents from the Munda tribe had said they had faced drought. The Sauria Paharia tribe had experienced drought at a rate of 94 percent, and 82 percent of the Korwa tribe had faced it. Pooled analysis had shown that 62 percent of the respondents from the tribal groups had suffered from drought. The data had also revealed that drought was a significant issue for the Korwa, Munda, and Sauria Paharia tribes to varying extents. The Santhal tribe had significantly less exposure to drought, possibly due to differences in geographical and climatic conditions or reporting bias.

3.2 Impacts of climate factors on millet yield and productivity

Table 2 presented the percentage and rating (High, Medium, Low) of moisture stress, drought, and low soil fertility among the selected tribal groups (Munda, Santhal, Sauria Paharia, and Korwa) and the pooled data. The intensity of agricultural stress among tribal groups in Jharkhand had been quite different, with some groups facing more stress than others. The Sauria Paharia respondents had the highest percentage under high stress (74%), followed by Korwa (42%), Munda (16%), and Santhal (10%), with the combined average across the tribal groups being 36 percent. Under medium stress, the Korwa were hit the hardest (50%), followed by Munda (32%), Santhal (22%), and Sauria Paharia (20%). Conversely, low stress conditions were most dominant among the Santhal (68%), reflecting comparatively higher resistance, followed by Korwa (8%) and Sauria Paharia (6%). These variations indicated different levels of vulnerability and capacity for adaptation among the communities and highlighted the necessity for specially tailored interventions to assist the more vulnerable groups. Pooled analysis revealed that most (44%) of the respondents had experienced medium moisture stress, while 36 percent experienced high moisture stress and 21 percent experienced low moisture stress.

Table 2: Frequency distribution of respondents according to their rating of adaptive potential of millets in diverse climatic conditions (N=200)

Climatic condition	Munda			Santhal			Sauria Paharia			Korwa			Pooled		
	H	**M**	**L**	**H**	**M**	**L**	**H**	**M**	**L**	**H**	**M**	**L**	**H**	**M**	**L**
Moisture stress	8 (16)	42 (32)	-	5 (10)	11 (22)	34 (68)	37 (74)	10 (20)	3 (6)	21 (42)	25 (50)	4 (8)	71 (36)	88 (44)	41 (21)
Drought	2 (4)	6 (12)	12 (24)	-	11 (22)	39 (78)	37 (74)	10 (20)	3 (6)	26 (52)	24 (48)	-	65 (33)	51 (26)	54 (27)
Low soil fertility	21 (42)	19 (38)	10 (20)	30(60)	17 (34)	-	33 (66)	15 (30)	5 (10)	41 (82)	9 (18)	-	125 (63)	60 (30)	15 (8)

Drought had continued to be one of the primary stressors on agriculture in Jharkhand, with susceptibility to drought varying among the different tribal groups. The Sauria Paharia were most susceptible to drought (74%), followed by Korwa (52%) and Munda (4%), meaning that these communities experienced the highest impact. With regard to susceptibility to medium drought, Korwa showed the maximum percentage (48%), followed by Santhal (22%), Sauria Paharia (20%), and Munda (12%). Low susceptibility, indicating greater drought resistance, was highest in Santhal (78%), followed by Munda (24%) and Sauria Paharia (6%). These differences reflected the varying exposure and adaptive capacity of different communities and indicated the imperative for community-based drought mitigation policies. Pooled analysis indicated that 33 percent of the cases were exposed to high drought susceptibility, 26 percent were at medium drought risk, and 27 percent were at low drought risk. These figures indicated that a considerable portion of the area was facing drought-related challenges, with high and medium drought conditions affecting the region.

