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Assessing the Quality of Pluralistic Extension Service Provided by KVK and ATMA in Cooch Behar District of West Bengal

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The two organizations KVK and ATMA are the organizations provided pluralistic extension services in the Cooch Behar district of Wes Bengal. The study was conducted in Cooch Behar district by taking four study clusters [viz. Dinhata-II block (operated by the Cooch Behar KVK), Cooch Behar-I block, Cooch Behar-II block and Mathabhanga-I block (operated by ATMA)]. A total of 100 farmers selected who are getting the benefits from the KVK and ATMA selected for the study. The study revealed that the according to KVK beneficiaries the quality of service provided by KVK having low cost (mean score=2.00) followed by timely (2.00), need based (1.88), applicable (1.80), diverse (1.84), effective (1.76) and accurate (1.68) and according ATMA beneficiaries the ATMA provides low-cost service having mean score 1.65 followed by timely (1.42), accurate (1.40), need based (1.32), effective (1.30), applicable (1.25) and diverse (1.16) information. The quality of service perceived by the beneficiaries of both KVK and ATMA was towards higher side.

Keywords: KVK, ATMA, Farmer, Extension service; Cooch Behar

INTRODUCTION

The agriculture system in our country is diversified and varies according to the agro climatic situation. The demands of farmers are also different from region to region. To full fill different needs and services of the farmers the role of agricultural institutions is very much important. In the present scenario of agriculture Krishi Vigyan Kendra (KVK) and Agricultural Technology management Agency (ATMA) plays a vital role in the development of agriculture sector. Both organizations are providing pluralistic extension services in the district to fulfill the need of the farmers. Birner and Anderson (2007) revealed that various options for providing and financing agricultural advisory services which involve the public and private sectors as well as a third sector comprising non-governmental organizations and farmer-based organizations. ATMA interventions were having positive and significant impact on improvement of the knowledge and skill level of the respondents of all the selected districts of Sikkim in agriculture and horticulture as well as animal husbandry (Subba and Mukhopadhyay, 2019). KVK training had made significant impact in increasing the knowledge level of the tribal farmers and farm women on various farm activities of selected tribal districts of Odisha (Bar, 2015). ATMA model at the district level would continue to play a prominent role in serving the larger group of small and marginal farmers as well as landless laborers and the other actors involved in the extension/transfer of technologies (Singh *et al*., 2013). Pluralistic extension service is a mixed approach of public and private extension system to deliver effective extension service and advisory work for the farmers. KVK and ATMA works with the different government and private organizations to provide good service to the farmers. Cooch behar, a Northern district of West Bengal having one KVK in the district and ATMA at different block levels providing service to the farmers. In this backdrop, the study has been designed by taking the objective to assess the quality of pluralistic extension service provided by KVK and ATMA in Cooch Behar district of West Bengal.

MATERIAL AND METHODS

According to restructured policy, ATMA and KVK have scope to provide pluralistic services by convergence with other actors. ATMA in Cooch Behar district is working in twelve blocks (Cooch Behar-I & II, Mathabhanga-I & II, Dinhata-I & II, Tufanganj-I & II, Sitalkuchi, Sitai, Mekhiliganj and Haldibari) in the district and KVK intensively working in four blocks (Cooch Behar-II, Tufanganj-II, Mathabhanga-II and Dinhata-II, although their network is extended to whole district) at present. Both ATMA and KVK work in a village/cluster area for a period of around 3 to 4 years and shift to another area in the block/district. Considering this spatial expansion of ATMA and KVK, the units of study was selected on random sampling basis (one out of four blocks of KVK represented by purposively selected adopted village in the block, and three out of twelve blocks of ATMA represented by a purposively selected adopted village/cluster in the block for each). The selected study units are working in selected villages/clusters for a period of last 3-4 years and covered around 50 % eligible families for service provisioning as beneficiary. So, from selected village/cluster 25 beneficiaries were randomly selected. A total of 100 respondents were selected. The quality of the organizations was measured with seven parameters. The parameters were timely, accurate, need based, effective, low cost, applicable and diverse. These parameters were assigned with three-point scale that were always, sometimes and never with the assigned score 2, 1 and 0, respectively.

RESULTS AND DISCUSSION

The analyzed result shows that more than two third beneficiaries responded that KVK provides timely service always which is low cost, need based, diverse, applicable, effective and accurate (Table 1). The beneficiaries were getting all type of services from the KVK through different projects, training programs, on farm testing, and frontline demonstration. The KVK also transfer technology or information through different projects like NICRA, DAESI and skill training for youth. The KVK officials frequently visit to the farmer’s field to observe the condition of crop and also give information disease, pest management. From the table it was shown that the service provided by the KVK was very low cost and timely having mean score 2.0 in each followed by need based (1.88), diverse (1.84), effective (1.76), accurate (1.68).

Majority of the beneficiaries were not fully satisfied with quality of service provided by ATMA (Table 2). More than half of the beneficiaries felt that the ATMA service was partially applicable and not always need based, not always diverse, sometimes ineffective and sometimes inaccurate but about three fourth of the beneficiaries revealed that the services provided by ATMA was low cost. As per the governing body meeting of ATMA, the ATMA provides different service to the farmers. The ATMA governing body decides the type of service given in which year and in which block according to the need of the farmer. So, the farmers were getting need based, diverse services from ATMA. ATMA provides monetary fund to the beneficiaries for the development of their farm. According to some of the beneficiaries, the ATMA gives service which was not at all required by the beneficiary. ATMA forms different farmer groups to provide diverse of services like mushroom cultivation, paddy nursery, fish cultivation, etc. From the table it was also explained that the ATMA provides low cost service having mean score 1.65 followed by timely (1.42), accurate (1.40), need based (1.32), effective (1.30), applicable (1.25) and diverse (1.16). Similar views of beneficiaries on agro advisory agents were also reported from Nadia district of West Bengal also (Saha *et al.,* 2015).

Table 1. Quality of service provided by KVK according to KVK beneficiaries

Sn	QP	KVK			MS	Rank
		Always (2)	**Sometimes (1)**	**Never (0)**		
1.	Timely	25 (100 %)	0	0	2	II
2.	Accurate	17 (68 %)	8 (32 %)	0	1.68	VII
3.	Need based	22 (88 %)	3 (12 %)	0	1.88	III
4.	Effective	19 (76 %)	6 (24 %)	0	1.76	VI
5.	Low cost	25 (100 %)	0	0	2	I
6.	Applicable	20 (80 %)	5 (20 %)	0	1.80	IV
7.	Diverse	21 (84 %)	4 (16 %)	0	1.84	V

Sn- Serial number; QP- Quality parameters; MS- Mean score

Table 2. Quality of service provided by ATMA according to ATMA beneficiaries

Sn	QP	ATMA			MS	Rank
		Always (2)	**Sometimes (1)**	**Never (0)**		
1.	Timely	35 (46.66 %)	37 (49.33 %)	3 (4.00%)	1.42	II
2.	Accurate	32 (42.66 %)	41 (54.66 %)	2 (2.66%)	1.40	III
3.	Need based	25 (33.33 %)	49 (65.33 %)	1 (1.33%)	1.32	IV
4.	Effective	28 (37.33 %)	42 (56.00 %)	5 (6.66%)	1.30	V
5.	Low cost	50 (66.66 %)	23 (30.66 %)	2 (2.66%)	1.64	I
6.	Applicable	21 (28.00 %)	52 (69.33 %)	2 (2.66%)	1.25	VI
7.	Diverse	20 (26.66 %)	47 (62.66 %)	8 (10.66%)	1.16	VII

Sn- Serial number; QP- Quality parameters; MS- Mean score

CONCLUSION

From the study it is concluded that both the organization provides low-cost service followed by timely, need based and accurate service to the farmers of Cooch Behar district. The study recommended that the pluralistic service provided by the organization should give more emphasis on diverse areas of agriculture and should be more effective. The organizations should more involve with other organization to provide more quality service to the farmers.

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Characterization and Grouping of Black Pepper (*Piper nigrum* L.) Cultivars of Kerala based on Morphological Traits

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The present study was undertaken to investigate the variability among black pepper (*Piper nigrum* L.) local cultivars. A total of thirty-four cultivars were identified and selected through an extensive survey carried out in the major black pepper growing tracts of Kerala. All these cultivars were characterized using twenty morphological traits. Considerable morphological variation was found among the cultivars. Variability was present for plant, leaf, spike, fruit and seed characteristics resulting in ample diversity to the cultivars. However, leaf and spike characters were most useful in distinguishing the cultivars. Hierarchical cluster analysis using SPSS method showed genetic variation amongst cultivars, dividing them into four major clusters comprising five, fifteen, thirteen and one cultivar, respectively. The natural triploid cultivar Vadakkan did not cluster with any other and was unique with very bold berries. Cultivars with special characteristics are the good genetic resources for future exploration and can be utilized in breeding programmes. Many cultivars of this species are becoming extinct over time. So, measures should be taken to conserve them.

Keywords: Black pepper, Cluster analysis, *Piper nigrum*, Cultivars, Characterization

INTRODUCTION

Black pepper (*Piper nigrum* L.), from the family of Piperaceae, is one of the most widely used spices in the world due to its distinct pungency. Known as the ‘king of spices’, it plays a prominent role in culinary purposes and indigenous medical systems. Its health benefits are attributed to the pungent compound piperine. The Western Ghats of the Indian peninsula is the primary centre of origin of the ‘black gold’ (Ravindran, 2000). It is a perennial woody climber (liana) suited to humid climate. Because of the humid climatic conditions and widespread consumption, this spice crop has become synonymous with the Asian continent. Kerala, the southernmost state of India, occupies a significant portion of the Western Ghats and is a rich source of wild relatives of this spice crop. The hot and humid climate of the sub-mountainous tracts of the Western Ghats is ideal for its cultivation, and thus, Kerala is one of the main centers for the production of the majority of black pepper in India (Joy *et al.*, 2007).

Over seventy distinct landraces of black pepper are under cultivation in Kerala, both as a mixed crop in homestead gardens and in semi plantation scale. Morphologically different intra-specific variants of black pepper have been reported from this region, both in the wild and in cultivation. The landraces differ significantly from one another in terms of the morphological characteristics of their plants, giving them a unique appearance (Mathew *et al*., 2005). The cultivars or local races are named either after the region where they are cultivated, the person who popularized it there, or based on certain morphological traits (Ravindran *et al.*, 1997). Morphological and qualitative characteristics have been found to vary within or between cultivars. Mathew *et al*. (2006) carried out a study on morphometrical analysis and grouping of related cultivars of black pepper from

Kerala and Karnataka. For the development of improved black pepper cultivars, various breeding methods such as clonal selection, open pollination and hybridization have been used (Krishnamoorthy and Parthasarathy, 2010). Plant breeding begins with germplasm identification and characterization. Characterization is required because each germplasm exhibits different characteristics depending on its environment. The availability of genotypes with specific characteristics will have a significant impact on the effectiveness and speed with which plant breeding programmes produce superior varieties with economic value (Prayoga *et al*., 2020). The usefulness of cluster analysis in taxonomic studies was earlier seen in *Piper* species (Ravindran *et al*., 1992). The objective of the present study was to characterize the black pepper cultivars and to group them based on qualitative morphological characters*.*

MATERIALS AND METHOD

The research was conducted during 2019-2021 in Kerala. A total of thirty-two black pepper cultivars at bearing stage, aged five to ten years, were selected from farmer's fields in various parts of Kerala (Table 1).

Table 1. Passport data of black pepper cultivars studied in Kerala

Sl. No.	Local cultivars	Code	Village	District
1	Karimunda 1	KRM1	Elappally	Idukki
2	Neelamundi 1	NLM1	Elappally	Idukki
3	Cheppukulamundi	CPKM	Cheppukulam	Idukki
4	Vattamundi	VTM	Cheppukulam	Idukki
5	Thulamundi	TLM	Cheppukulam	Idukki
6	Jeerakamunda	JRKM	Peringassery	Idukki
7	Balankotta1	BLK1	Peringassery	Idukki
8	Padarppan	PDP	Peringassery	Idukki
9	Arakkulamunda	ARM	Arakkulam	Idukki
10	Thevanmundi	TVM	Uppukunnu	Idukki
11	Munda	MD	Senapathy	Idukki
12	Malamundi	MLM	Senapathy	Idukki
13	Wayanadan	WYN	Noolpuzha	Wayanad
14	Chumala	CML	Noolpuzha	Wayanad
15	Velliyaranmunda	VLYM	Nenmani	Wayanad
16	Nadeshan	NDSN	Nenmani	Wayanad
17	Nadan	NDN	Nenmani	Wayanad
18	Karimunda 2	KRM2	Sultanbathery	Wayanad
19	Aimpiriyan	AMPN	Sultanbathery	Wayanad
20	Kalluvally 1	KLVY1	Sultanbathery	Wayanad
21	Vellanamban	VLN	Ambalavayal	Wayanad
22	Manjamunda	MJM	Ulikkal	Kannur
23	Kalluvally 2	KLVY2	Elappally	Kannur
24	Balankota 2	BLK2	Taliparamba	Kannur
25	Kuthiravally 1	KTV1	Taliparamba	Kannur
26	Vadakkan	VDKN	Taliparamba	Kannur
27	Chengannurkodi	CNGK	Vakathanam	Kottayam
28	Narayakodi	NYK	Vakathanam	Kottayam
29	Neelamundi 2	NLM2	Changanassery	Kottayam
30	Perumkodi	PMK	Changanassery	Kottayam
31	Kuthiravally 2	KTV2	Vallikunnam	Kollam
32	Arimulak	AMK	Soorandu	Kollam
33	Kottanadan	KTN	Pathanapuram	Kollam
34	Karivilanchy	KRVY	Pathanapuram	Kollam

A field survey was carried out in five main traditional black pepper growing districts of Kerala namely, Idukki, Wayanad, Kottayam, Kannur and Kollam. With the farmer's help, we selected plants that have been cultivated for years. Cultivars with the same name were also selected from different places. A minimum of three plant samples were chosen from each cultivar and the pooled data was used for analysis. Each plant sample was marked, and the morphological characteristics were observed. The morphological characters of black pepper (*Piper nigrum* L.) were observed in accordance with the IPGRI Descriptor and DUS guidelines (IPGRI, 1995; PPVFRA, 2009). The characters observed and the method employed is depicted in Table 2. A morphological relationship analysis among black pepper cultivars was also carried out based on the hierarchical cluster analysis using the SPSS method. Data obtained in this investigation was analyzed by means of a dendrogram.

Table 2. Morphological characterization of black pepper cultivars

Sl. No.	Morphological characteristics	Method used
1	Runner shoot tip colour	RHS colour chart used
2	Lateral branch habit	By observation
3	Lateral branch length	Measured using a ruler
4	Number of nodes per lateral branch	Counted manually
5	Leaf lamina shape	By observation
6	Leaf base shape	
7	Leaf margin	
8	Leaf petiole length	Measured using a ruler
9	Leaf length	
10	Leaf width	
11	Spike twisting	By visual inspection
12	Spike setting	
13	Spike length	Measured using a ruler
14	Spike peduncle length	
15	Number of spikes per lateral branch	Counted manually
16	Number of berries per spike	
17	Berry shape	By visual inspection
18	Berry size	Measured by using a vernier caliper
19	Seed shape	By visual inspection
20	Time of harvest maturity	Number of days from flowering to maximum maturity of berries were recorded

RESULTS AND DISCUSSION

For a long time, morphological characterization has been a standard method for identifying and describing distinct black pepper germplasm (Hussain *et al*., 2017; Bermawie *et al*., 2019; Prayoga *et al*., 2020). The characteristics used in the present investigation of black pepper cultivars included all parts of the black pepper plant, including the leaf, fruit, seed and shoot tips. The runner shoot tip colour of black pepper is an essential characteristic of black pepper cultivars (Ravindran *et al*., 1992).

The runner shoots observed in the selected black pepper cultivars were light green, light purple and dark purple, but majority had light purple shoot tips. Prakash *et al*. (2020) found similar results with 50 black pepper accessions. In the present study, the lateral branch pattern varied as semi-erect, horizontal and hanging. The lateral branch length and number of nodes per lateral branch were also found to be variable among the selected cultivars. Expressions of lateral branch length were short (<30 cm), medium (30-40 cm) and long (40 cm). The number of nodes per lateral branch ranged from few (< 20) to medium (20-40). The leaf and spike characteristics of black pepper are very important diagnostic characters.

The present study could establish differences among the cultivars for their leaf shape. In majority of cultivars leaf lamina shape was ovate-lanceolate and cordate, followed by ovate and ovate-elliptic. The leaf base shapes recorded include acute, round and cordate. The types of leaf margin observed among the studied cultivars were even and wavy. Cultivars with short, medium and long leaves were observed. The cultivars were classified into narrow, medium and broad based on the width of the leaf. There is almost a continuous spectrum of variation in leaf length and leaf breadth, ranging from the very small leaves of Karimunda to the large leaves of Balancotta. The length of the petiole varied from short (< 2 cm) to long (> 3 cm). Leaf characters form a major feature for cultivar identification in black pepper (Krishnamurthy *et al*., 2000). Variability was found among the cultivars for characters like spike twisting, spike setting, berry shape, berry size, seed shape, spike peduncle length, spike length, number of berries/spikes, number of spikes, number of spikes/laterals and time of harvest maturity. Twisted spikes were observed in Kottanadan, Narayakodi and Aimpiriyan. The cultivars were observed to have loose and compact setting of berries on the spike. The majority of the cultivars chosen had compact spike setting. Spike length varied as short (< 1 cm), medium (10-15 cm) and long (> 15 cm). Spike peduncle length observed to be varied as short (< 1 cm), medium (1-2 cm) and long (> 2 cm). The berry shape was round for all cultivars with the exception of the cultivars Narayakodi and Karivilanchy.

The seed shapes recorded include round and ovate. The cultivars that had oval shaped fruits had ovate shaped seeds. Fruit shape and size, although strongly associated, are less useful in cultivar delimitation, except in the case of cultivars with clearly defined characteristics, such as the oblong fruit shape of Karivilanchy (Ravindran *et al*., 1997). Three types of berries, viz., small (< 3 cm), medium (3-4.25 cm) and bold (> 4.25 cm) were observed among the black pepper cultivars in the present study. The number of berries per spikes varied from medium (25-50) and many (> 50). The selected cultivars were grouped into few (< 4), medium (4-7) and many (> 7) based on the number of spikes/lateral branch. Number of days from flowering to maximum maturity of berries varied among the cultivars. Majority of the cultivars showed medium maturity (7-8 months). Arimulak was an early maturing cultivar (< 7 months) whereas, Vattamundi and Aimpiriyan were observed to be late maturing (>8 months).

Cluster analysis plays a great role in taxonomic studies. It is helpful in determining how closely the cultivars resemble one another. In the present study, hierarchical cluster analysis was applied to a data set of 20 variables and 34 cultivars of black pepper. The association amongst different black pepper cultivars was represented by a dendrogram created using rescaled distances (Figure 1). The obtained dendrogram distinguished close genotypes. According to the hierarchical cluster analysis, the studied cultivars were grouped into four major clusters at 14 % distance on the hierarchical scale. The first cluster comprised of five cultivars (KTV1, KTV2, CPKM, BLK1 and BLK2) while, fifteen cultivars fell into the second cluster (ARM, NYK, CNGK, NLM1, NLM2, MJM, PDP, PMK, CML, AMK, VLN, WYN, NDN, NSDN and VTM).

Consequently, this suggests that there is a little morphological divergence from one cultivar to another. However, 13 cultivars were part of cluster III, showing a large amount of morphological diversity between clusters II and III. It is highly conceivable that several separate geographic and temporal locations served as the initial sites of the domestication of black pepper from forest-grown plants (Ravindran and Babu, 1988). Third cluster had KRM1, KRM2, MD, JRKM, KTN, VLYM, KRVY, KLVY1, KLVY2, AMPN, TVM, TLM and MLM. VDKN out grouped as a separate fourth cluster at a genetic distance of 25 % on hierarchical scale. The first cluster had two further subgroups with three cultivars in one subgroup and two cultivars in another subgroup at 10% distance.