Low soil fertility was a general farming limitation in Jharkhand, with extreme variation in its effect among tribal communities. Severe infertility was highest among Korwa (82%), followed by Sauria Paharia (66%), Santhal (60%), and Munda (42%). As regards medium infertility, the most impacted were the Munda (38%), followed by Santhal (34%), Sauria Paharia (30%), and Korwa (18%). Low fertility, suggesting relatively improved soil conditions, was highest among the Munda (20%), followed by Sauria Paharia (10%). Pooled analysis showed that 63 percent of the population was under high susceptibility to low soil fertility, 30 percent were under medium risk, and merely 8 percent had low risk. The above statistics underscored the need for urgent soil improvement measures, especially for the Korwa and Sauria Paharia, to promote sustainable agricultural productivity. Table 2 also revealed that low soil fertility and drought were the key environmental constraints significantly affecting agricultural productivity in the region. Although the Santhal community was more resilient to drought and moisture stress, Korwa and Sauria Paharia were more susceptible to these climate adversities. Overcoming these adversities through soil and water conservation, enhanced agricultural practices, and climate adaptation measures would be key to ensuring livelihoods in these communities.

3.3 Adaptive potential of millets production, productivity and total area cultivation

Finger millet and sorghum area, production and yield data during 2001-2023 in Jharkhand has been presented in Table 3. Though the overall area under millet cultivation has actually reduced since the bas year of 2001-02, the yield for finger millet as well as sorghum has exhibited intriguing trends. For finger millet, the overall area under cultivation has plummeted to 16 hectares in 2005-06 from 40.4 hectares in 2001-02, reflecting a sharp decline in the area under this crop. Yet, even with this decline in area, the yield itself fell marginally, from 624 tons to 550 tons, leaving a gap of -74 tons. This indicates that although less area was being covered under finger millet cultivation, overall productivity per hectare didn't take a drastic fall and this may reflect better agricultural practices or increased production efficiency. In the case of sorghum, through the overall area under cultivation fell further from 3.9 hectares to 0.3 hectares, the yield actually rose from 590 tons to 667 tons. This indicates that even through the area under sorghum cultivation was significantly lowered, the productivity of the crop per unit of land increased, perhaps due to improved farming methods, improved varieties or improved growing conditions.

The production of millets, namely finger millet and sorghum, during the years 2006-07 and 2010-11. These years reflect some observable trends, both area and yield-wise. For finger millet, the total area under cultivation decreased from 15.2 hectares in 2006-07 to 9 hectares in 2010-11, a decrease of 6.2 hectares. This reduction in cultivated area is considerable. But yield of finger mill*et al*so fell considerable, from 737 tons to 522 tons, down by 215 tons. This sudden drop in area and yield implies that a number of factors might have impacted production, including adverse weather, soil erosion or changes in agricultural priorities or practice. Conversely, sorghum recorded a rise in its harvested area from 0.5 hectares to 0.31 hectares (+0.26 hectares), as perhaps farmers were experimenting with or embracing sorghum as a usable crop. Yet even with the rise in area, the production of sorghum dropped from 600 tons to 363 tons that is fall by 237 tons.

The decade from 2011-12 to 2015-16 for finger mille and sorghum reveals combination of trends with both area sown and yield indicating varied pattern of growth. For finger millet, the area planted grew from 11.97 hectares to 14.33 hectares by increases of 2.36 hectares. The yield declined somewhat from 662 tons to 644 tons by drop of 18 tons. This indicates that while more land used in cultivating finger millet, the total productivity per unit of land decreases only slightly. The subtle drop in output may be due to a number of reasons including crop management issues, weather condition or change in agricultural practices. Even with the expansion in area, the output did not increase much, indicating that changes in agricultural practices or availability of resources may still be necessary o increase overall output. For sorghum, the area under cultivation went up from 1.09 hectares to 2.07 hectares (+0.98 hectares) which is a significant increase in sorghum cultivation. To go along with rise in area, the production also picked up from 502 tons to 594 tons (+92 tons). This is a welcome trend where the productivity per unit land actually rose, probably because of better methods of cultivation, improved crop varieties or other conducive factors.

Table 3: Total millet cultivation area, production and productivity of finger millet & Sorghum

Year	Finger millet					Sorghum				
	Total area (ha.)		Production (Tons.)	Productivity (Kg/ha.)		Total area (ha.)		Production (Tons.)	Productivity (Kg/ha.)	
2001-02	40.4		25.2	624		3.9		2.3	590	
2002-03	12.1	-28.3	8.8	727	+103	3.9		2.3	590	
2003-04	19	+6.9	14	737	+10	1	-2.9	2	513	-77
2004-05	18	-1	11	611	-126	2.2	+1.2	1.7	773	+260
2005-06	16	-2	8.8	550	-61	0.3	-1.9	0.2	667	-106
2006-07	15.2	-.8	11.2	737	+187	0.5	+0.2	0.3	600	-67
2007-08	13.2	-2	5.9	447	-290	0.6	+0.1	0.3	500	-100
2008-09	12.1	-1.1	8.5	702	+255	0.5	-0.1	0.3	600	+100
2009-10	10.4	-1.7	5.7	548	-154	0.2	-0.3	0.1	500	-100
2010-11	9	-1.4	4.7	522	-26	0.31	+0.11	0.11	363	-137
2011-12	11.97	+2.97	7.92	662	+140	1.09	+0.78	0.55	502	+139
2012-13	12.56	+0.59	10.58	842	+180	1.5	+0.41	1.12	747	+245
2013-14	11.87	-0.69	8.71	734	-108	0.5	-1	0.28	552	-195
2014-15	13.91	+2.04	11.65	838	+104	0.54	+0.04	0.29	537	-15
2015-16	14.33	+0.42	9.24	644	-194	2.07	1.53	1.23	594	+57
2016-17	22.69	+8.36	20.03	882	+238	3.95	+1.88	2.74	694	+100
2017-18	19.01	-3.68	18.48	972	+90	3.33	-0.62	2.21	664	-30
2018-19	14.03	-4.98	11.29	805	-167	2.05	-1.28	1.4	685	+21
2019-20	14.58	+0.55	12.76	875	+70	1.8	-0.25	1.35	750	+65
2020-21	18.77	+4.19	16.4	874	-1	1.23	+0.57	1.35	657	-93
2021-22	0.19	-18.58	0.17	878	+4	0.02	-1.21	0.01	817	+160
2022-23	0.16	-0.03	0.13	775	-103	0.01	-0.01	0.01	967	+150
t-test	<.001									

Between the years 2016-17 and 2020-21, the figures for both finger millet and sorghum indicate a fall in both the cropped area and yield indicating continued difficulty in millet cultivation during these years. For finger millet the area fell from 22.69 hectares, losing 3.92 hectares. While the area under cultivation went down, the production fell marginally from 882 tons to 874 tons with a shortfall of -8 tons. This indicates that even with the drop in area per hectare productivity of finger millet did not vary much and there was only a slight fall in overall production. This would suggest a measure of stability in finger millet production, yet raises the necessity of greater incentives or support in raising area and production over a long term span. For sorghum, overall area sown reduced considerably from 3.95 hectares to 1.23 hectares, a reduction of 2.27 hectares and the output also reduced from 694 tons to 657 tons by decline of 37 tons. This implies a greater drop in area as well as in output than finger millet. The intersection of falling area and yield suggests possible difficulties in sorghum cultivation which may be due to reasons such as poor climatic condition, pest attacks or a change in farmer interest towards other crops.

The data from 2021-22 to 2022-23 shows an interesting trend in which both finger millet and sorghum had a decline in area brought under cultivation but their yields had different patterns of change. For finger millet the overall area reduced to 0.16 hectares from 0.19 hectares, decline by 0.03 hectares. However the yield fell drastically from 878 tons to 775 tons a difference of -103 tons. This indicates that although the cultivated area reduced marginally the yield per hectare also fell markedly. The reduction in yield may be attributed to reasons like suboptimal conditions of growth, reduced quality of soil or other problems impacting productivity, even with a comparatively small decrease in area. As against this, sorghum underwent a similar area reduction from 0.02 hectares to 0.01 hectare, a decline of 0.01 hectare. The yield of sorghum, however rose significantly from 817 tons to 967 tons, an increase of +150 tons. This hike in yield might have been brought about by the cultivation of high-yield sorghum varieties better farm practices or more efficient management practices. The rise in productivity even after the decrease in area under cultivation is a good indicator that sorghum cultivation is becoming more efficient, perhaps because of more effective agricultural methods or the cultivation of superior seeds.