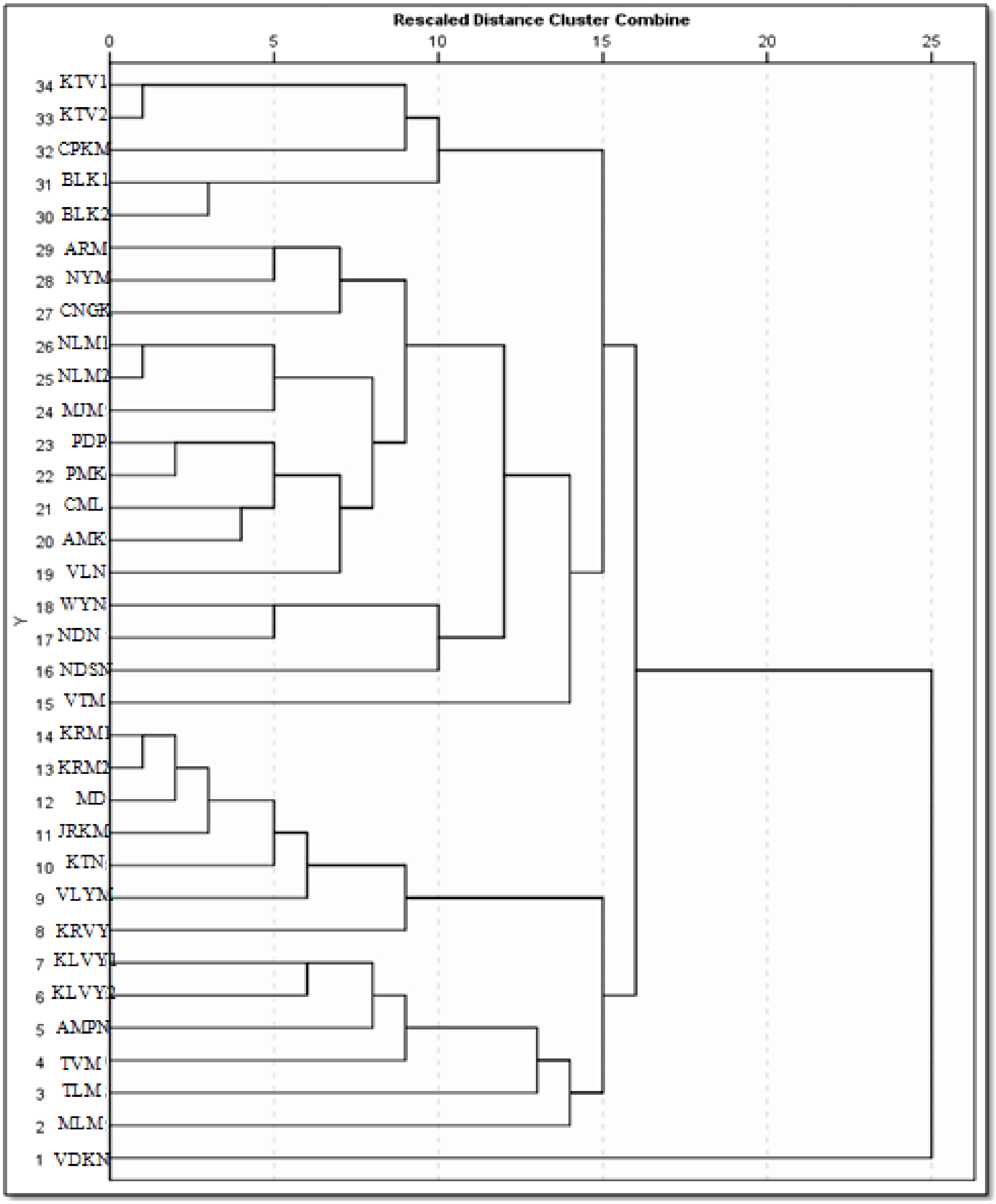

Figure1. Dendrogram of cluster analysis of Black pepper cultivars

Two cultivars (KTV1 and KTV2) in the first cluster were very close to each other and had the lowest genetic distance value, 1% on a hierarchical scale. These two cultivars known by the same name in two different places were found to be one and the same. The specialty of this cultivar is its long spike, but it is an alternate bearer. Another two cultivars (BLK1 and BLK2) were close at 3 % and they differed only in their spike length. This might be due to differences in management practices and agro-climatic conditions.

Similarly, in the second cluster, two cultivars, Arakulammunda (ARM) and Narayakodi (NYK) were close to each other and had lower genetic distance value (5 %). When comparing the characteristics of these two cultivars, everything else is the same except for the spike characteristics. Narayakodi had twisted spikes and oval berries with persistent stigma. Cultivars NLM1 and NLM2 (Neelamundi) were very close at 1% and they were also close to Manjamunda (MJM) at a genetic distance of 5 %. Hence, Neelamundi cultivars selected from Idukki and Kottayam showed the same characteristics. Both of them showed a lot of similarity to the selected Manjamunda cultivar from Kannur. CML and AMK were found to be very close at lower genetic distance (4 %). The two cultivars were similar in all other characteristics except for the shape of their leaves. The same cultivar may be known by different names in different places.

Three cultivars, VLN, WYN, and NDN, existed at 5 % on a hierarchical scale whereas, cultivar VTM had a genetic distance value of 14 % indicating that it is more divergent than the other cultivars in Cluster II. Hence, it was clear that three cultivars, namely, Vellanamban, Wayanadan and Nadan from Wayanad district, showed similar characteristics except spike length. All of them had bold berries and Nadan had long spikes (14.8 cm). In the cluster III, cultivars KRM1 and KRM2 were very similar at lower genetic distance (2 %) whereas, KLVY1 and KLVY2 were found to be closer at 6 %. Karimunda cultivar from Idukki and Wayanad districts showed slight differences in their spike length and berry diameter. Kalluvally (KLVY) plants from Wayanad and Kannur districts were more similar, which were close to Aimpiriyan (AMPN) at 8 % on hierarchical scale. All three of these had characteristic twisted spikes. Kalluvally is a promising cultivar in North Kerala and it is drought tolerant whereas, Aimpiriyan is very vigorous. Farmers might be given preference during the selection process for characteristics such as profuse and regular yielding habit, bold fruit size, and so on, rather than longer spikes (Ravindran *et al.*, 1997). The cultivar MLM was very divergent from other cultivars of cluster III at 13 % on hierarchical scale. (Krishnamoorthy and Parthasarathy, 2010) described Malamundi as a moderate yielder with medium quality. Vadakkan (VDKN) formed a separate cluster IV indicating that, it is a unique cultivar. Vadakkan is a natural polyploid (2n = 78) of black pepper with characteristic bold berries and vigorous vine. Black pepper exhibited significant variation in their plant, leaf, fruit and seed characteristics within the species. Characteristics of leaves and spikes can be taken into account for identifying cultivars. Regular bearing cultivars with long spikes, bold berries and consistent yield are popular among the farmers. In future, black pepper cultivars with these characters can be selected and used for breeding studies.

CONCLUSION

Kerala has a good diversity of black pepper. A field survey conducted in the main black pepper growing areas revealed most of the indigenous cultivars are facing extinction. In this study, black pepper cultivars showed significant variation within the species, and some of the characteristics, such as spike length and leaf shape, can be used to differentiate the cultivars. Identifying and conserving the cultivars that are on the verge of extinction can help preserve species diversity and improve varietal wealth. Regular bearing cultivars with long spikes, bold berries and consistent yield are popular among the farmers. In future, black pepper cultivars with these characters can be selected and used for breeding studies.

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An Overview of Broiler Contract Farming of Angul District, Odisha

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Contract broiler farming is the process of farming where farmers raise broilers for company with input support borne by company and is consider as a livelihood opportunity for the farmers. Farming alone is not providing sustainable livelihood to small and marginal farmers. This unorganized sector is also referred to as backyard poultry provide supplementary income in addition to ensuring family nutrition to the grower. Broiler contract farming was adopted in the villages of Angul district in Odisha. This study was carried out with 90 respondents of Angul district with a multistage sampling technique. The contract farmers were medium, small and marginal but with broiler contract farming earned benefits with a benefit cost ratio of 6.4. This study was an attempt to understand the pattern of contract broiler farming including information related facilities provided by the company, feeding practices and marketing support system.

Keywords: Poultry, Contract farming, Livelihood, Odisha

INTRODUCTION

Poultry sector was responsible to provide a massive supply of protein rich food for the world's population. Poultry meat and eggs were preferred to other kinds of animal food products for a variety of reasons in all over the globe (Alem *et al*., 2013). It was estimated that 25 % of the world's meat supply is derived from poultry, i.e., chicken, turkey, duck, geese and domesticated quail (Shahjahan *et al*., 2016). The trend has been more noticeable in developing countries like India and China in recent years. Poultry farming is getting more popular in India and China due to its increasing food demand for increasing population (Alam *et al*., 2014). The worth of Indian poultry market consisting of broilers and eggs was INR ₹ 1,750 billion in 2018 which is projected to increase up to INR ₹ 4,340 billion by 2024 i.e., growing at a compound annual growth rate of 16.2 % annually (Singh *et al*., 2017).

Broiler contract farming quite familiar in Odisha by the intervention of companies those not only provide chicks but also all necessary support with a buy back policy (Singh *et al*., 2017). Nearly 70 % of the Odisha farmers depend on agriculture for their livelihood and poultry considered as an essential part of farming system (Rajbongshi *et al*., 2020). Farmers often rear broilers and poultry for their domestic uses but now most of them had adopted the broiler contract farming. These broiler contract farming is also becoming popular among the villagers of Angul district particularly the small and marginal farmers in Odisha because adopting contract farming farmers can divert the risk associated with agriculture (Pratap *et al*., 2017; Dhakal, 2019). The district has highest broiler contract farms among other districts of Odisha but is still developing. The contract farmers don't have adequate capital and inputs and the contracting company only provides the production cost. However, the contract farmer can use the contract agreement as collateral to arrange credit with bank in order to fund inputs and the contract give the farmers a sense of security like getting a monthly salary (Bhimraj *et al*., 2018). So, the study was attempted to understand the processes and benefits of broiler farming contract system to help the contract farmers of Odisha.

MATERIALS AND METHOD

The present study was carried out in Angul district of Odisha and with purposive sampling technique and a total number of 90 responding farmers were selected randomly for the study. Then again from the district 3 Blocks were selected purposively viz., Chhendipada, Angul and Banarpal based on the secondary data source. From each block three Gram panchayats were selected and to make the complete sample size 8 contact and 2 non-contract boiler farmers were selected randomly. Thus, the total of 72 contract broiler farmers & 18 non-contract broiler farmers had selected from 3 blocks of Angul district. Relevant information was collected through personal interview schedule. *Ex-post-facto* research design was applied for the study. For the measurement of independent variables included in this study, different kinds of scales and scoring techniques developed by other researcher were used with minor modifications (Pratap *et al*., 2017; Adebwasi *et al*., 2019; Rajbongshi *et al*., 2020). The statistical tools, such as percentage, frequency, mean score, coefficient of correlation was used.

RESULTS AND DISCUSSION

The mean and standard deviation score of selected independent variable is given in Table 1.

Table 1. Mean distribution of chosen independent variables

Sn	Selected independent variable	Mean	Standard Deviation
1.	Annual income	3.34	0.50
2.	Experience in broiler farming	1.25	0.43
3.	Distance of the nearest market	2.11	0.87
4.	Size of agricultural land	2.67	0.46
5.	Total number of family members	6.31	1.44
6.	No. of members help in family farming	2.34	0.63
7.	No. of adult Male	2.0	0.44
8.	No. of adult female	2.0	0.55
9.	Others type of land (acre)	2.84	1.22
10.	Housing condition	10.02	0.79
11.	Owned Major implements	1.42	1.38
12.	Owned Minor implements	2	1.55
13.	Household appliances	3.12	0.51
14.	Communication devices	4.20	0.42
15.	Nature of participation	2.01	0.10
16.	Extend of participation	4.80	0.47
17.	Frequency of visit to nearby areas	22.78	2.13

The mean annual income of the contract broiler farmers was 3.34 lakhs whereas; experience in broiler farming of the contract broiler farmers was 1.25 years. The mean distance of nearest market from the farmer's house was 2.11 km and mean land holding was 2.67 acres. The average family size of the contract farmers was six members with average of two adult male and female members. All the family members were engaged in the activities of poultry farming. Mean score of the housing condition major and minor implements of the farmers was 10.02; 1.42 and 2.0, respectively. Mean score of the household appliances and communication devices hold by the farmers was 3.12 and 4.20, respectively. The mean score of the nature of participation and extend of participations in different organization of broiler contract farmers was

2.01 and 4.80, respectively. The mean score of the frequencies of visits to near-by areas by the farmers was 22.78.

Information related Contract Broiler Farming

The information related to contract broiler farming is summarized in Table 2. Bird capacity the farms were categorized into five groups with interval of 1000. About 79 % of the farmers reared a total of 2500-4500 birds in one lot. All the breeds of broiler get ready for selling after four week and more than 70 % of the farmers have birds of two weeks. More than half of the respondents (55.6 %) were in contract with the Suguna Poultry Farm Ltd. In other words, the Suguna breed birds were reared by most of the farmers.

Table 2. Impact on broiler farming in Angul district of Odisha

SN	Particulars	**Distribution**(N=90)	
1.	Number of Chicks /Farm	1000	4.4 %
		1500	16.7%
		2500	34.4%
		3500	27.8
		4500	16.7%
2.	Age of broiler available / farm (in weeks)	1	3.33%
		2	72.2%
		3	24.2%
3.	Chicks provided by contract Poultry Company	Pasupati group	30 %
		Suguna Poultry Farm Ltd.	55.6 %
		Sahu Poultry Farm Private Ltd.	10%
		Others (Kalimark Flavours Pvt. Ltd, Shalimar Group)	4.4 %
4	Cost of per chick (initial stage)	INR ₹ 40 (on an average)	
5	Chicks made available by	Company	78.9 %
		Self	21.1%
	Physical information of farm		
6	Size of Building	90 x 25	18.9 %
		140 x 40	13.3 %
		110 x 35	23.3 %
		70 x 50	14.4%
		80 x 40	10 %
		Others	30 %
7	Total area of farm in acre	1	26.6 %
		2	40.0 %
		3	3.3 %
		4	1.1 %
Information about feeding			
8	Amount of Synthetic food used by farm	265 Kg/day (on average)	
9	Amount of organic food Kg/day	Not in practice	
10	Number of feeding/days	4 times	
11	Feeding made available by	Self-purchased	21.1%
		Company provided	78.9%
12	Cost of synthetic feed	INR ₹ 32/ kg (on an average)	
Information about vaccination			
13	Number of vaccinations	3 (on an average)	
14	Age of chicks during vaccination	1st	1-7 days
		2nd	5-10 days or 8-21 days
		3rd	3 to 4 weeks
15	Vaccination cost	Self-purchased	22.2%
		Company provided	77.8%
Growth Period			
16	Age of chicks during selling	30 days old	1.1%

		35 days old	51.1%
		36 days old	33.23%
		37 days old	2.2%
		40 days old	12.3%
17	No. of batch in a year (on an average)	7	
18	Weight of chicks per bird (on an average)	<2.2 kg	4.5%
		2.2-2.48 kg	86.6%
		> 2.48 kg	8.9%
19	Weight of chicks per batch (on an average)	< 5438kg	22.3%
		5438-7895 kg	34.4%
		> 7894 kg	41.3%
Economics of broiler contract farming			
20	Age during selling of Broiler chicks	40 days (on average)	
21	Investment of farmer	< 2.2 lakhs	86.7 %
		> 2.2 lakhs	13.3 %
22	Total cost of production	Rs. 15,01,667 /- (on average)	
23	Income of farmer per batch (INR lakh ₹)	< 0.39	32.3 %
		0.39-1.5	47.8%
		> 1.5	19.9 %
24	Income of farmer per year (INR lakh ₹)	< 1.89	11.2 %
		1.89-2.79	24.4%
		> 2.79	64.4 %
25	Net Profit (INR lakh ₹)	2,34,444 /- (on an average)	
26	B:C ratio	6.4	
Information about marketing			
27	Payment method of farmer from contract farming	Bank	95.56 %
		Bank &Cash	4.44 %
28	Product selling in market	By self	21.1%
		By company	78.9%
29	Price/broiler at the time of marketing	INR ₹ 200	15.6%
		INR ₹210	2.2%
		INR ₹220	74.4%
		INR ₹230	7.8%
30	Transport of broiler from industry to farm	Self-arranged	21.1 %
		Company provided	78.9 %
31	Mode of transport marketing of Chicks	Two-wheeler	1.1
		Van and Truck	98.9

Availability of Chicks

Most of the chicks (78.9 %) were provided by the contract company and remaining were arranged by the farmers themselves. Generally, farmers didn't buy the chicks as company provided all the chicks. But in case of non-contract famers, all the chicks were arranged by the farmers themselves.

Building Size

Poultry shed is one of the most important investments of the broiler contract and non-contract farming. It is necessary to prepare a spacious farm for adequate growth and development of the chicks. Area of most of the sheds was 110 feet x 35 feet (23.3 %) which can adjust about 2500 chicks comfortably. The shed was roofed with asbestos. The sheds were constructed within the land holding of the farmer. The land holding of the respondents varied in the range of 1-4 acres.

Feeding and Vaccination

The farmers on an average were using 265 kg per day synthetic feed and no organic foods were fed to the birds (Table 2). The frequency of feeding was 4 times a day with ensured water supply. On an average, the cost of the synthetic food per kg was INR ₹ 32. The farmers vaccinated their chicks thrice i.e., first vaccine was after a week of starting a lot to week old chicks, 2nd vaccine to 5-10 days old chicks and final vaccine at 3-4 weeks old chicks. Entire feeds, vaccination and medicines were provided by the contract company but non-contract farmers arranged these inputs feeds.

Disposing the Chicks

The birds become marketable after 30-40 days (Table 2). Most of the birds (51.1%) were sold when 35 days old. On an average seven batches of were reared annually. The average body weight of marketed birds during varied from less than 2.2 kg to more than 2.48 kg but mostly the birds weighed in the range of 2.2-2.48 kg.

Investment and Income

Majority of the farmers invested below INR ₹ 2.2 lakhs (Table 2). The contracting company provided the chicks free of cost to the contract farmers but at an average cost INR ₹ 40 for a chick to the non-contracting farmers. Most of the farmers earned INR ₹ 2.79 lakhs a batch after selling the birds with net average profit of about INR ₹ 2.3 lakhs. The benefit-cost ration was 6.4 i.e., the farmers more than six time of what they invested. The farmers were paid either directly by cash or the amount deposited in their bank account. The non-contract farmers sell their broilers in the local market. The selling price of broiler varied from INR ₹ 200 to INR ₹ 230 a bird. The contract farmers get a higher price for their birds than the non-contract farmers i.e., INR ₹ 230 a bird. The contract company procure the birds from their contract farmers i.e., with no liability of transportation cost on the farmers whereas; the non-contract farmers arrange their own transportation to sell their birds in the market

CONCLUSION

Broiler contract farming is a profitable venture as the contracting company provide entire inputs to the farmer with regular technical guidance and support which is not the case for non-contract farmers.

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Impact of Forest Fire on Forest Ecosystem

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Fire is a common hazard in forest which plays an important role in shaping a community with its ecosystem components. Recent fire records show an increasing trend in fire incidents with manipulated fire regime due to anthropogenic activity. Changes in the fire regime cause a negative impact on forest vegetation and ecosystem process. Broad range of literature on forest fire ecology gives information on the characteristics of fire effects on vegetation cover, composition, density and functions of forest ecosystem for better management of ecosystem and its process. Understanding the patterns of effects of forest fire on forest ecosystem will help to critically reduce the risk of unpredicted wildfires and suitable use of fire as a forest management tool. This review is a synthesis of impact of forest fire on forest ecosystem, effect on vegetation, soil, water and air relations closely discussed with priority on fire as a major cause. Fire can clearly alter the vegetation composition, density, diversity by encouraging fire adapted species, change the soil properties through addition of ash and changing the nutrient level, change the water quality through addition of chemicals. Effects of fire depend on the fire regime, climate and vegetation type.