The computed t-value (t=<0.001) shows a statistically significant correlation between the total area and yield of finger millet and sorghum for 22 years. This phase shows that, even through the total area covered by millets declined for both crops, the rise in the yield of sorghum might be a sign of improved technology or the introduction of better crop varieties. For finger millet, the sharp decline in the yield indicates that more work could be required to enhance productivity. Perhaps the introduction of higher-yield varieties might help to offset the fall in finger millet yield and enhance its overall performance.

3.4 Major Pest & Diseases in millets

Millets such as sorghum and finger millet through normally resistant to pests and diseases may still suffer from infestation and infection under specific conditions. The principal pest and diseases were presented in the Table 4 and 5. Pest has the capacity to cause considerable damage to millet crops, both in terms of yield as well as the quality of the crop. Several pests attack in millets at different growth stages, ranging from germination to post-harvest. The information of insect and pest of millets is presented in Table 4.

Table 4: List of insect and pest of sorghum and finger millet

Sl. No.	Name of the pest & insect	Scientific name	Family
1	Black cutworm	*Agrotis ipsilon*	Lepidoptera
2.	Shoot bug	*Peregrines soccata*	Muscidae
3.	Earhead worm	*Helicoverpa armigera*	Noctuidae
4.	Shoot fly	*Atherigona soccata*	Muscidae

Table 5: Percentage distribution of insect and pest experience in millets (N=50)

Sl. No.	Name of the millet	Tribe type	Frequency (%)
1.	Sorghum	Sauria Paharia	38 (76)
2.	Finger millet	Munda, Korwa	-
3.	Little millet	Korwa	-

Both Table 4 and 5 explain that 76 per cent of Sauria Paharia respondents had reported having pest attacks on their sorghum crops i.e. black cutworm, shoot bug, earhead worm and shoot fly. These insects were reported to inflict extensive damage on sorghum crop, resulting in substantial yield loss. The damage by these insects was likely to affect both the quantity and quality of the sorghum harvest with implications for the livelihood of farmers in this area. No pest problems were reported in finger millet and little millet crops by the respondents from Munda and Korwa tribes. This implies that these crops may be less prone to pest infections in areas where they are grown by these communities. It might also suggest that finger millet and little millet are being grown in conditions or with practices that naturally reduce pest problems or these varieties may have some degree of innate resistance to pest relative to sorghum. Sauria Paharia respondents experienced serious pest problems in sorghum production whereas the Munda and Korwa communities d not experienced pest attacked in finger millet and little millet production. This variation may be attributed to several factors including crop type, local environmental conditions, pest management practices and perhaps the utilization of pest resistant varieties.

Millets like other agricultural crops can be affected by a range of diseases that would impact both their yield and quality. These would include diseases triggered by fungi, bacteria, viruses or any other pathogens. Based on the data from both Table 6 and 7 demonstrated that millets disease infections are of concern to Munda, Sauria Paharia and Korwa respondents showed different levels of disease effects. 46 per cent of the Sauria Paharia respondents indicated that sorghum was infected with diseases. This shows that controlling diseases was an important issue for this community during their sorghum production. 14 per cent of Munda and 6 per cent of Korwa respondents reported the infection of diseases in finger millet. While no respondents reported diseases infection in little millet. Smut, ergot and downy mildew are the prevalent diseases observed on sorghum and finger millet which reduce the yield of millets. This indicates that although the incidence of the disease is lower in finger millet than in sorghum, it remains a threat to these communities.

Table 6: List of diseases of sorghum and finger millet

Sl. No.	Name of the Disease	Causal Organism	Symptom
1.	Smut	*Tolyposporium penicillariae*	A fungal disease that leads to the formation of dark, spore-filled masses on the grain, affecting the yield and quality of the crop. Millets grain turn into gall like bodies which are large than normal size grain.
2.	Ergot	*Claviceps fusiformis*	Another fungal infection that causes abnormal growths on the seeds, rendering the crop inedible or unmarketable.
3.	Downy mildew (Green ear disease)	*Sclerospora graminicola*	A fungal disease affecting the leaves and stems, leading to reduced photosynthesis and weakened plants, thus impacting overall yield. The base of the lamina become yellow in colour.

Table 7: Distribution of respondents according to disease in selected tribe in (N=200)

Sl. No.	Tribe type	Sorghum	Finger millet	Little millet	Pooled
1.	Munda	-	7(14)	-	7 (4)
2.	Sauria Paharia	23 (46)	-	-	23 (12)
3.	Korwa	-	3 (6)	-	3(2)

Around all the respondents were asserted that insect and pest attacked and disease infection were happened when the crops were sowing late or there is excess humidity or unfavorable climate condition, pest and disease attacks are more. If the crop is sowing timely and the weather is favorable, the crops are never affected by pest or diseases. Other than this, if there is any pest or disease in the nearby cereal crop then it is transmitted to the neighboring millets and depending upon which the disease occurs.

3.5 Control measures

Pest and disease control is the management and regulation of insects, pest and diseases such as different insects, fungi, viruses and bacteria by using pesticides, bactericide, fungicide and other control methods. While millets are relatively hardier than most crops, a healthy soil environment and proper field management practices play a key role in avoiding infestations by pest and diseases. In this study, data were gathered concerning modern and indigenous methods applied in pest and disease management.

Table 8: Percentage distribution of respondents according to control measures used for control pests in selected tribal groups (N=200)

Sl. No.	Tribe type	Munda	Sauria Paharia	Korwa	Pooled
1.	Modern	13 (26)	17 (34)	4 (8)	34 (17)
2.	Indigenous	-	14 (28)	46 (92)	60 (30)

Based on the data presented in the Table 8 that control practices differ radically among different tribal population and the trend is towards chemical pesticides and differing application of native methods. In Munda tribe 26 per cent of the respondents indicated that they used chemical pesticides for pest management. No Munda respondents indicated the use of indigenous pest control practices. This implies that chemical pesticides are preferred compared to traditional practices or there may be limited access to or availability of knowledge about indigenous pest control practices. Among Sauria Paharia tribe 34 per cent of the respondents applied chemical pesticides, showing a moderate usage of synthetic chemicals as pesticides for pest control. Also, 28 per cent of Sauria Paharia respondents utilized indigenous practices like spraying wooden ash and dissolved rotten fish scales as pesticides. Such traditional methods form part of the cultural heritage of the tribe and reflect a mixture of indigenous and modern pest control methods. In Korwa tribe 8 per cent of Korwa respondents alone have adopted the practice of using chemical pesticides. Such a high rate indicates a strong dependence on modern farm inputs, perhaps because chemical pesticides are more available, more effective or are more accessible. 92 per cent of Korwa respondents indicated that they use traditional methods of pest control a very low proportion further reinforcing the trend towards chemical solutions among this population.

3.6 Indigenous Pest Control Methods

The Sauria Paharia and Korwa tribes mentioned the use of wooden ash and dissolved rotten fish scales as part of their traditional pest control practices. These methods are typically used for

- **Wooden Ash:** Often used to deter pests like insects, particularly by sprinkling it on the soil or leaves. It works as a physical barrier and can also have a mild pesticide effect due to its alkaline nature.
- **Rotten Fish Scales:** A natural pesticide that may have strong odors or compounds harmful to pests. This method reflects an intimate knowledge of the local ecosystem and utilizes available resources to manage pest problems.