Keywords: Forest fire, Fire regime, Forest ecosystem, Vegetation, Soil, Water

INTRODUCTION

Fire is a major ecological event that affects a substantial proportion of the world's terrestrial ecosystems across a wide range of regions and biomes (Bond and Keeley, 2005; Certini, 2005; Kutiel, 2012). The severity and frequency of fire seasons are expected to rise globally by the end of the century, especially in the northern latitudes (Flannigan *et al.,* 2013). Forest fire effects are influenced by ecosystem properties like fire sensitive versus fire adapted ecosystem and fire regime like intensity and duration (Archibald *et al*., 2013). Fire productivity hypothesis is linking the fire activity into productivity and aridity gradient imposed by the location climate, in which claiming less conducive of fire activity at the both end of the gradient, either due to a discontinuous fuel (high aridity ecosystem) or excess moisture (highly productive ecosystem) (Krawchuk and Moritz, 2011; Pausas and Ribeiro, 2013). Furthermore, this connection may be altered by plant features, making the flammability threshold of a particular ecosystem context sensitive (Archibald *et al.,* 2013; Pausas and Paula, 2012). Wildfires are emphasised as major negative disturbances in terrestrial ecosystems like forest and woodlands (Thom and Seidl, 2016). Fire can burn enormous biomass, change soil properties (Mataix-Solera *et al*., 2011), effect on major ecosystem process, affecting biochemical (Santín *et al*., 2015, 2016) and hydrological cycles (Shakesby and Doerr, 2006). Alteration in these processes can influence soil erosion, runoff, soil fertility, water quality and air quality (Shakesby, 2011; Caon *et al*., 2014; Vieira *et al*., 2015).

Forest fire has traditionally been an essential mechanism in generating ecological succession by acting like an environmental filter, selecting species and shaping ecosystem communities (Parashar and Biswas, 2003; Satendra, 2014). However, recent decades witnessing frequent fires with high intensity can cause permanent changes to the ecosystem and its components (Cha *et al.,* 2020). To achieve successful and appropriate fire and land management, a better knowledge of the effects of fire on ecosystems is required, including the impacts of both wildfires and controlled burns (Pausas and Keeley, 2019). In this context current review critically focus on impacts of forest fire on forest ecosystem, its impacts on vegetation with regional forest types, impacts in soil and water of the forest ecosystem.

CAUSES OF FOREST FIRE

Anthropogenic activities are directly altering the fire regimes through new ignition patterns and fire suppression from encroachment in the recent decades (Moritz *et al.,* 2014). Increased forest fragmentation (Potapov *et al.,* 2017; *Hansen et al.,* 2020) and degradation (Ghazoul *et al.*, 2015) due to anthropogenic activities declining the resilience of forest to fire (Cochrane, 2003; Xu *et al.,* 2020) as it changes the fire regime critically. The factors that cause forest fires can be classified as natural or anthropogenic and the World-Wide Fund (WWF) report 2020 states that humans are directly responsible for 75 % of forest fires through road construction, conversion of land to agriculture, urbanisation, and domestic livestock grazing (Figure 1).

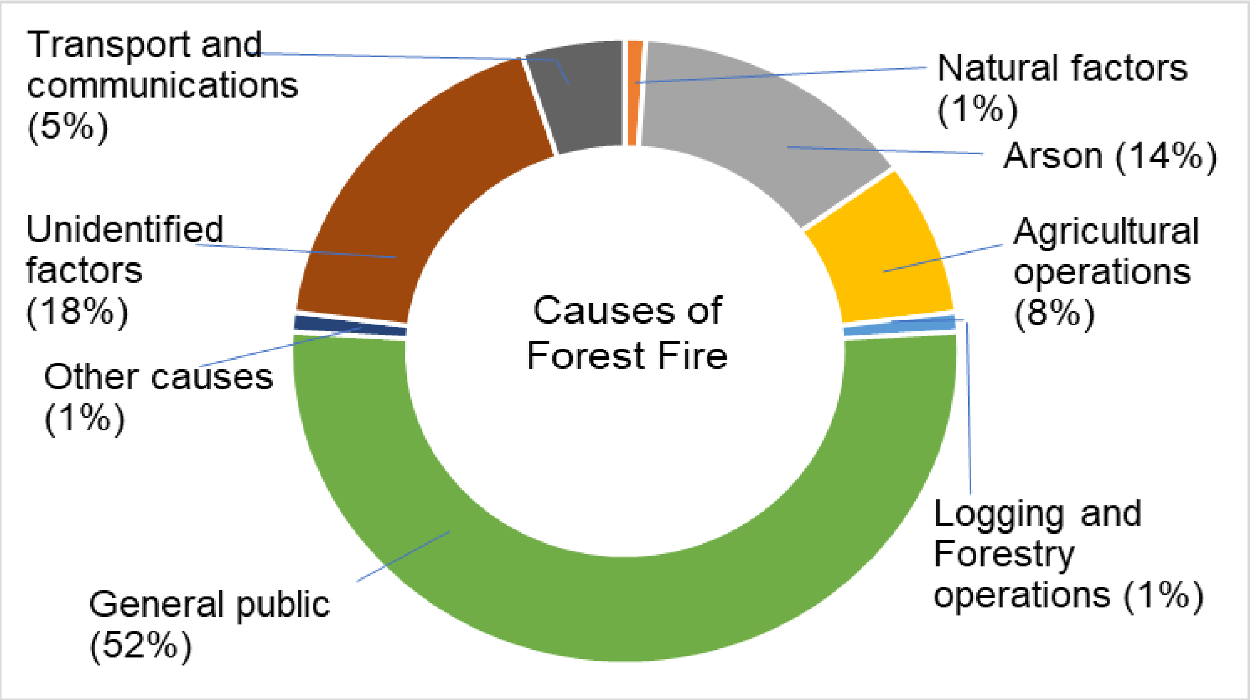
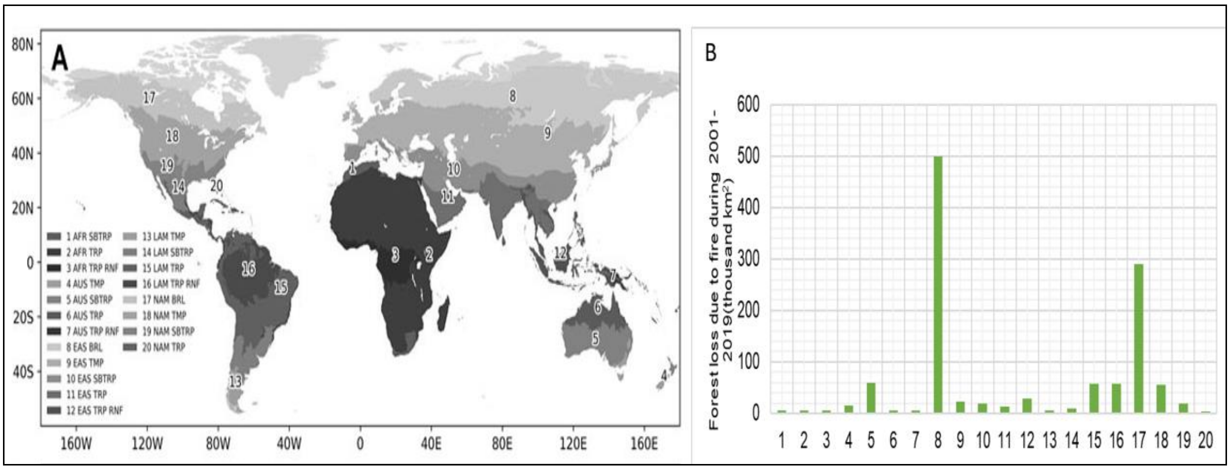


Figure 1. Causes of forest fire

TRENDS IN FOREST FIRE

During 2001-2019, 119 million hectares (27 %) of tree cover were lost globally due to fires while, 318 million hectares lost due to all other causes of loss. Russia recorded with highest tree cover loss (50 M ha) due to fires during 2001-2019 (Figure 2, Tyukavina *et al.,* 2022). Also, 2016 is marked as the year with highest tree cover (9.61 M ha) loss due to fire (Tyukavina *et al.,* 2022). Dominant individual forest fire during past decade was recorded in Australian region by burning around 24 M ha in a fire event (Table 1). India reported with 3,45,989 forest fire events during November 2020-June 2021 with Odisha (51,968) recorded the highest fire event followed by Madhya Pradesh (47,795), Chhattisgarh (38,106), Maharashtra (34,025), Jharkhand (21,713) and Uttarakhand with 21,487 events (Anon., 2021b).



1=AFR SBTRP, 2=AFR TRP, 3=AFR TRP RNF, 4=AUS TMP, 5=AUS SBTRP, 6= AUS TRP, 7=AUS TRP RNF 8=EAS BRL, 9=EAS TMP, 10=EAS SBTRP, 11=EAS TRP, 12=EAS TRP RNF 13=LAM TMP, 14=LAM SBTRP, 15=LAM TRP, 16=LAM TRP RNF, 17=NAM BRL, 18=NAM TMP, 19=NAM SBTRP, 20=NAM TRP. AFR: Africa, AUS: Australia and Oceania, EAS: Eurasia, LAM: Latin America, and NAM: North America

Figure 2. Forest loss due to fire between 2001 and 2019 (modified from Tyukavina *et al.,* 2022)

Table 1. Prominent forest fires in the world from past decade (Source: Anon., 2021a)

Rank	**Name**	**Country**	**Area burned (Km^2)**
1	2019-2020 Australian bushfire season	Australia	240,000
2	2021 Russia wildfires	Russia	200,000
3	2019 Siberia wildfires	Russia	43,000
4	2014 Northwest Territories fires	Canada	34,000
5	2009 Black Saturday bushfires	Australia	21,000
6	2020 California wildfires	United States	18,000
7	2010 Bolivia forest fires	Bolivia	15,000
8	2011-2012 Australian bushfire season	Australia	14,000
9	2006-2007 Australian bushfire season	Australia	13,000
10	2017 British Columbia wildfires	Canada	12,000

IMPACTS OF FOREST FIRE ON FOREST ECOSYSTEM

On Vegetation in Regional Forest Type

Forest fire can affect vegetation cover, structure, density, diversity, composition and productivity (Cochrane and Laurance, 2002) since some species have thick bark, resprouting ability and fast colonization nature after fire as an adaptation to survive fire conditions (Abrams, 1992; Peterson and Reich, 2001). But these vegetation characteristics and adaptations are regional specific and they are provided according to their nature of ecosystem.

Tropical rain forest

Historically rain forest is safe from high severity wildfires due to their high moisture content in the ecosystem, which diminishes the frequency of wildfires (Cochrane, 2003). Majority trees are having thin bark and fire sensitive since thicker bark increases the fire resistance (Pinard *et al.,* 1999; Eriksson *et al.,* 2003). After a fire event tee species recovery takes more time while, it favours higher density of herbs, vines (Pinard *et al.,* 1999) and ferns. Fire may affect the forest structure and biomass accumulation which may recover after ecological succession. Overall, fire decreases the density and biomass of dominant tree species in tropical rain forest (Fig. 3a-b; Holdsworth and Uhl, 1997; Cleary and Priadjati, 2005), although some species get dominance after a fire event which has vigorous resprouting ability (Goldammer and Seibert, 1990).

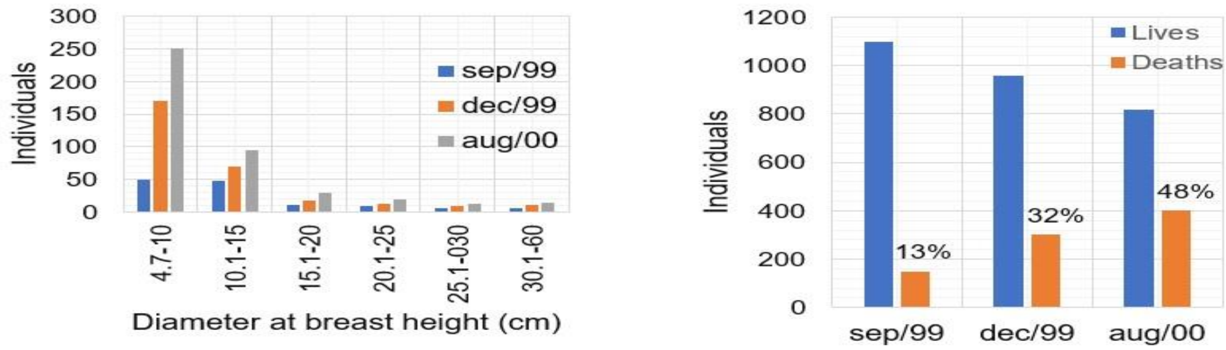


Figure 3. Affect of forest fire total dead individuals (a) and tree population before and after fire (Modified from Ivanauskas *et al.,* 2003)

Dry deciduous tropical forest

Surface fires with low intensity are very common in tropical dry deciduous forest during dry season than any other forest in the world (Janzen, 1988; Slik *et al.,* 2008). The tropical dry deciduous forest has suffered the most forest fires in India followed by the tropical wet deciduous forest and the tropical semi-evergreen forest (Anon., 2012). Under frequent forest fires, exotic species dominate the forest (Hiremath and Sundaram, 2005; Anon., 2011). Over time, regular fires transform forests into scrub vegetation and grasslands (Cochrane, 2003; Barlow and Peres, 2004). Species such as *Cassia fistula*, *Chloroxylon swietenia* and *Dolichandrone atrovirens* will dominate because they can resprout very quickly.

Mediterranean forest

Mediterranean ecosystems are characterized as fire prone due to its dry and hot climate (Hernández *et al.,* 1997; Vila-Escalé *et al.,* 2007) as well as dry fuel load (less decomposition rate). Understory fires are being rare, dominated by high intensity burning. However, their adaptation and resilience to these fires are well recorded (Whelan, 1995; Calvo *et al.,* 2002). Californian *Adenostoma fasciculatum* have domination with high resprouting capability after wildfire. Overall, there is a substantial association between community resilience and the incidence of fires in Mediterranean ecosystems. In general, fire-sensitive species are uncommon in these habitats (Lloret *et al.,* 2005).

Temperate deciduous forests

Usually, low intensity understory fires are in temperate deciduous forest, playing important role in dynamics of forest (Pyne, 2017). Fire frequency maintain the balance among shade-intolerant plants like oak and aspen (early successional) and species like linden, sugar maple and beech (late successional). Fire frequent areas were dominated by oak and aspen (Grimm, 1984; Abrams, 1992). From 19th century, stand replacing fires were introduced due to high exploitation which resulted in a decline of regeneration in oak and replaced by mesophytic species (Brose *et al.,* 2001; Ruffner and Groninger, 2006).

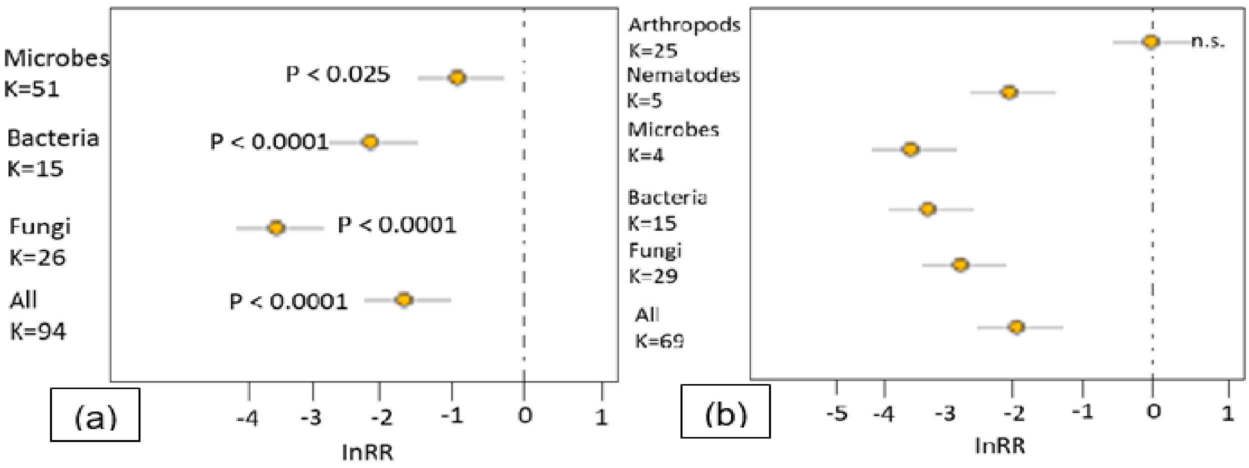
Boreal forests

Vegetation dynamics after a fire in boreal forest is controlled by species composition before fire, seed availability (Johnson, 1992; Sirois, 1995), surface deposit (Sirois, 1995; Kemball *et al.,* 2005), competition, fire frequency and intensity (Kasischke and Johnstone, 2005; Johnstone and Chapin, 2006; Greene *et al.,* 2007). Greater fire frequency promotes shade intolerant and early successional species (*Betula papyrifera* and *Populus tremuloides*) and fire adapted species like *Picea mariana* and *Pinus contorta* (Johnstone and Chapin, 2006). Increased fire frequency in eastern Canada's spruce-moss forests has caused transition from dense forests to open woodlands during the last 50 years (Girard *et al.,* 2008).

On Soil

Fire has the capability to significantly alter the soil properties during fire (directly) and post fire recovery period (indirectly) (Bodí *et al.,* 2014; Mataix-Solera *et al.,* 2011). Heat generated by the burning of biomass and dry necromass, as well as the burning of dead and living organic matter of the soil, has a direct influence on soil properties (Mataix-Solera *et al.,* 2011). Forest fire alter physical (McColl and Grigal, 1975; Startsev *et al.,* 2017), chemical (Lukina *et al.,* 2019) and biological (Schoch and Binkley, 1986; Daniel, 2005; Singh, 2016) properties of the soil.

Lower severity forest fires alter the soil chemical properties by increasing the total nutrient pool on a site (organic carbon, nitrogen, calcium, potassium, and magnesium ions) in absents of erosion. Medium to high intensity fire may decrease the organic carbon and nitrogen content due to their lesser threshold temperature to volatilisation and convection (DeBano *et al.,* 1998; Alcañiz *et al.,* 2018). Change in physical properties after a forest fire include soil structure degradation due to addition of ash in the soil pores, water repellence enhancement due to the volatilisation of hydrophobic substance into the deeper soil according to temperature gradient and these two factors cause a reduction in soil infiltration causes an increased runoff and soil erosion (Shakesby and Doerr, 2006; Shakesby, 2011). Biological property of the soil is mainly determined the microorganism present in the soil, fire can affect the mortality of microorganisms (Figure 4 a-b) and thus changing the biological properties of soil (Dunn *et al.,* 1985; Klopatek *et al.,* 1988). Macrofauna have high mobility and burrowing capacity is less affected by fire.



Ln RR is the estimated overall effect size ± SE from Meta regression model; k is the number of observations included in each analysis

Figure 4. Effect of fire on soil biota biomass (a) and abundance (b) (modified form Pressler *et al.,* 2019)

Impact of Forest Fire on Water

Forest catchments are managed for potable water as it is an important source of water for the communities. Precipitation flowing a fire event increases the surface runoff (Fernandes *et al*., 2020; Thomas *et al.,* 2021) due to decrease in infiltration capacity (Klopatek *et al.,* 1988; Rust *et al.,* 2018; Rhoades *et al.,* 2019), increase in fluid density and absence of vegetation which will incorporate sediments in forms of ash (Cannon, 2001; Gabet and Sternberg, 2008) that increase the turbidity (Horowitz and Elrick, 1987; Ongley *et al.,* 1992) as well as water temperature of rivers and lakes and affect the water quality. Increased turbidity decreases the light penetration to the lower depth of laker and rivers which affect the photosynthesis of vegetation in lower depth. Increased water temperature initiates thermal pollution in lakes and rivers which can increase the biological activity of lake that may result in increased biological oxygen demand (DeBano *et al.,* 1998; Aregai and Neary, 2015) and decreased dissolved oxygen (Silins *et al.,* 2014), affects badly the aquatic faunal survival and population. Further, forest fire increases the nutrient concentration of lakes and rivers (Chorover *et al.,* 1994; Aregai and Neary, 2015) through the ash deposit (Aregai and Neary, 2015). Low intensity fire increases the organic carbon (Minshall *et al.,* 2001; Mast and Clow, 2008), nitrogen (Stednick, 2000), phosphorus (Lane *et al.,* 2008; Mast and Clow, 2008; Blake *et al.,* 2009) and total dissolved solids (Lathrop, 1994; Gerla and Galloway, 1998). Fire retardants used during fire suppression contain nitrogen compounds affect the water quality and aquatic life very badly (Kalabokidis, 2000; Gimenez *et al.,* 2004).