The pooled analysis reveals the overall pest control practices among the respondents. 17 per cent of respondents reported using chemical pesticides, which are modern pest control techniques. This indicates that a significant portion of the population is relying on synthetic chemicals for managing pest infestations, likely due to their effectiveness and ease of use. 30 per cent of respondents indicated they are using indigenous methods for pest control. This represents a much smaller proportion, highlighting that traditional practices are not as widely adopted as modern chemical methods.

Table 9: Distribution of respondents according to control measures used for disease control in selected tribal groups (N=200)

Sl. No.	Tribe type	Munda	Sauria Paharia	Korwa	Pooled
1.	Modern	7 (14)	-	50 (100)	57 (28.5)
2.	Indigenous	-	-	-	-

The data from the Table 9 revealed the disease control practices used by the Munda**,** Sauria Paharia and Korwa tribes, highlighting the shift toward chemical solutions and the decline of indigenous methods**.** 14 per cent of Munda respondents use chemical fungicides/bactericides for disease control, indicating some adoption of modern disease management techniques. The Munda tribe does not use indigenous methods for disease control. This suggests that they have fully transitioned to modern agricultural practices for managing plant diseases. Cent-per-cent of Sauria Paharia respondents were not using either modern or indigenous methods for disease control. This may indicate a lack of awareness, resources, or infrastructure to effectively manage crop diseases. It also suggests that disease management might be neglected or under-prioritized in their farming practices. The Sauria Paharia tribe does not appear to use any disease control methods, whether modern or traditional, which could be indicative of a significant gap in disease management practices or a lack of access to both modern agricultural technologies and traditional knowledge. Cent-per-cent of Korwa respondents used chemical fungicides or bactericides for disease control, signifying a complete reliance on modern agricultural inputs to manage diseases. The shift toward chemical fungicides/bactericides is very pronounced in the Korwa tribe (100%), and to a slightly lesser extent in the Munda tribe (14%).

No respondents in the Korwa tribe use indigenous methods for disease control, pointing to a complete shift away from traditional practices. Across the three tribes, there is a clear decline in the use of indigenous methods for disease control, with no tribe fully relying on traditional techniques. This loss of indigenous knowledge may be due to various factors such as changing farming practices, lack of knowledge transfer, or the perception that modern methods are more effective. The data indicates a strong preference for chemical solutions (fungicides/bactericides) for disease control, particularly in the Korwa tribe**.** Indigenous methods for disease control are in decline, with very few respondents using them, which may lead to the erosion of traditional knowledge. There is an urgent need to revitalize indigenous knowledge of disease control and find ways to integrate it with modern practices for sustainable and resilient agricultural systems. Additionally, addressing the lack of disease management in the Sauria Paharia tribe should be a priority to ensure crop health and food security.

4. Conclusion

Analysis of agricultural limitations and millet farming in the case of Munda, Santhal, Sauria Paharia, and Korwa tribes in Jharkhand shows that moisture stress, drought, and decreasing fertility in the soil are major problems, which, in proportion to the population, disproportionately hit the Korwa and Sauria Paharia tribes because of their increased exposure to climatic and infrastructural risks. While there seems to be a relatively less impact on the Santhal tribe, the collective data do show that most respondents (67%) are under moisture stress, 62% endure drought, and 33% have soil fertility problems. While there has been a declining trend in the cropped area under millet cultivation since 2001 to 2023, finger millet and sorghum have maintained stable yields, which speaks volumes about their resilience and the significance they play in providing food and nutritional security. Yet, the general upswings in area, production, and productivity of millet underscore the necessity for policy interventions such as climate-resilient agriculture, soil and water conservation, intensification of drought-resistant millet varieties, and farmer capacity building. Millet cultivation revitalized through a combination of traditional wisdom and improved practices provides a sustainable route to build tribal livelihoods and agricultural resilience in

Jharkhand.

5. References

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