On Air Quality

Forest fire burns the ground vegetation as well as standing vegetation which release CO_2, CO, CH_4, NO, NO_2, other hydrocarbons and particulate matter (Liu *et al.,* 2016). Forest fire release the long-stored carbon inside the wood and soil within a matter of time contributing immensely to global warming (Langmann *et al.,* 2009).

MANAGEMENT OF FOREST FIRE

Fire is an essential component of the forest, and fire control is an essential part of forest management (Singh, 2016). The practise of planning, preventing, and fighting fires to safeguard people, property, and forest resources is known as fire management (Anon., 2014). Forest fire management involves a cycle of events which are fire prevention, fire detection, fire suppression and post fire management (Figure 5).

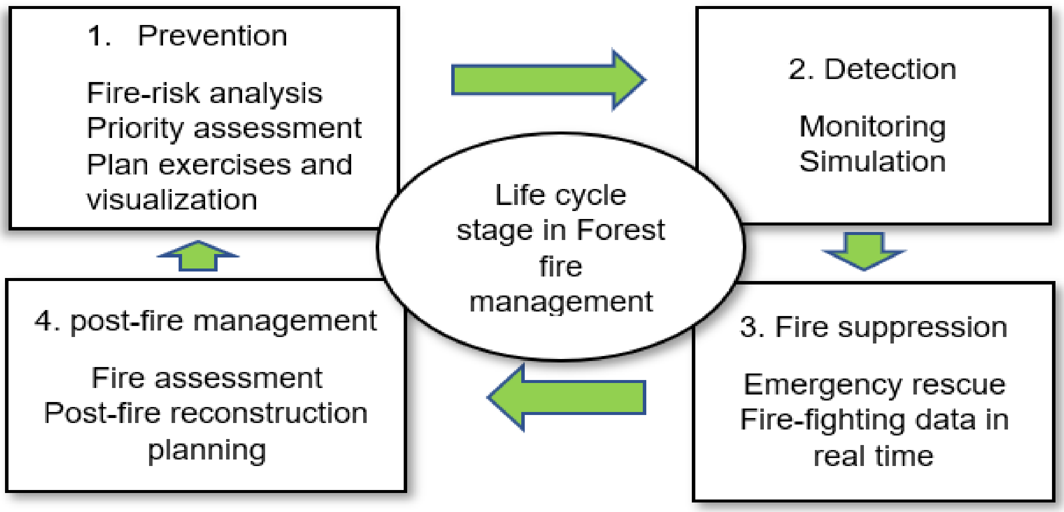


Figure 5. Life cycle stage in forest fire management (adapted from Neal, 1997)

As an important preventing measure, sophisticated and real time early warning systems should be used to map fire prone area (Chandra and Bhardwaj 2015). In India, Forest survey of India (FSI) is responsible for the early warning and detection of forest fire. FSI has FFDRS (Forest Fire Danger Rating System), which map fire prone area according to Fire Weather Index (FWI) and they share information to all responsible officials every Thursday which is valid for a week. Other prevention methods are prescribed burning, installing watch tower, demanding a positive law and policy towards forest fire activities and training Joint Forest Management (JFM) and NGOs for fire fighting. Fire detection by FSI in India is done by latest sensors- MODIS and SNPP-VIIRS which has a resolution of 375 m x 375 m (Figure 6). Fire detection data created through these sensors were shared with the officials by email and text message to take further actions. Fire suppression is carried out according to the severity of fire. Low intensity fire is suppressed through direct intervention using standard fire fighting equipments while, moderate and high severity fire is suppressed through indirect intervention using helicopters and aeroplanes for aerial spray of fire retardants and foams. Post fire management is done by arresting soil erosion (Fernández *et al.,* 2019; Caon *et al.,* 2014) through installation of erosion barriers and restoration and rehabilitation of area by naturally or assisting vegetation (Fernández-Fernández and González-Prieto, 2020).

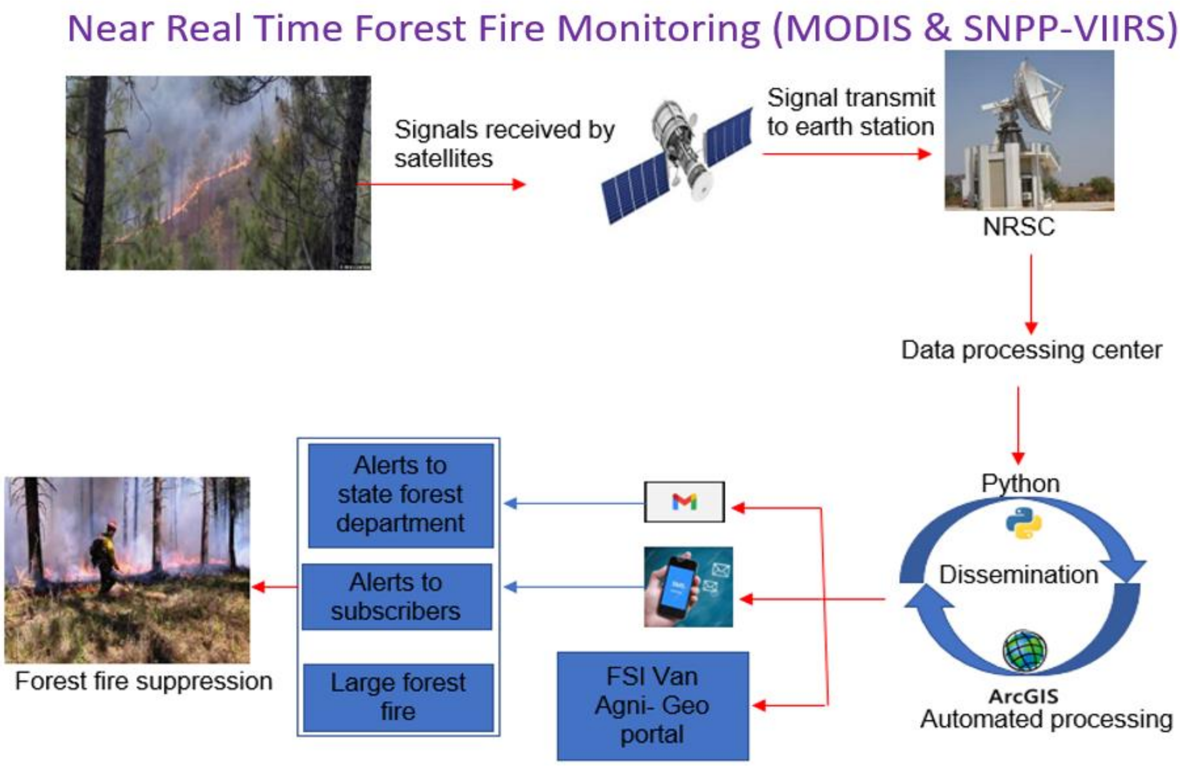


Figure 6. Fire detection using MODIS and SNPP- VIIRS (Anon., 2020)

CONCLUSION

Forest fires are natural ecological factor in forest ecosystem that can shape forest composition and structure. Increased anthropogenic activities in recent decades immensely contributed in changing the fire regime and enhancing the fire events that drastically effect vegetation, soil, water and air. Vegetation recovery after a fire event depends upon the resprouting ability, thick bark establishment from viable seeds that buried in soil or canopy. High intensity fire has a negative impact on forest soil and water. Manipulated fire regime force a greater investment in fire prevention, detection, suppression and recovery. In current scenario, forest fire events are increasing which had a serious effect on forest ecosystem, which needs to be studied and management aspects be improved accordingly.

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Effectiveness of a Protected Cultivation Video Documentary on Farmer's Behaviour in the Shivalik Himalayas

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The present study was carried out in Nainital district of Uttarakhand. A total of 80 respondents were selected from four villages of two blocks in proportion to their population using probability proportionate to size method. Effectiveness of video was measured in terms of gain in knowledge using pre-test and post-test analysis. The post-test scores of all respondents were significantly higher than the pre-test scores. The designed video on protected cultivation had significant effect on gain in knowledge. The pre - exposure mean knowledge score was 6.063 and the mean knowledge score of the post-exposure stage was 14.238. The mean score of difference was found to be 8.175. Response of the respondents on quality assessment of video revealed that video has normal speed of delivery (52.5 %), full understandable language (51.25 %), full adoptability of message (51.25 %) and full clarity of vision (53.75 %).

Keywords: Video, Protected cultivation, Quality assessment, Knowledge gain

INTRODUCTION

The effectiveness of an extension program is based on its ability to effectively communicate. Different factors affect efficacy of the communication (Ali, 2012). The decision of a communication channel or technique, usually referred to as an extension method, is one of the considerations. Communication is successful when the appropriate extension techniques are chosen, combined and used. In agriculture, videos may be used to increase awareness and generate demand for farmer-to-farmer extension, training on agriculture innovation (Sousa *et al*., 2019)

Video is appropriate extension tool combines both visual and verbal communication. The attractive tool is extensively used in present scenario to disseminate the information and transmission of skill and knowledge (Vidya and Chinnaiyan, 2010). It allows the standardization of information for accurate transmission from a technical source, in situations where high quality trainers may not be available, and is suitable for low literacy population in developing countries (David and Asamoah, 2011). Globally, video catalyzing the effective knowledge transfer to societies in rural areas. Using video as a tool for dissemination of agricultural information is just one among the many initiatives aimed at enhancing farmers' access to and utilization of agricultural information. However, video is not commonly used in agricultural knowledge dissemination (Tumwekwase, 2013). Video is used more in entertainment than extension services. Video has advantages in rural areas because it does not require face-to-face presentation by skilled trainers. Video might be an attractive alternative or supplement if the production cost is low enough, or if conventional lecture/demonstration cannot meet the demand for training. Using local actors, video shooting in the local environment and using local languages enhance the effectiveness of video for training purposes. When used to demonstrate a farming technique or practice in a group setting, videos were found to enhance interaction (discussion and peer learning) among farmers (Cai and Abbott, 2013). Video is a powerful medium that can be produced at low cost and could be potential to reach a mass audience. The power of moving images to inform, educate and entertain has long been recognized, but only since digital video equipment became widely available has the technical process of producing video become less complicated and more accessible.

The potential of video as a tool for agricultural extension has to be evaluated. Therefore, it is necessary to evaluate the applicability of video, the extent to which it improves message retention and use, as well as the potential and constraints of utilizing video as a medium for information transmission. In the present scenario there are very less studies that examine the creation, testing, and efficacy of the video (Selvaraj, 1997; Campenhout *et al*., 2017). In this study, we create awareness among farmers about the cultivation of off-season vegetables under protective cultivation of vegetable production in poly or plastic houses to increase the income of farming communities. Changing the attitude of farmers by creating awareness and empowering them by providing skills is an important component of agricultural extension (Minh *et al*., 2010). Therefore, to understand the farmer's behaviour on designed video was examined through knowledge gain. An effective analysis of a crop cultivation video based on behaviour and response of farmers is directly related to their knowledge. The region where limitations of wider communication gap in agriculture extension to overawe the production problems of a large majority of small farmers there is a hysterical search for alternative approach to develop useful technologies.

MATERIAL AND METHODS

Locale of the study

Nainital District of Kumaon region was selected as the locale of study. Nainital is situated in the sub-Himalayan region of Uttarakhand. The district is most heterogeneous and divided into three distinct regions *viz*., Hill, *Bhabar, and Terai*. Geographically, the district is situated between 29°05'N and 80°14'E to 29°33'N and 78°80'E. The key considerations for the selection of study of locale were highest vegetable production in the district. The selection of study of locale was based on researcher's convenience and time, limited resource use and familiarity with the environment.

Sampling Design and Selection of Respondents

Nainital district is comprised of eight blocks (Betalghat, Bhimtal, Dhari, Haldwani, Kotabagh, Okhalkanda, Ramnagar, and Ramgarh). Out of which two blocks namely Kotabagh and Bhimtal were selected through simple random sampling using chit method. Kotabagh and Bhimtal blocks comprise 108 and 115 villages, respectively. For each block two villages were selected through simple random sampling using chit method. The statistical details of the selected villages are given in Table 1.

Research Design

Experimental research design comprising pre-test and post-test one group design was used in the study (Table 2). The study seeking to test the effectiveness of video with respect to gain in knowledge of respondent on protected cultivation of vegetables. Pre-tests were administered to each of the four chosen groups of responders. Each group received treatment after the pre-test was administered. All groups had post-tests immediately following the treatment.

Characteristics of the Video

A 12 minutes video documentary in Hindi on *'Greenhouse Nirman Ewam Poudh Ropan'* i.e., *'Construction of green house and planting'* with instrumental music at a rural setting located at Vegetable Research Centre of G. B. Pant University of Agriculture & Technology, Pantnagar.

Gain in Knowledge

Gain in knowledge was determined by the respondent's overall knowledge score, which is calculated by subtracting the respondent's post-test score from their pre-test score. Knowledge is the whole amount of comprehended knowledge that a person possesses. The information may also be referred to as a person's corpus of comprehended knowledge (Li *et al*., 2006; Graesser *et al*., 2009). Gain in knowledge refers to the increased in knowledge of respondents as a result of exposure from message treatment (X_1). The farmer's knowledge was assessed using an open-ended knowledge test regarding protected agriculture. The gain in knowledge was calculated by following formula:

Gain in knowledge = $X_2 - X_1$

Where, X_1= Test score in pre-exposure test, X_2= Test score in post exposure test

Table 1. Demographic details of the villages

Particulars	**Blocks**			
	Kotabagh		Bhimtal	
	Villages			
	Somjala Narsingh	Sonjala Naya Abad	Bhaluty	Sariyatal
Population*	339	300	574	300
Male	163	150	291	160
Female	176	150	283	140
Families	70	48	121	54
Distance from university (km)	70	60	50	50
School	2	-	1	1
Anganwadi	1	-	-	1
Hospital	1	-	-	1
Bank	-	-	-	-
Cooperative society	-	-	-	1
Market	-	-	-	-

***The total population of selected villages was 1513 out of which only 5 per cent (n = 80 respondents) of them were selected through PPS methods.**

Table 2. Research design of the study

Pre-test	**Villages**	**Treatment**	**Post-test**
Random observation of X_1 (pre-test) was taken.	Sariyatal (V_1) Bhaluty (V_2) Sonjala Narsingh (V_3) Sonjala Naya Abad (V_4)	Designed video on protected cultivation (X_1) was used.	Post-test observation of X_1 was taken.

Statistical Analysis

The difference among respondents in terms of knowledge gain and effectiveness of protected cultivation video was subjected to paired 't' test or dependent sample 't' test to accept and reject hypothesis (Snedecor and Cochran 1989). Null hypothesis (H0: P1 = P2) = Respondents have same knowledge in pre- and post-knowledge test. Alternative hypothesis (H1: P1 < P2) = Respondents have higher post-knowledge scores than pre-knowledge scores.

RESULTS AND DISCUSSION

Effectiveness of Video in terms of Knowledge Gain

Effectiveness of protected cultivation video was measured in terms of gain in knowledge. The pre-test mean of 80 respondents score was 6.063. After post-test or application of treatment (X_1) the mean difference in knowledge gain score was 8.175 (Table 3). The significance difference ($P < 0.05$) in pre- and post-test analysis, the calculated value of 't' was higher than the tabulated value. Thus, null hypothesis that respondents have same knowledge in pre- and post-knowledge test is rejected and alternate hypothesis that respondents have higher post knowledge scores than pre-knowledge scores is accepted. The mean score of difference was found to be 8.175. It has also been supported by the 't' value of 31.729* which was found to be statistically significant.

Table 3. Effectiveness of video programme (n = 80)

Mean of pre-test	Mean of post-test	Mean of difference	Variance in difference	't' cal	't' tab
6.063	14.238	8.175	2.377	31.729*	1.99

***Significant at 5% level, 't' tab (5%) = 1.99**

The respondents had significant effect on the level of knowledge regarding protected cultivation. The documentary was determined to be the most efficient for disseminating knowledge relevant to dairy health management practices because it combines visual and verbal communication approaches (Vidya and Chinnaiyan, 2010; Campenhout *et al*., 2017)

Response on Quality Assessment of Documentary

The quality of the documentary was determined by the content of the message and presentation which influences effectiveness of the video programme (Hanjalic and Xu, 2005) presented in Table 4.

Table 4. Responses on quality assessment of video

Aspects	Frequency	Per cent
Back ground music		
a. Appropriate	33	41.25
b. Inappropriate	47	58.75
Duration of the programme		
a. Too long	11	13.75
b. Normal	43	53.75
c. Too short	26	32.5
Clarity of voice		
a. Fully clear	46	57.5
b. Partially clear	34	42.5
c. Not at all clear	-	-

Music usually brings liveliness to any video programme but with respect to video on agriculture, majority of the respondents felt the music was inappropriate (Table 4). They were of the view that giving unnecessary music to such educational documentary diverts away their mind from the original content. However, about 45 % respondents doesn't think so, they believed the music was 'appropriate'. More than half of the respondents (53.75 %) felt that duration of the documentary is 'normal' while, others felt either it was 'too short' or 'too long'. Majority of the respondents (57.5 %) declared that audio of the documentary was normal with clarity in voice but remaining respondents found the audio 'partially clear'. With regards to the speed of delivery of content in the documentary, it was normal for more than half of the respondents (52.5 %) but remaining others found it either fast or slow (Table 4). The effective dissemination of technology through video documentaries ultimately depends on its quality of presentation with technical quality as well where respondents can understand the content easily and can replicate the technology (Hanjalic and Xu, 2005).

Effectness of Video

We examined the speed of delivery, clarity of language, adoptability of message and clarity of vision of protected cultivation video. Majority of the respondents (51.25%) clearly understood the content of the documentary while, about 44 % of the respondents understood it partially and only 5 % of the respondents didn't understand the language of the documentary (Table 5). On clarity of vision about the documentary video, majority of the respondents (53.75 %) were 'fully clear' on visual while, remaining respondents felt that they were 'partially clear'. However, the documentary was adaptable to all the respondents but the degree of adaptability was near about 50-50, i.e., about half of them adapting fully and rest partially. Differences in opinion of respondents directly related to knowledge gap theory that could be probability of reducing or minimizing differences between people (Corley and Scheufele, 2010; Mocumbe, 2016). The process of assessment of self-developed programs providing effective extension and advisory services involves much more than technical solutions (Manfre *et al*., 2013).

Table 5. Responses on effectiveness of video

Aspects	Frequency	Per cent
Speed of delivery		
a. Fast	22	27.5
b. Normal	42	52.5
c. Slow	16	20
Understanding of language		
a. Fully understandable	41	51.25
b. Partially understandable	35	43.75
c. Not understandable	4	5
Adaptability of message		
a. Fully adopted	41	51.25
b. Partially adopted	39	48.75
c. Not adopted	-	-
Clarity of vision		
a. Fully clear	3	53.75
b. Partially clear	37	46.25
c. Not clear	-	-

CONCLUSION AND RECOMMENDATION

A short video shown to the respondents had significant effect on the level of knowledge pertaining to protected cultivation of vegetable. The designed video was effective in increasing the knowledge level of the respondents. The protected cultivation video could be improved and made more effective by plummeting the use of English and difficult words and long sentences. In addition to this, speed of delivery, visual clarity, and commentary synchronization are important aspects for video to attract the farmers. The present study can be replicated on a larger sample to increase its popularity. Similar video film can be prepared on other subject or topics in agriculture, fisheries, agroforestry, home science and veterinary for extension programs.

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Agro-Morphological Diversity of Clove in India

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Clove i.e., *Syzygium aromaticum (L.)* Merr & Perry of the Myrtaceae family is a widely traded spice for the dried aromatic fully grown unopened flower buds and is one of the most expensive spices in the world. Clove is native to the Moluccas Islands of Indonesia and was introduced to India in the 18th century. However, no further enrichment of clove germplasm has taken place in the country. Thus, the variability of clove in India is limited and its autogamous nature also limits the extent of variability. This paper was aimed at reviewing the studies on the morphological diversity of clove in India. In India, research on clove is limited, and thus no improved varieties exist. From the few studies, there is sufficient diversity of clove in India both for qualitative as well as quantitative characters. Those can be used for further breeding studies. High yielding clove trees producing large-sized flower buds with a dwarf bushy nature can be utilized in breeding programmes. Exploring and preserving the clove germplasm is one method for creating commercial clove varieties.

Keywords: Clove, Genetic diversity, Conservation, India

INTRODUCTION

The clove of commerce comprises unopened flower buds of the clove tree, *Syzygium aromaticum* (L.) Merr. & Perry, which belongs to the family Myrtaceae. The genus *Syzygium* contains more than 500 species, but *Syzygium aromaticum* (L.) Merr. & Perry is the only commercialized aromatic spice. The important species of *Syzygium* that occur in the Indian subcontinent are *S. aromaticum, S. cumini, S. fruticosum, S. jambos* and *S. zeylanicum*. But the cultivated *Syzygium aromaticum* is not very close to any of these species (Sasikumar *et al*., 1999). Clove has been employed for centuries as a food preservative and as a medicinal plant because of its antioxidant and antimicrobial activities. Clove buds, a common source of raw materials for the cigarette industry, and spices are the main products. Other products include oil and oleoresin, which can be extracted from flowers or leaves. Eugenol is the primary constituent of clove oil. Eugenol compounds have antibacterial, antifungal, antiseptic, antioxidant, and antivirus properties (Alfian *et al*., 2019).

Clove is one of the oldest and most valuable spices, grown primarily in Indonesia, Zanzibar, Madagascar, Pemba, and Sri Lanka. The major clove-growing regions in India are Kanyakumari, the Nilgiris of Tamil Nadu, Calicut, Kottayam, Quilon and Trivandrum districts of Kerala and South Kanara of Karnataka (Balakrishnamoorthy and Kennedy, 1999). Because clove was introduced to India infrequently, the genetic base of the clove is narrow (Ravindran, 1999). Furthermore, clove is self-pollinated, resulting in a lack of variation. There are no true varieties of clove in India; only local types are under cultivation (Nybe *et al*., 2006). Information as well as assessment of genetic variability in the existing germplasm of a crop is a prerequisite for varietal development. The agro-morphological characterization of genotypes is essential for providing information for plant breeding programmes. For any crop, a greater chance of identifying traits of agronomic interest is associated with higher levels of diversity. There is a little knowledge of the types and diversity of cloves in India.

Observing the morphological characteristics of clove in the field can be used to determine its diversity. In this present review, the agro-morphological diversity of clove (*Syzygium aromaticum* (L.) Merr. & Perry) in India is highlighted.

ORIGIN AND TAXONOMY OF CLOVE

A spice with origin dating back to the first century before Christ, clove is one of the most valuable and ancient of the spices. Our first indication of the use of fragrant clove dates back to the Han dynasty in ancient China, which lasted from 207 B.C. to 220 A.D. Its origin and source were unknown until the Portuguese discovered the Moluccas Islands, or Indonesia, in the 16th century. Approximately half of the commercial supply of cloves available worldwide is consumed by Indonesians. Tobacco and cloves are combined to create a unique cigarette that is common in Indonesia. The Dutch and Portuguese were two major naval European powers during the 17th and 18th centuries and were involved in a long tussle over competition for cloves. Dutch eventually gained a complete monopoly on the trade in cloves by destroying every viable clove tree in all the islands, sparing only the Dutch colonized island of Ambon, on which vast acreage was devoted to clove plantations. This Dutch monopoly persisted until the 19th century, when the plant was grown in numerous tropical regions of the world. In India, the East India Company introduced cloves in 1800 AD (Milind and Deepa, 2011). The trade of cloves and the hunt for this valuable spice has long fueled the economic growth of Asian region. These days, the major clove producing countries are Indonesia, India, Malaysia, Sri Lanka, Madagascar, and Tanzania, particularly the island of Zanzibar.

BOTANICAL DESCRIPTION OF CLOVE

The clove tree is a small to medium-sized, evergreen tree that reaches a height of 12 to 15 meters and initially has a conical shape before changing to a cylindrical one. The leaves of a clove are simple, opposite, coriaceous, estipulate, hairless and fragrant and are 7-13 cm in length and 3 cm in breadth. The leaf stalk is slender, about 2-3 cm long, swollen and pink at the bottom. The leaf shape is obtuse or acuminate. Newly emerged within the flushes, they are pink in colour, while mature leaves are dark green (Purseglove *et al*., 1981). Forest clove trees are large, sturdy trees with less pointed canopies than other varieties of cloves. They have round and oval canopies, low branching in their main stems. The tree is an evergreen tree that starts to flower in about 7 years and continues to yield for 80 or more years (Pruthi, 2001). According to Ravindran (2006), clove leaves are opposite, obovate, oblong to elliptic, and abundantly covered with oil glands on the underside.

The inflorescence of the clove tree is a terminal branching cyme with three to twenty hermaphrodite flowers that are all about one and a half inches long. Each ovary measures one-quarter inch in length and is cylindrically thick, making each pale-yellow floret. A hypanthium of four fleshy ovate sepals, four tiny petals, numerous thin, white, 3/8-inch filaments, and a narrow central style are located above the ovary. The hypanthium is 1–1.5 cm long, 5 mm in diameter, angled, cylindrical, and slightly narrowed at the base. In the young bud, the hypanthium is green. It turns flushed pink at anthesis and deep reddish after the stamens have fallen. Every year, there are two flowering seasons: November to January and July to October. Few flowers mature into fruit. The fruit known as the mother of cloves contains one or, very rarely, two seeds. The ovary and sepals are the economically valuable parts sold as cloves (Purseglove *et al*., 1981). The word "Clove" is derived from the French and English words "Clou" and "Clout," both of which mean "nail," due to the resemblance of the Clove tree's flower bud to a broad-headed nail. When 1.5 to 2 cm long, cloves are harvested. They are made up of four unopened petals that form a small ball in the centre, a long calyx that ends in four spreading sepals, and a long calyx that extends to the ground (Milind and Deepa, 2011).

AGRO-MORPHOLOGICAL VARIABILITY IN INDIA

Research on clove is limited in India. It has been documented that clove varies in terms of tree shape, cropping season, bearing habits, yield, shape, colour and dimension. But the two most important morphological characteristics for determining productivity are tree girth and leaf area (Balakrishnan *et al*., 1998; Kennedy and Nageswari, 2000). Two clove trees at Black Rock Estate in Kanyakumari were identified as dwarf, bushy and 2 m tall with a canopy width of 5 m. The main trunk measured only 0.6 m in height but had numerous branches. The seedling derived from these trees exhibits dwarf characteristics. For its dwarf stature, this promising accession was registered with NBPGR, New Delhi, with accession number INGR-04112. The morphological characteristics of this dwarf clove reported were 52.62 cm plant height at 8th year with a canopy of 50 cm and a bushy shape (Anon., 2019).

To select high yielding elite clove trees for seed collection, Krishnamoorthy and Rema (1992) surveyed the major clove-growing areas in Kanyakumari, Nilgiris, and Salem districts of Tamil Nadu and Quilon and Trivandrum districts of Kerala. They identified a total of 35 elite clove trees from three private estates in India's Ashamboo hills, which are the southernmost hills and are home to the country's oldest clove trees. Three distinct different morphological variants in clove; One king clove, two dwarf bushy clove at Black Rock Estate and three small leaved clove trees from Maramalai Estate were also reported (Krishnamoorthy and Rema, 1994) during the surveys conducted at Tamil Nadu. The identified promising variants presented significant opportunity for crop improvement programmes to make use of diversity in *Syzygium aromaticum*. Balakrishnamoorthy and Kennedy (1999) conducted a survey in the Keeriparai and Maramalai regions of Kanyakumari and reported two king clove types (KC-1 and KC-2) and one dwarf clove (DC-1) based on morphological and flower bud characters, and collected variants were evaluated at the Horticulture Research Station, Yercaud.

Avinash (2017) found considerable variability in clove for qualitative as well quantitative morphological characters. Variation was noticed among the accessions for the qualitative characters such as canopy shape, branching pattern, colour of young leaf, colour of mature leaf, leaf lamina shape, leaf apex shape, bud forming season, bud clustering habit, bud size, colour of hypanthium, petal colour, sepal colour, colour of stigma, fruit shape and seed shape. Quantitative characterization of bud, flower, fruit, seed and quality parameters summarized based on the descriptive statistics revealed wider range of variability in number of inflorescences per m2 and single bud weight fresh and dry. A unique accession was identified with purple red colour young leaf with light green tinge, dark purple red hypanthium**,** green brown petal, dark purple red sepal and yellow green stigma. Variability among four promising genotypes of clove was also reported from Dapoli (Anon., 2020). The accessions had plants that varied in height from 5.89 to 7.15 m, girth from 35 to 40 cm, and canopy spread from 2.50 to 3.05 m. When compared to local check, SA-1 (9.31 m tall), which is one of the 24 clove accessions kept at Pechiparai, had the tallest trees at 11.78 m, followed by SA-3 at 11.63 m. The accession SA-13 recorded the highest stem girth (49.59 cm) in comparison to the local check (40.57 cm) and was noticeably superior to other accessions. The accession SA-3 recorded the highest dry bud yield (1.52 kg/tree/year), number of branches (16) leaf length (12.47 cm) and leaf breadth (7.46 cm).

CONCLUSION

Morphological and agronomic characterization is the basic and key step for the identification of genotypes visually, and thus it is the initial step for diversity assessment before employing any other advanced methods. Variability studies of clove are very less in India. The above literature summarises different research papers on the genetic variability of clove for agro-morphological traits in India. There exists a wide variation in different germplasm collections, which is important for the improvement of this crop. The diversity of clove can be obtained by identifying plant morphological diversity in the field. Clove is one of the most traded commodities from India. Hence, research work on this crop has to be strengthened.

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Effects of Perforated LDPE Packaging Bags in Different Seasons of Harvest for Storage Quality Attributes of Okra Fruits in Terai Agro-Climatic Zone of West Bengal

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The lowest physiological loss of weight after 2 days of storage was recorded in July harvested fruits stored in LDPE bags with 2% perforations, after 4 days in September harvested fruits stored inLDPE bags with 2 % perforationsand after 6 days in May harvested fruits stored in LDPE bags with 2% perforations. The highest ascorbic acid content after 2 days of storage was recorded in July harvested fruits stored in LDPE bags with 2 % perforations, after 4 days and 6 days in November harvested fruits stored open in bowl. The lowest crude fibre content after 2 days of storage was recorded in July harvested fruits stored open in bowl, after 4 and 6 days in July harvested fruits stored in LDPE bags with 2% perforations. At the end of the storage periods at ambient temperature i. e. 4 and 6 days of storage e, fruits from November harvested crop showed the highest marketable fruits of 89.94 % and 56.50 %, respectively in okra fruits in pooled analysis. Perforated LDPE bags with 8 perforations recorded highest marketable fruits of okra fruits of 48.46 % at the end of 6 days in pooled analysis.

Keywords: Okra, Harvesting seasons, Storage, Perforated LDPE bags

Okra (*Abelmoschus esculentus* L. Moench) is an economically important vegetable crop widely cultivated in tropical, subtropical and warm temperate regions of the world. It is a member of the hibiscus family, Malvaceae and has the typical floral characteristics of that family originating from Africa. Okra is a multipurpose crop due to its various uses of the fresh leaves, buds, flowers, pods, stems and seeds. The immature fruits of okra (green seed pods), which are consumed as vegetables, can be used in salads, soups and stews, fresh or dried, fried or boiled. Okra is a highly perishable commodity. The post-harvest losses of fresh okra are caused due continued respiration and transpiration after harvest. The normal shelf life of fresh and raw okra is 2-3 days. Okra pods lose quality through blackening, shriveling, and decaying within two days under room temperature conditions leading to heavy post-harvest losses. Okra left for more than two days become fibrous and unsuitable for direct use, thus proper packaging and storage allows for better quality and extends shelf-life for some days (Schippers, 2000). Okra fruits were better preserved with cartons lined with bitter gourd leaf than baskets lined with bitter gourd leaf at room temperature for an optimum period of 9-10 days (Chukunda and Nwonuala, 2013). Okra should be packaged in low-density polyethylene (LDPE) and stored at room temperature for an optimum period of nine days and more than nine days in a thermostatically controlled refrigerator at 15.50 ± 2.50^{0}C. Therefore, it is necessary to find out suitable agro-techniques particularly for sowing time and spacing for its production, and also suitable packaging material and method of storage for okra to reduce post-harvest wastage. If the rates of the activities like moisture loss, shrinkage, toughening, yellowing and decay are reduced, the shelf life of okra can be increased (Ghai, 2002). In okra, low temperature can most effectively extend the shelf-life of okra and reduce the post-harvest losses by arresting the metabolic breakdown and fungal deterioration of the commodity (Babarinde and Fabunmi, 2009). The information available so far regarding suitable packaging bags for storage of okra fruits is inadequate. Therefore, the present study was carried out to study the effects of perforated LDPE packaging bags in different seasons of harvest for storage quality attributes of okra fruits.

MATERIALS AND METHODS

The experiment was carried out at the Post Graduate Laboratory of the Department of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar ($26^0$19´ 86´´ N latitude, 89^0 23' 53" E longitude and altitude of 43 m above the mean sea level) in two factor factorial randomized block design with three replications to find out the individual as well as their interaction effects of perforated LDPE packaging bags in different seasons of harvest for storage quality attributes of okra fruits under Terai agro-climatic zone (25^0 57" to 26^0 36" N latitude and 89^0 54" to 88^0 47" E longitude) of West Bengal during 2020 and 2021. Three packaging conditions with LDPE packaging bags of 8 perforations (2 % perforation), 12 perforations (3 % perforation) and control (no bag) at normal room temperature and four seasons of both harvest and storage were used with the harvested fruits of 2^{nd} picking of Mahyco Hybrid No.10 for studying its storage quality attributes.

RESULTS AND DISCUSSION

Physiological Loss of Weight

The physiological loss of weight (%) in okra fruits was significantly influenced by different harvesting time and packaging material individually for both the years and also in pooled analysis. At the end of the storage periods at ambient temperature i. e. 2 and 4 days of storage, S_1 showed the lowest physiological loss of weight of 5.82 % and 12 % in okra fruits in S_1 and that after 6 days 16.96 % in S_2. Perforated LDPE bags with 8 perforations recorded lowest physiological loss of weight of okra fruits of 3.04 %, 5.42 % and 7.24 % at the end of 2, 4 and 6 days in pooled analysis. The interaction effect of harvesting time and packaging material in pooled analysis also showed significant difference. The lowest physiological loss of weight after 2 days of storage was recorded in S_2P_1, after 4 days in S_3P_1 and after 6 days in S_1P_1 (Table 1). The weight loss was due to uncontrolled water loss and food reserve from tissues of okra fruits due to biochemical activities such as transpiration and respiration. The results of this study are in close conformity with results reported by Chukundaand Nwonuala (2013).

Ascorbic Acid Content

The ascorbic acid content (mg/100g) in okra fruits was significantly influenced by different harvesting time and packaging material individually for both the years and also in pooled analysis (Table 2). At the end of the storage periods at ambient temperature i. e. 2 and 4 days of storage, S_2 showed the highest ascorbic acid content of 20.37 and 18.13 mg/100g in okra fruits and that after 6 days 16.88 mg/100g in S_4. Perforated LDPE bags with 8 perforations recorded highest ascorbic acid of okra fruits of 20.20, 17.88 and 15.99 mg/100g at the end of 2, 4 and 6 days in pooled analysis. The interaction effect of harvesting time and packaging material in pooled analysis also showed significant difference. The highest ascorbic acid content after 2 days of storage was recorded in S_2P_1, after 4 days in S_4P_0 and after 6 days in S_4P_0 (Table 2). Studies have reported gradual decrease of ascorbic acid content of okra fruits with increase in storage period (Rani *et al.*, 2015).

Crude Fibre Content

The crude fibre content (%) in okra fruits was significantly influenced by different harvesting time separately for both the years and also in pooled analysis but packaging material individually showed marked difference for both the years and not in pooled analysis (Table 3). At the end of the storage periods at ambient temperature i. e. 2, 4 and 6 days of storage, S_4 showed the lowest crude fibre content of 12.68, 17.09 and 18.77 % in okra fruits. Perforated LDPE bags with 8 perforations recorded lowest crude fibre content of okra fruits of 12.75, 17.09 and 18.47 % at the end of 2, 4 and 6 days in pooled analysis. The interaction effect of harvesting time and packaging material in pooled analysis also showed significant difference. The lowest crude fibre content after 2 days of storage was recorded in S_2P_0, after 4 and 6 days in S_2P_1. The crude fibre of okra fruits increased gradually with increase in storage period.

Marketable Fruits

The marketable fruits (%) in okra fruits were not significantly influenced by different harvesting time separately at 2 days storage, but significant difference after 4 and 6 days of storage for both the years and also in pooled analysis (Table 4). Packaging material individually showed no marked difference at 2 and 4 days of storage but marked difference for second years and in pooled analysis at 6 days of storage period. After the end of the storage periods at ambient temperature i. e. 4 and 6 days of storage, fruits from September sown crop (S_4) showed the highest marketable fruits of 89.94 % and 56.50 %, respectively in okra fruits in pooled analysis.

Perforated LDPE bags with 8 perforations (P_1) recorded highest marketable fruits of okra fruits of 48.46 % at the end of 6 days in pooled analysis. The interaction effect of harvesting time and packaging material in pooled analysis showed non-significant difference for marketable fruits. The highest marketable fruits after 6 days of storage were recorded when fruits from September sown crop stored in LDPE bag packages with 8 perforations (S_4P_1). The marketable fruits of okra fruits decreased gradually with increase in storage period.

CONCLUSION

It is concluded that after harvesting, the tender okra fruits packaged in LDPE polyethylene bags with 2 % perforations has extended their shelf-life up to 6 days when half of the stored fruits under ambient temperature conditions got wasted. The fruits also have lesser physiological weight loss with better quality in terms of ascorbic acid and crude fibre content.

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Table 1. Physiological loss weight loss (%) in okra fruits influenced by seasons and LDPE perforated bags

Treatment	Storage period								
	2 days			4 days			6 days		
	Y_1	Y_2	P	Y_1	Y_2	P	Y_1	Y_2	P
Harvesting time									
S_1	5.56	6.08	5.82	11.96	12.05	12.00	18.60	17.96	18.28
S_2	5.83	5.99	5.91	13.35	13.21	13.28	17.54	16.39	16.96
S_3	6.70	6.19	6.44	13.14	13.10	13.12	19.55	18.10	18.82
S_4	8.94	8.08	8.36	15.20	14.60	14.90	21.05	19.80	20.43
SEm (±)	**0.22**	**0.20**	**0.16**	**0.30**	**0.33**	**0.20**	**0.45**	**0.48**	**0.38**
CD ($P_{0.05}$)	**0.64**	**0.60**	**0.45**	**0.87**	**0.97**	**0.58**	**1.34**	**1.42**	**1.08**
Packaging material									
P_0	9.80	9.49	9.64	20.52	20.21	20.37	25.35	25.37	25.36
P_1	2.92	3.16	3.04	5.49	5.34	5.42	7.20	7.27	7.24
P_2	7.32	7.11	7.21	14.23	14.17	14.20	25.00	21.55	23.27
SEm (±)	**0.19**	**0.18**	**0.14**	**0.26**	**0.28**	**0.18**	**0.39**	**0.42**	**0.33**
CD ($P_{0.05}$)	**0.55**	**0.52**	**0.39**	**0.76**	**0.84**	**0.50**	**1.16**	**1.23**	**0.93**
Interaction									
S_1P_0	8.48	9.47	8.97	18.42	18.30	18.36	26.97	26.80	26.88
S_1P_1	2.47	3.19	2.83	4.64	5.04	4.84	5.46	5.49	5.47
S_1P_2	5.72	5.59	5.66	12.82	12.81	12.82	23.36	21.61	22.48
S_2P_0	8.93	8.86	8.90	20.83	20.98	20.90	22.78	22.85	22.82
S_2P_1	1.93	1.96	1.95	5.63	5.34	5.48	6.28	6.38	6.33
S_2P_2	6.63	7.14	6.89	13.61	13.31	13.46	23.55	19.94	21.74
S_3P_0	10.41	9.28	9.84	20.59	20.56	20.58	24.97	24.99	24.98
S_3P_1	2.51	2.65	2.58	4.77	4.44	4.60	7.17	7.27	7.22
S_3P_2	7.15	6.64	6.90	14.06	14.29	14.16	26.51	22.00	24.26
S_4P_0	11.39	10.33	10.86	22.25	21.01	21.63	26.69	26.83	26.76
S_4P_1	4.75	4.84	4.80	6.93	6.54	6.73	9.89	9.94	9.92
S_4P_2	9.77	9.05	9.41	16.42	16.25	16.34	26.56	22.64	24.60
SEm (±)	**0.37**	**0.35**	**0.27**	**0.51**	**0.57**	**0.35**	**0.78**	**0.83**	**0.66**
CD ($P_{0.05}$)	**NS**	**1.04**	**0.78**	**NS**	**NS**	**1.01**	**2.32**	**NS**	**1.86**

Y_1-Year 2020, Y_2-Year 2021, P-Pooled, NS- Non-significant, S_1- Middle of May; S_2- Middle of July; S_3- Middle of September; S_4- Middle of November, P_0- Unwrapped plastic bowl; P_1-Perforated L.D.P.E bags with 8 perforations; P_2-Perforated L.D.P.E bags with 12 perforations under room temperature condition

Table 2. Ascorbic acid content (mg/100 g) in okra fruits influenced by seasons and LDPE perforated bags

Treatment	Storage period								
	2 days			4 days			6 days		
	Y_1	Y_2	P	Y_1	Y_2	P	Y_1	Y_2	P
Harvesting time									
S_1	19.84	20.01	19.92	16.47	16.36	16.41	12.54	12.52	12.53
S_2	20.34	20.40	20.37	18.23	18.04	18.13	16.39	16.30	16.35
S_3	18.30	18.18	18.24	17.14	17.18	17.16	16.25	16.13	16.19
S_4	19.52	19.36	19.44	17.95	17.72	17.84	16.82	16.93	16.88
SEm (±)	**0.33**	**0.33**	**0.21**	**0.23**	**0.25**	**0.15**	**0.20**	**0.21**	**0.13**
CD ($P_{0.05}$)	**0.98**	**0.97**	**0.60**	**0.69**	**0.73**	**0.44**	**0.60**	**0.61**	**0.38**
Packaging material									
P_0	19.53	19.64	19.59	17.24	17.15	17.20	15.32	15.34	15.33
P_1	20.25	20.14	20.20	17.95	17.82	17.88	15.98	16.00	15.99
P_2	18.71	18.68	18.70	17.15	17.01	17.08	15.20	15.07	15.14
SEm (±)	**0.29**	**0.28**	**0.18**	**0.20**	**0.21**	**0.13**	**0.18**	**0.18**	**0.11**
CD ($P_{0.05}$)	**0.85**	**0.84**	**0.52**	**0.59**	**0.63**	**0.38**	**0.52**	**0.52**	**0.33**
Interaction									
S_1P_0	20.61	21.09	20.85	14.06	13.90	13.98	9.00	9.23	9.12
S_1P_1	20.23	20.39	20.31	18.69	18.60	18.65	15.12	14.99	15.05
S_1P_2	18.66	18.54	18.60	16.65	16.59	16.62	13.51	13.33	13.42
S_2P_0	20.89	21.13	21.01	19.14	19.02	19.08	18.29	18.28	18.28
S_2P_1	21.70	21.64	21.67	18.36	18.03	18.20	15.59	15.33	15.46
S_2P_2	18.44	18.44	18.44	17.18	17.06	17.12	15.30	15.30	15.30
S_3P_0	15.74	15.75	15.75	15.77	15.67	15.72	15.20	14.86	15.03
S_3P_1	18.71	18.36	18.54	16.88	16.99	16.93	16.53	16.58	16.55
S_3P_2	20.45	20.42	20.44	18.78	18.87	18.82	17.02	16.94	16.98
S_4P_0	20.89	20.59	20.74	20.01	20.01	20.01	18.81	18.99	18.90
S_4P_1	20.35	20.18	20.26	17.86	17.64	17.75	16.69	17.08	16.86
S_4P_2	17.31	17.32	17.31	15.98	15.51	15.75	14.97	14.73	14.85
SEm (±)	**0.58**	**0.57**	**0.37**	**0.40**	**0.43**	**0.27**	**0.35**	**0.36**	**0.23**
CD ($P_{0.05}$)	**1.70**	**1.68**	**1.04**	**1.19**	**1.26**	**0.76**	**1.04**	**1.05**	**0.65**

Y_1-Year 2020, Y_2-Year 2021, P-Pooled, N. S.- Non-significant, S_1- Middle of May; S_2- Middle of July; S_3- Middle of September; S_4- Middle of November, P_0- Unwrapped plastic bowl; P_1-Perforated L.D.P.E bags with 8 perforations; P_2-Perforated L.D.P.E bags with 12 perforations under room temperature condition

Table 3. Crude fibre content (%) in okra fruits influenced by seasons and LDPE perforated bags

Treatment	Storage period								
	2 days			4 days			6 days		
	Y_1	Y_2	P	Y_1	Y_2	P	Y_1	Y_2	P
Harvesting time									
S_1	13.54	13.58	13.56	17.66	17.71	17.68	19.18	19.19	19.19
S_2	12.08	12.16	12.12	16.64	16.45	16.55	17.83	17.74	17.78
S_3	13.39	13.48	13.43	17.66	17.46	17.56	18.79	18.79	18.79
S_4	12.61	12.75	12.68	17.14	17.03	17.09	18.84	18.71	18.77
SEm (±)	**0.14**	**0.13**	**0.09**	**0.16**	**0.17**	**0.11**	**0.18**	**0.17**	**0.11**
CD ($P_{0.05}$)	**0.42**	**0.37**	**0.25**	**0.48**	**0.50**	**0.31**	**0.54**	**0.49**	**0.32**
Packaging material									
P_0	12.92	12.99	12.95	17.09	16.99	17.04	18.69	18.60	18.65
P_1	12.73	12.77	12.75	17.11	17.06	17.09	18.45	18.50	18.47
P_2	13.07	13.22	13.15	17.62	17.44	17.53	18.84	18.72	18.78
SEm (±)	**0.12**	**0.11**	**0.08**	**0.14**	**0.15**	**0.09**	**0.16**	**0.14**	**0.10**
CD ($P_{0.05}$)	**NS**	**0.32**	**0.21**	**0.41**	**NS**	**0.26**	**NS**	**NS**	**NS**
Interaction									
S_1P_0	14.11	14.20	14.16	18.06	18.25	18.16	19.90	19.95	19.93
S_1P_1	13.44	13.42	13.43	17.88	17.88	17.88	18.59	18.75	18.67
S_1P_2	13.07	13.11	13.09	17.03	17.00	17.02	19.06	18.87	18.96
S_2P_0	11.45	11.41	11.43	16.31	16.27	16.29	18.17	17.98	18.08
S_2P_1	11.43	11.55	11.49	15.48	15.48	15.48	16.74	16.73	16.73
S_2P_2	13.36	13.53	13.45	18.14	17.61	17.88	18.57	18.52	18.55
S_3P_0	12.58	12.72	12.65	16.35	16.06	16.21	17.93	17.74	17.84
S_3P_1	13.56	13.60	13.58	17.67	17.53	17.60	18.59	18.79	18.69
S_3P_2	14.04	14.11	14.07	18.96	18.79	18.88	19.84	19.83	19.83
S_4P_0	13.54	13.62	13.58	17.64	17.40	17.52	18.75	18.73	18.74
S_4P_1	12.47	12.51	12.49	17.43	17.33	17.38	19.88	19.72	19.80
S_4P_2	11.82	12.11	11.97	16.36	16.35	16.35	17.88	17.63	17.78
SEm (±)	**0.25**	**0.22**	**0.15**	**0.28**	**0.29**	**0.19**	**0.32**	**0.29**	**0.19**
CD ($P_{0.05}$)	**0.74**	**0.64**	**0.42**	**0.83**	**0.86**	**0.53**	**0.93**	**0.84**	**0.55**

Y_1-Year 2020, Y_2-Year 2021, P-Pooled, N. S.- Non-significant, S_1- Middle of May; S_2- Middle of July; S_3- Middle of September; S_4-Middle of November, P_0- Unwrapped plastic bowl; P_1-Perforated L.D.P.E bags with 8 perforations; P_2-Perforated L.D.P.E bags with 12 perforations under room temperature condition

Table 4. Marketable fruits (%) of okra influenced by seasons and LDPE perforated bags

Treatment	Storage period								
	2 days			4 days			6 days		
	Y_1	Y_2	P	Y_1	Y_2	P	Y_1	Y_2	P
Harvesting time									
S_1	99.80	99.37	99.34	84.33	87.44	85.89	31.56	36.89	34.22
S_2	99.70	99.66	99.61	85.33	88.67	87.00	43.67	44.44	44.06
S_3	99.62	99.24	99.38	87.78	89.11	88.44	53.11	55.00	54.06
S_4	99.98	99.13	99.25	89.89	90.00	89.94	56.00	57.00	56.50
SEm (±)	**0.08**	**0.19**	**0.13**	**0.93**	**0.56**	**0.53**	**1.68**	**0.64**	**0.85**
CD ($P_{0.05}$)	**NS**	**NS**	**NS**	**2.74**	**1.64**	**1.50**	**4.97**	**1.87**	**2.42**
Packaging material									
P_0	99.65	99.38	99.37	86.83	89.50	88.17	43.92	46.33	45.13
P_1	99.71	99.52	99.51	87.00	88.42	87.81	47.33	49.58	48.46
P_2	99.75	99.15	99.30	86.67	88.50	87.58	47.00	49.08	48.04
SEm (±)	**0.07**	**0.16**	**0.11**	**0.80**	**0.48**	**0.46**	**1.46**	**0.55**	**0.74**
CD ($P_{0.05}$)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1.62**	**2.10**
Interaction									
S_1P_0	99.66	99.21	99.22	84.33	88.00	86.17	28.67	34.67	31.67
S_1P_1	99.95	99.56	99.41	84.33	87.00	85.67	32.33	39.00	35.67
S_1P_2	99.79	99.35	99.40	84.33	87.33	85.83	33.67	37.00	35.33
S_2P_0	99.70	99.71	99.67	85.67	89.00	87.33	42.00	43.67	42.83
S_2P_1	99.55	99.82	99.74	85.00	88.33	86.67	46.00	46.33	46.17
S_2P_2	99.85	99.44	99.42	85.33	88.67	87.00	43.00	43.33	43.17
S_3P_0	99.54	99.50	99.46	87.67	91.00	89.33	52.00	54.00	53.00
S_3P_1	99.66	99.38	99.46	88.67	88.33	88.50	54.00	55.67	54.83
S_3P_2	99.67	98.83	99.21	87.00	88.00	87.50	53.33	55.33	54.33
S_4P_0	99.71	99.08	99.15	89.67	90.00	89.83	53.00	53.00	53.00
S_4P_1	99.66	99.34	99.41	90.00	90.00	90.00	58.00	60.67	59.33
S_4P_2	99.67	98.98	99.19	90.00	90.00	90.00	57.00	57.33	57.17
SEm (±)	0.13	0.32	0.23	1.61	0.96	0.91	2.92	1.10	1.48
CD ($P_{0.05}$)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**3.25**	**N S**

Y_1-Year 2020, Y_2-Year 2021, P-Pooled, N. S.- Non-significant, S_1- Middle of May; S_2- Middle of July; S_3- Middle of September; S_4- Middle of November, P_0- Unwrapped plastic bowl; P_1-Perforated L.D.P.E bags with 8 perforations; P_2-Perforated L.D.P.E bags with 12 perforations under room temperature condition

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Screening of Wheat Genotype against Spot Blotch Disease in Hot Spots of West Bengal

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Spot blotch, an important foliar fungal disease of wheat caused by *Cochliobolus sativus* (anamorph: *Bipolaris sorokiniana*), is the influential production restraint over the global wheat-growing regions. A set of 140 diverse wheat genotypes collected from national and international sources were screened for spot blotch disease, grain yield and some biochemical parameters associated with defence mechanism in the plant under natural disease infestation followed by artificial inoculation in Rabi seasons of 2016-2018. The present investigation revealed significant variation among the genotypes for spot blotch resistance. This study also recorded 11 genotypes as resistant source against spot blotch disease. Identified resistant genotypes increased grain yield as a consequence of resistance offered against spot blotch disease. The different enzyme activities like peroxidase, polyphenol oxidase and super oxide dismutase in resistant genotype were significantly higher than susceptible one, Sonalika.

Keywords: Wheat, Spot blotch, Resistance, Defence enzymes

INTRODUCTION

Spot blotch (SB) of wheat is a major threat to successful wheat production in warm and humid areas of the world. SB, also called leaf blight, is caused by *Cochliobolus sativus* (anamorph: *Bipolaris sorokiniana*), and is responsible for high yield losses in Eastern Gangetic Plains Zone in India (Chowdhury *et al.,* 2013). Globally, an estimated 25 million ha of wheat land is affected by SB (Yadav *et al.,* 2015), out of which around 10 million ha is in the Indian sub-continent and 9 million ha of this is in the North-Eastern Plain Zone of India (Duveiller and Sharma, 2012; Chowdhury *et al.,* 2013). This disease is extending gradually toward the North-West part of India characterized by high temperature and humidity occurring late in the season (Saari, 1998) with an average yield loss of about 15-20 % (Chand *et al.,* 2003). The disease also causes serious damage in seed quality and market value of the produce leading to substantial economic losses (Singh and Kumar, 2008). Under heavy infestation, yield losses vary from 80 to 100 % (Kumar *et al*., 2008). It is chiefly a seed-transmitted disease and the conidia can also survive in the soil. Deployment of resistant cultivars is considered as the most economical and ecologically sound measure to avoid losses due to this disease. However, identification of donor lines resistant to SB remains a major continuing challenge (Joshi *et al.,* 2007). At CIMMYT, a number of *Aegilops* and *Triticum* species were used as donors for resistance to leaf blight which included *Aegilops triuncialis*, *Aegilops cylindrica*, *Aegilops speltoides*, *Aegilops triaristata*, *Triticum dicoccoides* (wild emmer wheat), *Triticum boeoticum*, *Triticum persicum*, *Triticum timopheevii*, *Triticum araraticum*, *Triticum urartu*, and *Triticum sphaerococcum* (Singh and Dhaliwal, 1993; Smurova and Mikhailova, 2007). *Aegilops* species is considered as a good and less exploited source for increasing the genetic potential of cultivated wheat to various biotic and abiotic stresses. Based on the above information and development, a study was conducted to identify the disease resistant genotype in hot spot of northern parts of West Bengal and biochemical changes associated with disease resistance.

MATERIALS AND METHODS

A total of 140 advance genotypes with diverse backgrounds were collected from ICAR-IIWBR, Karnal, India and CIMMYT, Mexico. The genotypes were sown initially in 3 m x 1 m with spacing of 20 cm initially to observe the disease reaction. After selection, the selected genotypes were sown in 4 m x 3 m plots in RBD with recommended agronomic package of practices. The fields were inoculated at 50 days after sowing with *B. sorokiniana* pathogen (10^6 spores/ml concentration). The fields were irrigated before artificial inoculation for creating high moisture. After harvesting from the net plot, wheat crops were properly dried with the help of sun drying and crops were threshed subsequently. The grains from each plot in all the cases were sun dried, cleaned thoroughly and weighed.

Canopy temperature and SPAD value were recorded with handheld Infra-red thermometer and SPAD meter (Minolta). The severity of the disease was visually scored employing double digit scale (00-99). The double-digit scale was developed as a modification of Saari and Prescott's severity scale to score foliar disease of wheat plant (Saari and Prescott, 1975). Data were taken immediately after completion of 50 % anthesis and continued thereafter at 7-10 days interval throughout the season. Area under Disease Progress Curve (AUDPC), measure the amount of disease as well as the rate of progress, was calculated following Das *et al*. (1992). The value of AUDPC was estimated using the midpoint rate or so-called trapezoidal integration method. The AUDPC has no unit.

$$AUDPC = \sum_{i-1}^{n-1} [(Xi+Xi+1)/2](ti+1-ti)]$$

Where, xi is the spot blotch severity on ith date, the ti is the ith day and n is the number of scoring days.

Estimation of Peroxidase

Peroxidase was estimated following Sadasivam and Manickam (1996). The enzyme extract was prepared by taking 0.2 g of leaf samples in 0.8 ml of 0.1 M phosphate buffer (pH 7.0) by crushing with liquid nitrogen in a mortar and pestle at freezing temperature and the homogenate was centrifuged at 15,000 rpm at 4°C for 20 minutes. The supernatant was used as enzyme source. In a cuvette 3 ml buffer (0.05 M) Pyrogallol solution, 0.1 ml enzyme extract and 0.5 ml hydrogen peroxide were taken by using micropipette and were mixed well. Thereafter the cuvette was placed in the Spectrophotometer and the absorbance was measured at 436 nm against a reagent blank without enzyme extract at an interval of 30 seconds up to 180 second replicated six times.

Estimation of Poly Phenol Oxidase

Poly phenol oxidase was estimated following Mayer *et al.* (1965). The enzyme extract was prepared by taking 0.2 g leaf samples and 2 ml of 0.1 M sodium phosphate buffer (pH 6.6) by crushing with liquid nitrogen in a motor with pestle. The homogenate was centrifuged at 20,000 rpm for 30 min at 4°C. The supernatant was used as enzyme source. The reaction mixture consisted of 100 µl of the enzyme extract and 2.4 ml of 0.1 M sodium phosphate buffer (pH 6.0). To start the reaction, 0.5 ml of Pyrogallol solution was added, and the enzyme activity was expressed as changes in absorbance at 495 nm against a blank 3 ml of phosphate buffer (pH 6.0) at 5 minutes interval replicated four times.

Estimation of Superoxide Dismutase

Superoxide Dismutase activity (SOD) is assayed in infected and healthy leaves and is done for wheat with *Bipolaris sorokiniana* using the method of Dhindsa *et al.* (1981). The enzyme extract was prepared by taking 0.5 g leaf samples and 5 ml of extraction buffer (0.1 M phosphate buffer, PH 7.5 containing 0.5 mM EDTA).

The grinded samples are centrifuged at 10000 rpm for 15 minutes at 4°C temperature. After centrifugation supernatant is collected in small glass bottle with the help of micro pipette. This supernatant was serving as enzyme source. A 3 ml of mixture containing 0.1 ml of 1.5 M sodium carbonate, 0.2 ml of 200 Mm methionine, 0.1 ml of 2.25mM NBT, 0.1 ml of 3 mM EDTA, 1.5 ml of 100 mM potassium phosphate buffer, 1 ml of distilled water and 0.1 ml of enzyme extract was taken in glass test tube with two replications. Two test tubes without enzyme extract were taken as control. The reaction was started by adding 0.1 ml of riboflavin (60 µM) and placing the tubes below the laminar light sources. In this experiment the test tubes are placed below the two laminar lamps each of the light power for the time period of half an hour. Reaction was stopped by switching off the light and covering the tubes by blank cloth. The tubes without enzyme extract develop maximum colour. A non-irradiated complete mixture that does not develop any colour was serving as blank. Absorbance was recorded at 560 nm in spectrophotometer (ELICO, SL 196).

Peroxidase isozyme analysis by polyacrylamide Gel Electrophoresis (PAGE)

Extract for peroxidase isozymes analysis was prepared by crushing 1 g of leaf tissue in mortar with pestle in 2M sodium phosphate buffer (pH-7) on ice as described by **Davis (1964)** and immediately used for the gel.

RESULTS AND DISCUSSION

Screening Genotype against Spot Blotch Disease

Among the 140 genotype, 14 numbers of tolerant genotype based on their AUDPC along with the two local checks i.e., HD2967 and Sonalika were characterized for disease reaction, canopy temperature, SPAD value. The observations on disease reactions are presented in Table 1.

Table 1. List of resistant genotypes against spot blotch disease, SPAD value and canopy temperature

Sn	Pedigree	A	Y	SPAD*	CT
1.	LBP-2015-04 (WH 730 / MACS 2496 (F_5)	344	6.40	31.7	23
2.	LBP-2015-10 (HW 2045 / CHIRYA 7 (F_8)	422	5.92	31	21.5
3.	LBP-2015-12 (SSD-C3-288 (DBW 16 / BH 1146)	348	5.22	35.9	22.4
4.	SSD-C2-303 (Chirya/DBW16/NI5439)	466	5.52	33.7	22.8
5.	CHIRYA 3/ KH 65// CHIRYA 3 - $BC_1P_1F_4$ (330)	424	3.65	28.9	21.7
6.	HD 2985/ KH 65 -F_5- LxT- 77	400	4.18	28	24
7.	HUW 234/ CHIRYA 7 -F_5- LxT- 52	466	4.73	30	22.8
8.	HW 2045/ CHIRYA 7 -F_5- LxT- 50	544	4.21	30.8	21.6
9.	GW 322/ CHIRYA 7 -F_5- LxT- 40	504	4.87	28.3	23.1
10.	WH 730/ NI 5439 -F_5- LxT- 179	426	4.73	32	22.4
11.	WH 730/ NI 5439 -F_5- LxT- 180	462	3.45	31.4	21.9
12.	PBW 550/ SW-89-5422 -F_6-LxT- 198	468	2.51	29	22.8
13.	NW 1014/ CHIRYA 7 -F_9-LxT- 161	554	2.57	35.2	23.8
14.	SONALIKA / BH 1146 -F_9-LxT- 155	466	3.36	33.4	23
15.	HD2967	390	4.42	31	21
16.	Sonalika	818	2.10	26	24.3
C.D at 5 %		**121.7**	**1.29**	**1.78**	**1.34**

A- Area under Disease Progress Curve (AUDPC; observation at 109 days after sowing); Y- Yield (t ha^{-1}), CT- canopy temperature (observation at 104 days after sowing)

In general, resistant genotypes have significantly less (P = 0.05) disease, higher yield, less canopy temperature and more SPAD value which indicates its resistance nature. Among them, Genotype 1, 2, 3 and HD2967 had less disease whereas Sonalika was very susceptible having AUDPC of 818. Regarding yield of genotype, mostly had moderate disease except Genotype-1 which recorded 30 % higher yield than the widely cultivated variety HD2967. The canopy temperature and SPAD value at milk stage indicates that resistant genotypes have more cooling environment and higher chlorophyll content. Previous results revealed that different genotypes respond to spot blotch pathogen differentially, although most of the genotypes are moderate in their disease reaction. However, some genotypes showed high resistance response against the pathogen.

In many fungal diseases host cell walls after coming in contact with the fungus, produce or accumulate defence related substance(s) which promotes the resistance against fungal invasion. These compounds are the product of interaction of between host and pathogen, defence related enzymes such as peroxidase, polyphenol oxidase, superoxide dismutase, phenyl alanine ammonia lyase, PR- proteins (chitinase, glucanase) and phytoalexin. On the other hand, susceptible genotypes cannot produce these compounds in adequate amount to cope up with the pathogen. To explore these possibilities studies on changes in various biochemical responses associated with disease resistance in different genotypes were undertaken separately into two groups. Area of studies include a) Peroxidase activity (PO) b) Polyphenol oxidase activity (PPO) and c) Super oxide dismutase activity (SOD) in healthy and infected tissues of five different genotypes 1,3,5,8 and 10 having differential disease reaction along with HD2967 and Sonalika after 24, 48, 72 hours of inoculation.

Peroxidase Activity

The data of PO activity presented in Table 2 revealed that resistant genotypes had higher (37-73 %) levels of peroxidase activity than that of the susceptible genotype (Sonalika) at 0 hour of observation.

Table 2. Peroxidase activity (∆490/min/g fresh wt.) in selected genotype, at different intervals of inoculation

Genotype no.	0 hr	24 hr	48 hr	72hr	AUDPC
1	9.87	12.56	13.73	8.12	344
3	10.12	12.42	14.52	13.25	348
5	11.23	21.34	16.08	22.75	400
8	12.21	22.36	21.73	16.52	504
10	12.34	21.63	15.75	17.40	462
HD-2967	9.89	11.38	20.17	14.73	390
SONALIKA	7.12	8.03	7.20	6.63	818
CD at 5 %	**0.782**	**0.813**	**0.654**	**2.988**	

The susceptible plants responded to inoculation with moderate increase i.e., 24 % enzyme activity at 24 hours but at the later stage, the activity declined to (-) 6-11 % increases. The resistant genotypes responded to inoculation with pronounced increases, 27 % to 75 % after 24 hours and 39 % to 77 % after 48 hours of inoculation and 1.7- 102 % after 72 hours of inoculation. The final post-infection levels in resistant plants were higher than that of the comparable susceptible plant. The data shows that resistant genotype always had more enzyme activities than susceptible and a correlation was found between degree of resistance and stimulation of enzyme activity with minor variations.

Polyphenol oxidase Activity

All genotypes including Sonalika recorded moderate to high decreases in PPO activities following infection in different date of sowing (Table 3). In Sonalika, the enzyme activities were 88 %, 97 % and 56 % less as that of the healthy tissues after 24, 48 and 72 hours of inoculation respectively whereas HD 2967 recorded 90 %, 91 % and 43 % less activity than healthy tissues following inoculation at 24, 48 and 72 hours. The selected genotype showed same trend as that of HD 2967.

Table 3. Polyphenol oxidase activity (∆495/min/g fresh wt.) in selected genotype

Genotype no.	0 hr	24 hr	48 hr	72 hr	AUDPC
1	1.525	0.21	0.17	1.04	344
3	2.145	0.24	0.18	1.01	348
5	1.185	0.16	0.47	0.49	400
8	1.555	0.16	0.12	0.94	504
10	1.500	0.18	0.13	0.79	462
HD-2967	1.890	0.17	0.17	1.07	390
SONALIKA	1.115	0.13	0.03	0.49	818
CD at 5 %	**0.234**	**0.002**	**0.006**	**0.041**	

Superoxide Dismutase Activity

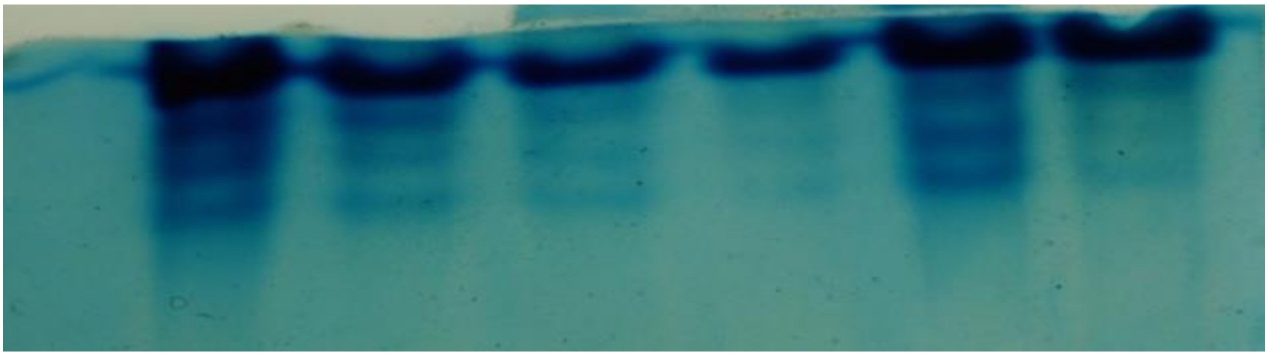
A good correlation was found between resistant genotype and stimulation of SOD activity. All genotypes showed an initial increase in SOD activity immediately after infection reaches peak at 48 hours of inoculation and then decline (Table 4). In contrast, Sonalika had less pronounced effect. The final post-infection level of SOD activity was higher (4-30 %) in resistant genotypes than Sonalika. The strongest effect was recorded in Genotype-1 followed by HD 2967.

Table 4. SOD activity (EU /g fresh wt.) in different genotype at time intervals before and after inoculation

Genotype No.	0 hr	24 hr	48 hr	72 hr	AUDPC
1	0.52	0.63	0.73	0.55	344
3	0.47	0.63	0.77	0.54	348
5	0.45	0.49	0.70	0.47	400
8	0.51	0.58	0.71	0.56	504
10	0.48	0.50	0.75	0.53	462
HD-2967	0.46	0.60	0.76	0.54	390
SONALIKA	0.43	0.46	0.59	0.43	818
CD at 5 %	**0.021**	**0.013**	**0.022**	**0.024**	

Peroxidase Isozyme Pattern

Finally, peroxidase isozyme pattern of Sonalika, HD2967 and Genotype-1 was studied in healthy and 48 hours of inoculation. The gel electrophoresis pattern is depicted in Photo A.



7 6 5 4 3 2 1

Photo A. POX gel of susceptible wheat varieties to infection by *Bipolaris sorokiana* after 64 hrs. 1= Untreated leaf (HD2967), 2= Treated leaf (HD2967), 3= Untreated (Sonalika), 4= Treated leaf (Sonalika), 5= Untreated (Genotype-1), 6= Treated leaf (Genotype-1) and 7= only buffer.

Gel Electrophoretic Separation of Crude Enzyme

Extracts and subsequent staining with benzidine reveal a complex pattern of distinct isoperoxidases. The pattern shows that following infection, more intense band was observed in HD2967 and Genotype-1 than Sonalika which indicates stimulation of peroxidase in infected resistant genotype. Among 140 diverse genotypes, 11 genotypes were identified as resistant and some of them also have the potential for higher yield. These are the additional genotype beside the earlier reports having high degree of disease resistance (Singh *et al.*, 2015, 2016; Chowdhury, 2021) Increase in peroxidase may be viewed only as a biochemical symptom of other and earlier events which actually cause resistance. The fact that specific peroxidase is increased, however, may provide some information about biochemical events preceding or associated with the development of resistance. Examination of isozyme band in connection with biochemical reaction suggested to be mediated by PO *in vivo* (lignin biosynthesis, aromatic hydroxylation, ethylene formation) can lead to a more precise description of changes induced in resistant hosts by pathogens (Almagro *et al.,* 2009). Increased activity of the SOD enzyme has been reported to induce cell dysfunction and death. Moreover, H_2O_2 has been implicated not only in triggering hypersensitive cell death but also in limiting the spread of cell death by induction of cell protectant genes in surrounding cells. The oxidative potential of H_2O_2 also contributes to plant cell wall strengthening during plant pathogen interactions through peroxidase-mediated crosslinking of proline-rich structural proteins and phytoalexin biosynthesis during oxidative burst (Scandalios, 1997).

CONCLUSION

Spot blotch of wheat, a serious constraint of South-East Asia reduces 15 % grain loss on an average. The resistant germplasm against spot blotch disease identified in this study can be excellent potential candidates to be employed for breeding resistance into the background of high yielding wheat cultivars through conventional or molecular breeding approaches and are expected to contribute toward food security at national and global level.

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Diversity of Wild Edible Fruits Consumed by the Khasi Community of Mawsynram in East Khasi Hills District of Meghalaya

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Wild edible plants (WEPs) are an important component of household food baskets all over the world. Many wild edibles are nutritionally rich which complement dietary requirements, particularly vitamins and micronutrients. The underutilized wild genetic resources of fruits species can be used for new crop species development and domestication. Hence, the present study was conducted with an attempt to document the WEFs consumed by the Khasi community of Mawsynram in Meghalaya. Using simple random sampling method, 10 households each from 12 villages were selected after survey from the study area i.e., Mawsynram Block of East Khasi Hills district, Meghalaya inhabited by Khasi indigenous community. Information on collected fruit species, local name, season of collection, mode of use and trading were recorded during 2021 to 2022. A total of 18 WEF species belonging to 14 families and 16 genera were found consumed by the community. Tree contributes the highest number of species (11) followed by shrubs (5) and climbers (2). Most of the fruit species consumed were available during monsoon (10 species) followed by winter with five species, spring, autumn and all round the year with 3 species each. The ripe fruits were mostly consumed raw (17 species), followed by unripe fruits as vegetables (8 species), pickle (4 species), spices (2 species) and medicine 1 species. The study highlighted the importance of WEF species which provide the nutritional source and livelihood. Efforts are needed to document and preserve the existing genetic diversity by incorporating them in agro- and farm-forestry and reforestation programme to improve and diversify the food base. Further proper scientific inventory and database on nutritional aspects, pharmacological prospects on WEFs is recommended for better monitoring, management and conservation.

Keywords: Wild Edible Fruits (WEFs), Khasi Community, Diet, Livelihood

INTRODUCTION

Forestry provides important service that benefits both the national socio-economic and environmental functions. The forest is home to a diverse range of trees, shrubs, herbs, climbers, epiphytes and considered as a wealth of non-timber forest produce (NTFPs). Globally, the role of NTFPs in rural development and poverty alleviation is well recognized in improving rural livelihoods and conserving biodiversity (Sundriyal and Rai, 1996; Sundriyal and Sundriyal, 2003; Sundriyal *et al*., 1998, 2003). Wild edible plants (WEPs) are an important component of household food baskets and traditional ethnic foods all over the world (Mahapatra and Panda, 2012; Mavengahama *et al*., 2013; Kumar *et al*., 2017; Wang *et al*., 2020). WEPs are those species that are neither cultivated nor domesticated but growing wild and are edible (Beluhan and Ranogajec, 2010). It includes a range of plant parts such as leaves, fruits, stems, roots, flowers, inflorescences, stems, shoots, seeds, pods, barks and mushrooms. The rich diversity of wild plant species in India offers opportunity to indigenous population in food, diet and contributes to household food security (Chakravarty *et al*., 2016; Bhutia *et al*., 2018). These plants are collected from forests or areas which are designated for extraction of resources and controlled by local communities in the North Eastern region of India.

The indigenous wild edible fruits (WEFs) collected from the wild play an important role in the food and nutritional need of rural poor and tribals. Several wild fruits have been known to have superior nutritional value than cultivated fruits (Eromosele *et al*., 1991; Maikhuri *et al*., 1997). From the past, WEFs have played a vital role in supplementing the diet of the indigenous communities. The introduction of exotic varieties of fruits led to gradual decline on the dependence on WEFs. Few of the WEFs are still popular and consumed by the indigenous communities. They are commonly consumed in raw as a supplementary diet, vegetables in making various traditional cuisines or in processed form, which aid to compensate the day-to-day calorie requirement. Several fruits are found to be sold in the rural markets providing income, employment and life support sustenance. WEFs provides a source of carbohydrates, proteins, vitamins C (ascorbic acid), A, thiamine (B1), niacin (B3), pyridoxine (B6), folacin (also known as folic acid or folate) (B9), E, minerals, dietary fiber with therapeutic potential (Quebedeaux and Bliss, 1988; Quebedeaux and Eisa, 1990; Craig and Beck, 1999; Wargovich, 2000). Many WEFs are nutritionally rich which complement dietary requirements, particularly vitamins and micronutrients (Bhutia *et al*., 2018).

They are known to provide fiber content which prevents constipation and many others ailments. It is important to document and promote research on wild fruits in order to preserve the indigenous knowledge and information for future societies for wise use and conservation (Momin *et al*., 2016). It is critical for people to understand the traditional food plants that exist in their locations and to improve for long-term food security and nutrition (Jeeva, 2009). The underutilized wild genetic resources of fruits species can be used for new crop species development and domestication. Thus, the present study was conducted with an attempt to document the WEFs used by the Khasi community of Mawsynram in Meghalaya. This is an effort to generate base line information to assist in ensuring sustainable utilization of WEFs of Meghalaya.

MATERIALS AND METHODS

Study Area

The study was conducted in Mawsynram block, wettest place on the earth of East Khasi Hills District, Meghalaya (Figure 1). .

Figure 1. Map of the study area

According to Census of India, (2011), the block has 148 villages with a total population of 54,109, of which 27,143 men and 26,966 women. The block has a subtropical highland climate with a long monsoon season and a short dry season. It receives approximately 10,000 mm of rain during the monsoon season and average monthly precipitation less than 30 mm during winter.

Sampling Methods and Data Collection

A total number of 12 villages were selected using simple random sampling method with 10 households from each village to document the WEF species collected, consumed and traded. A questionnaire survey was conducted among the Khasi community of the block, which have rich traditional knowledge about the utilization of the plant resources. A semi-structured questionnaire was used to collect demographic profile of the households and information related to WEFs along with intensive field survey assisted by the collectors, well informants or the head of the family during 2021-2022. Head of the family was generally the respondent of the survey and as Khasi community is matriarchal, mother responded to our questionnaire. In case of absence of mother during the interview any senior member of the household was interacted. Information on collected fruit species, season of collection, quantity, ethnobotanical uses, mode of use and trading were documented. The species documented were identified with the help of floras of Meghalaya, research papers, books, articles and the plant list website.

RESULTS AND DISCUSSIONS

Socio-economic Profile of the Respondents

Out of the total 120 respondents, majority were literate about 82 % of the respondents.

The primary occupation of the respondents was farming.

Taxonomical Diversity and Season

A total of 18 WEF species represented by 14 families and 16 genera were found utilized by the Khasi community of Mawsynram Block of East Khasi Hills, Meghalaya (Table 1). Rutaceae was the prominent family with four species followed by Cucurbitaceae with two species and remaining 12 families were represented by only one species each. Earlier studies from Meghalaya documented 11-151 WEF species from different localities and communities (Sewian *et al.*, 2007; Jeeva, 2009; Singh and Mathew, 2021). Similar studies from neighbouring states of Assam, Nagaland and Manipur also documented diverse species of WEFs utilized by the inhabitant indigenous communities (Narzary *et al*., 2013; Rongsensashi *et al*., 2013; Apshahana and Sharma, 2022).

The habit distribution of WEF species illustrated that the prominence of trees with 11 species followed by shrubs with five species and climbers with two species. WEPs were mostly collected for self consumption (46 %), followed by both self consumption and sale (38 %) and remaining 16 % sold in the local markets. The collection and consumption of WEFs play an important role in the indigenous community for their day-to-day life. Generally, women and children are engaged in collection from the forest and community area. The highest number of 10 species were collected during monsoon season (May-September) followed by winter season (December-February) with five species, spring (March-April), autumn (October-November) and all round the year with three species each. Monsoon being the growing season of the plants, thus the edible plants were abundantly found and collected for home consumption.

Table 1. Documented wild edible fruit species

Sn	BN; VN; F	PU	Mode of use	CT
Trees				
1	*Artocarpus hirsutus*; *Deing Soh Phan, tebrong*; Moraceae	S	Ripe fruit eaten raw and unripe fruits vegetable	May-Jun
2	*Averrhoa carambola* L.; *Soh pyrshong;* Averrhoaceae	-	Ripe fruit eaten raw and treat skin diseases	Apr-Jul
3	*Baccaurea sapida* (Roxb.) Müll.Arg.; *Soh Ramdeing*; Euphorbiaceae	-	Ripe fruit eaten raw	Jan-Dec
4	*Calamus erectus* Roxb.; *Soh thri*; Arecaceae	-	Ripe fruit eaten raw	Jun-Jul
5	*Citrus assamensis* R.M.Dutta & Bhattacharya; *Soh Myndong*; Rutaceae	-	Ripe fruit eaten raw	Mar-Jul
6	*Citurs macroptera* Montrouz.; *Chambil*; Rutaceae	-	Ripe fruits eaten raw, for pickles, cooked as vegetable	Dec-Feb
7	*Emblica officinalis* Gaertn.; *Soh Mylleng*; Phyllanthaceae	-	Fruit eaten raw	Mar-Apr
8	*Eugenia claviflora* Roxb.; *Chambu;* Myrtaceae	-	Ripe fruits eaten, for pickles	Dec-Feb
9	*Litchi chinensis* Sonn.; *Soh Manir*; Sapindaceae	-	Fruit eaten raw	May-Jun
10	*Zanthoxylum rhetsa* DC.; *Smitcheng;* Rutaceae	L	Leaves vegetable, fruits aromatic, for chutney /spice	Dec-Feb
11	*Ziziphus mauritiana* Lam.; *Soh broi/ angkil*; Rhamnaceae	-	Ripe fruits eaten raw, for pickles	Dec-Feb
Shrubs				
12	*Elaeagnus latifolia* L.; *Soh shang*; Elaeagnaceae	-	Fruit eaten raw	Apr-Jul
13	*Musa flaviflora* Simmonds; *Te rik*; Musaceae	P, St	Fruit eaten raw; stem pith cooked as vegetable	Jan-Dec
14	*Rubus elliptus*; *Soh shiah*; Rosaceae	-	Fruit eaten raw	May-Jun
15	*Solanum kurzii* Prain; *Khimkha*; Solanaceae	-	Fruit eaten raw, cooked as vegetable	WY
16	*Zanthoxylum oxyphyllum* Edgew; *Me cheng*; Rutaceae	L, S	Cooked as vegetable, seeds as spice	May-Oct
Climbers				
17	*Momordica subangulata* Blume; *Apolka*; Cucurbitaceae	-	Cooked as vegetable	May-Jul
18	*Sechium edule* (Jacq.) Sw.; *Biskot/skot*; Cucurbitaceae	L	Cooked as vegetable	Oct-Nov

Sn- Serial number; BN- Botanical name; VN- Vernacular name; F- Family; PU- Parts used other than fruits; (L- leaf; P- Pith; S- Seed; St- Stem); CT- Collection time

Consumption Pattern

The collected WEFs were utilized in various ways and forms (Table 1). The ripe fruits were mostly consumed raw as supplementary food diet which account to 17 species, followed by fruits used as vegetables with 8 species, pickle with 4 species, spices with 2 species and as medicine 1 species. The fruits are used in diverse ways such as consumed ripe fruits, cooked as vegetable, mixed with curry, eaten with salt or cooked with dry fish and processed to pickles and chutneys. The ripe fruits of *Artocarpus hirsutus* are eaten raw and raw fruits are also used as vegetable in cooking various traditional cuisines. Ripe fruits of *Averroes carambola* are consumed raw and used in making medicine for skin treatments. Fruits of *Zanthoxylum oxyphyllum* and *Zanthoxylum rhetsa* are used as spices and for garnishing in chutney, and non-vegetarian cuisines. Ripe fruits of *Eugenia claviflora, Ziziphus mauritiana* and *Citurs macroptera* are processed to pickles and preserved for future consumption and sale. The ripe fruits of *Baccaurea sapida* are available round the year. These WEPs are also traded by the collectors. Most of the WEFs are well known to the community but are rarely traded due to less market value and marketing opportunity. Nevertheless, the interest of indigenous community in wild fruit collection has reduced due to introduction and cultivation of cultivated fruits and the change in life styles.

The Use Value (UV) of the fruit species varied from 0.28 to 0.79. *Citrus assamensis* was estimated with highest UV of 0.79, followed by *Emblica officinalis* (0.74), *Calamus erectus* and *Artocarpus hirsutus (*0.71 each) while, remaining species were estimated with UV below 0.7. *Averrhoa carambola*, *Baccaurea sapida*, *Calamus erectus*, *Citrus assamensis*, *Citurs macroptera*, *Elaeagnus latifolia*, *Emblica officinalis* and *Ziziphus mauritiana* were commonly traded. *Zanthoxylum oxyphyllum* and *Zanthoxylum rhetsa* were sold as vegetable. Therefore, a greater number of collectors was involved in collection of these species to earn hard cash. It was reported that the annual rural market trade in Sikkim was approximately 140 tons of WEPs with a gross income of ₹ 15 lakhs INR (Sundriyal, 1999). During the survey, it was observed that some WEF species were grown by the households and the community in their private or community land. This practice of the community needs to be encouraged for mass plantation or for introduction in traditional agroforestry systems. The community needs to be trained to adopt sustainable harvesting practices while collecting the WEFs from the wild or elsewhere. The community should also be capacity build in value addition of these WEFs and they are empowered providing technical assistance, infrastructure and institutional support.

CONCLUSION

The Khasi community of Mawsynram in East Khasi Hills district of Meghalaya Wild consumed 18 species of WEFs. Monsoon season provides abundance of WEFs to the community. Most of the WEFs were tree based. Majority of the fruits were relished as dessert and a few were used as recipes for traditional cuisines. Fresh fruits were also sold in the local market. In addition to the fresh use, many of these fruits were value added either for self consumption or sale. Many endemic edible fruits are still unexplored which are collected and used by the local community in the area. However, due to increasing population, over exploitation and depletion of biodiversity by natural calamities and faulty land use systems, many species are on the verge of extinction. There is a need to document and preserve these species along with their associated traditional knowledge. Further proper scientific inventory and database on nutritional aspects, pharmacological prospects on wild edible fruits are recommended for better monitoring, management and conservation.

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Kerala Homegardens as a Source of Timber

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Kerala Homegardens are multispecies and multi-storied combinations of trees and crops around homesteads traditionally managed by families for food security, livelihood opportunities and ecological balance. The objective of this mini review is to critically evaluate the timber diversity of Kerala homegardens, the competence of Kerala homegardens to meet the state timber supply, challenges in adopting tree integration and sustainability of homegardens in terms of timber diversity. Timber production seems to be the most obscured value of Kerala homegardens and they are rarely taken up as a commercial venture. Besides that, tree diversity from the homegardens of Kerala is decreasing due to unscientific tree management strategies, poor market strategy, accelerated fragmentation of holdings and restrictions on timber extraction by Kerala Forest policies. The capacity of homegardens to meet the significant timber demands of society can be ensured by effective farmer awareness, species diversification, stakeholder involvement, and policy modifications.

Keywords: Agroforestry, Wood, Socio-economic change, Forest Policy, Sustainability

INTRODUCTION

Tropical homegardens are multispecies and multi-storied combinations of trees and crops around homesteads. According to Kumar and Nair (2004, 2006), homegardens are considered the epitome of sustainability. Kerala homegardens are a typical representation of tropical homegardens which are structurally diverse, functionally complex, and ecologically and economically sustainable land use practices. For the majority of households, homegardens are not just farmlands or a land use practice where crops and trees are grown deliberately on a piece of land, they act as their living space. Homegardens cover about 34 % of Kerala's geographical area with 473 species of which 44 % comprises trees (Kumar, 2011). According to the India State of Forest Report (FSI, 2021), Kerala is one of the three states of India with increasing forest cover which is mainly attributed to trees outside forests (TOF).

Trees are considered an integral component of Kerala homegardens and they are the core of TOF (trees outside forest) in Kerala. Kerala homegardens are known for their potential for attaining food security, livelihood opportunities and ecological balance. However, timber production seems to be the most obscured value of Kerala homegardens and they are not taken up as a commercial venture despite the fact that they are known for their high functional diversity. These land use practices have the capacity to meet a substantial proportion of society's wood demand thereby can also reduce the dependency on international timber imports. However, this thought of commercialization of timber species in homegarden implies a significant amount of economic value, which can trigger a paradigm shift from a subsistence economy to a market economy that can lead to the homogenization of the whole land-use practice.

On the other hand, the recent decade has witnessed an extensive erosion in tree wealth from the homegardens of Kerala (Krishnankutty and Chundamannil, 2012; Unnithan *et al*., 2017). This can be attributed to several reasons such as unscientific tree management strategies, poor market strategy, accelerated fragmentation of holdings and spatial constraints due to infrastructural development and restrictions on timber extraction from private land by Kerala Forest policies. Nonetheless, the current contribution from homegardens towards state timber supply is substantial i.e., 35.3 % (Krishnankutty and Chundamannil, 2012). Moreover, the contribution from other major wood sources such as *Hevea brasiliensis* (rubber) plantations is highly fluctuating according to the market scenario which is again creating heavy dependency on homegardens towards a consistent supply of wood. Hence, in this mini review, we tried to critically evaluate the following: (i) timber diversity of Kerala homegardens (ii) competence of Kerala homegardens to meet the state timber supply, (iii) challenges in adopting tree integration and (iv) sustainability of homegardens in the current socio-economic scenario.

TIMBER DIVERSITY OF KERALA HOMEGARDENS

Traditional homegardens functioned for local subsistence that mainly produced vegetables and other staple food crops (Peyre et al., 2006) along with multipurpose trees for fruits and fuelwood. However, the scenario is slightly different now, where farmers started to include timber species as a long-term investment. On average, Kerala homegardens have at least four timber species (Mohan, 2004). But in general staple food crops and fruit species are preferred near the living quarter of homegardens from the distant part dominated by timber species (Kumar and Nair, 2004). Now-a-days, the fully grown timber species occupy the upper most layers of the land use practice along with *Cocos nucifera* (Coconut palms) and *Areca catechu* (Arecanut palm). A variety of timber species are prominent across the homegardens of Kerala (Table 1). It is pretty evident that framers started to favour economically potential timber species and took it as a criterion in tree integration of homegardens especially fast growing, high yielding, multipurpose (fruits, fuelwood, pulpwood, and timber) and less labour-intensive timber species.

Table 1. Source of major timber species processed in sawmill industry of Kerala

Timber species	***Volume**			**Source of timber supply**
	C	**E**	**TT**	
Jack Tree	195	0	195	Homegardens
Wild Jack	113	1	114	Homegardens
Teak	76	14	90	Homegardens and forests
Coconut palm	76	0	76	Homegardens
Mango tree	8	0	8	Homegardens
Rosewood	5	2	7	Homegardens and forests
Other domestic timbers	95	61	156	Homegardens
Imported timbers	58	0	58	Import
Total	626	78	704	

C- Construction; E- Export; TT- Total timber; *Volume in thousand m^3 of round wood; Source: Krishnankutty *et al.*, 2008

Earlier *Artocarpus heterophyllus* (Jack tree) and *Mangifera indica* (Mango tree) dominated the homegardens, grown for both fruit and domestic timber requirements (Krishnakutty *et al.*, 2008). Whereas recent studies by Kunhamu (2015) and Unnithan *et al.* (2017), reported that timber species have been emerging as the most prominent functional group of trees over fruit species, 43.45 and 32% respectively. Of the economically important trees, Jack tree and *Tectona grandis* (Teak) found to be the prominent species of selected homegardens (Unnithan *et al.*, 2017). Teak is a high quality and high-value timber species of Kerala which recently earned a GI tag and Jack tree is another premium timber used for construction and furniture manufacturing. Other timber species such as *Swietenia macrophylla* (Mahogany), *Artocarpus hirsutus* (Wild Jack), *Ailanthus triphysa* (Ailanthus) and *Dendrocalamus strictus* (Solid bamboo), constitute the garden bunds and boundaries (Kumar and Nair, 2004; Chandrashekara and

Baiju, 2010). Very valuable timber species such as *Dalbergia latifolia* (Rosewood) and *Santalum album* (Sandal) were also reported from the homegardens (Krishnakutty *et al.*, 2008). There is a gradual change in farmer's choice where, timber species such as Teak, Jack tree and Ailanthus were preferred over fruit species. This is supported by Unnithan *et al*. (2017) and Kumar (2011) in which the highest frequency distribution was found to be Ailanthus, Jack tree, and Teak respectively. Even though timber trees received less attention in tribal homegardens, 7 % of the tree species contribute to domestic timber requirements with species such as *Albizia chinensis* (Chinese Albizia)*, Grewia tiliifolia* (Dhaman), *Tectona grandis* (Teak) and *Mitragyna parvifolia* (True Kadam) (George and Christopher, 2019).

Even though more than 50 % of Kerala homegardens are dominated by coconut palms (*Cocos nucifera),* the potential of coconut palms as a timber species has not yet been explored. The construction industry of Asia-Pacific is the fastest developing industry where coconut wood has a higher demand (Anoop *et al*., 2011). Traditionally coconut palms were considered as an oil crop. Recent studies indicated that properly seasoned coconut wood can substitute conventional timber species at a lower cost since they are comparable in durability, sturdiness, and versatility (Anoop *et al*., 2011, 2018). The scope of income and livelihood security derived from the utilization of coconut wood in homegardens is significant and is economically and socially attractive. However, the demand for coconut timber has not yet reached to farmers. They still consider the wood of coconut as good fuel wood and nothing more. Thus, functional diversity of tree species in Kerala homegardens is still untapped.

We agree with the argument put forward by Unnithan *et al.* (2017), that species diversity is related to the functional priorities of farmers along with regional variations and geographical conditions. Though farmers started to integrate timber species in homegardens, they have underrated their market scope. There is now a trend to grow profitable cash crops such as rubber and oil crops on this land-use practice replacing traditional tree species to increase productivity. However, in Kerala, the bright sunshine with ample rainfall provides the ideal environment for timber tree species. As Krishnankutty *et al.* (2008) stated, Kerala homegardens have the potential to yield more growing stock with a relatively high level of wood production by taking into consideration these natural advantages. Therefore, it is evident that Kerala homegardens are potential sources of timber and have the ability to reduce the pressure on timber imports and natural forests for state timber demand.

STATE TIMBER SUPPLY

The competence of Kerala homegardens to meet state timber supply in the current socio-economic scenario is unquestionable. But the economic potential behind the standing stock of homegardens is unrecognized. Green felling from natural forests is banned by the Forest Conservation Act (GOI, 1980) in the state which altered the demand and supply of the timber industry. Even though state forest harbors about 817 tree species of which 144 are timber species (Anoop *et al*., 2018); forests could only provide 10 % of the state timber demand (Krishnakutty and Chundamannil, 2012). Approximate, the timber demand of Kerala was about 2228000 m^3 where the major supplier of timber in Kerala was TOF (approximately 75-80 %) of which homegardens alone contribute about 35.3 % (Krishnankutty and Chundamannil, 2012).

Earlier the homegardens were the major supplier (45-65%) (Krishnakutty *et al*., 2008) of state wood demand and since 2001, rubber plantations surpassed their production (Table 2) (Krishnankutty and Chundamannil, 2012). Besides TOF, recent years have also witnessed the dramatic increase in timber imports. Despite being considered Kerala as the land of Teak, interestingly, the state has seen the highest import of Teak during the last couple of years especially from Myanmar (Krishnankutty *et al.*, 2008). The total import increased from 2,84,000 m^3 in 2010-11 to 4,20,000 m^3 in 2011-12 (Krishnankutty and Chundamannil, 2012). Almost 96 % of the total teak import was from other nations. Earlier it was traditional homegardens which were the major source of Teak timber in the state. The decline in large-sized teak trees may be due to over-exploitation of immature trees (Anoop *et al*., 2018).

Table 2. Supply of timber and industrial wood from different sources in Kerala

Sources	Volume (in ’000m^3 round wood)		
	1987-88	2000-01	2010-11
Homegardens	830	790	785
Rubber plantations	599	817	1038
Forests	156	75	35
Interstate imports	78	143	154
International imports	106	159	216
Total	1769	1984	2228

Source: Krishnakutty and Chundamannil, 2012

Even though the contribution of imports is increasing, it is approximately 15 % of the total timber supply of the state and remaining is provided by homegardens and rubber plantations (Unnithan *et al.*, 2017). Even though mature Teak from homegardens is decreasing, the results of Unnithan et al. (2017) states that the Mango tree possessed the highest standing volume (12.76 m^3/ ha), followed by Teak (10.65 m^3/ha) and Jack tree (10m^3 /ha) in the homegardens. In this study standing stock of coconut palm is not considered and its potential to act as timber resource is ignored. According to Kumar *et al.* (1994), the average standing stock of timber ranged from 6.6 to 50.8 m^3/ha from homegardens of which coconut palms constituted the principal component. Though here coconut palms are considered for growing stock assessments, they were not recognized as timber species. If there is a trigger for coconut lumber supply from homegardens, the contribution of homegardens to the society’s timber demand will rise and surpass all other timber sources of Kerala.

CHALLENGES IN ADOPTING TREE FARMING

Kerala farmers are still disorganized when it comes to tree integration on farmlands. They are highly market driven. The recent increase in rubber plantations; although highly labour intensive, the economic advantages of the crop in the market have replaced most of the indigenous timber species in the homegardens of Kerala. This argument is supported by Unnithan *et al.* (2017), where they found that rubber trees had replaced timber trees like *Terminalia paniculata, Caraea arborea, Bridelia retusa, Dalbergia latifolia, Terminalia tomentosa* and *Calophyllum inophyllum*. Thereby found an extensive loss of tree wealth from Kerala homegardens. The frequency distribution of timber trees declined substantially due to the accelerated fragmentation of homegardens. This is mainly due to the absence of a market strategy for homegarden timber trees. Even today, farmers have not realized the economic potential of timber trees in their farmland. They grew timber species as long-term investments and pay them the least attention. According to Krishnankutty *et al*. (2008), timber species of homegardens are under severe threat due to the expansion of road networks. Timber species that would usually occupy the boundaries within homegardens are eliminated by the widening of roads to support the increase in vehicle density. These are not a severe concern for farmers may be due to the government disincentives faced by them for adopting tree farming.

The Kerala Forest Produce Transit Rules, 1975 and the Kerala Preservation of Trees Act, 1986 impose restrictions on timber harvesting from private land (Guillerme *et al*., 2011). Although the 61 tree species do not require a pass and are exempted from rules, species of high-quality timber such as Teak, Rosewood, and Sandal are, however, covered under this rule. These policies prevent farmers from adopting tree farming. Since tree farming is a long-term investment, conflicting perceptions of policymakers and farmers influence profitability and hence decision-making (Guillerme *et al*., 2011). Besides the policy restrictions, farmers are also averse to planting trees due to the lack of institutional support, especially concerning quality planting stock availability, financial assistance, and marketing of timber products (Kumar and Peter, 2002). According to Peyre *et al.* (2006), even if farmers integrate trees, most of the management practices are concerned only with the tree environment and that of the economically profitable cash crops like rubber. Most of the valuable timber species in the homegardens such as Teak and Rosewood receives the least attention and its productivity solely depends on the natural ecological interactions. The largest scope of future tree incorporation in tropics is homegardens, primarily due to spatial constraints. Simons and Leakey (2004) found that in developing countries, when farmers worked directly with the end users, they earned more economic advantages. This can make a change in the world of agroforestry, where farmers focus on cultivating trees for cash. Kumar and Peter (2002) throw light on the essential amendments required for forest policies to enhance tree adoption. The agroforestry tree domestication is not only a market-led process but also a farmer-driven approach. Therefore, government policies should alleviate the disincentives for the adoption of tree farming, develop timber trade consortium and should make them aware of the scientific tree husbandry and management strategies.

SUSTAINABILITY OF KERALA HOMEGARDENS

Currently, the internal sustainability of homegardens is under question due to the intensification of monoculture, especially of attractive cash crops like rubber. The spatial constraints faced by a developing state such as Kerala is yet another problem. The cultural transformation due to globalization and changes in the diet and infrastructure development undermine the stability of the land use practice that can eventually reduce the dependence of smallholding farmers on the homegardens. The land is a highly valuable property in a land deprived state like Kerala (Kunhamu, 2013, 2015). The unprecedented escalation in the land opportunity costs due to development opportunities and labour costs has resulted in the massive conversion of the present homegardens (Kunhamu, 2013). Yet another problem is the expansion of residential buildings that reduces the net homegarden area. Besides all these challenges, the commercialization and market pressures can put the diversity of homegardens under threat (Jose and Shanmugharatnam, 1993; Kumar *et al*., 1994; Kunhamu, 2015). It is a fact that economic value is a strong determinant of the preferences for certain species (Kumar and Nair, 2004; Kunhamu, 2013).

The deliberate integration of trees in the farmland to increase economic potential is a threat to the sustainability of homegardens. As per Peyre et al. (2006), modernization of homegardens with a higher focus on the limited number of cash yielding trees leads to the homogenization of the structure and function of homegardens. The threat behind high incentives on timber tree farming is that it may lead to a drastic decline in the functional diversity of homegardens as witnessed in the case of cash crops. This is supported by Kumar (2011), in which he stated that ‘Teak Boom’ in Kerala has the ability to reduce species diversity of its homegardens eventually. Wood resources in Kerala homegardens are declining at the same time; increased incentives on tree farming have the potential to transform floristically rich homegardens to monoculture plantations. One of the solutions is to develop an exclusive market for homegarden products. As a pioneering step, the National Agroforestry policy (GoI, 2014) provides 10 strategies for the promotion of agroforestry which holds good for homegardens, and state-level modifications were suggested by conducting a stakeholder meeting in which farmers were the integral component.

CONCLUSION

There is no doubt that homegardens are the major source of timber in the state of Kerala. However, there is a severe decline in the structural and functional attributes of this land use practice in Kerala owing to various factors. Recent depletion of tree species in homegardens is already raising the questions of the contribution of imports to help meet the supply and demand of the state. Concerted efforts are essential for the revival of these unique land-use practices to regain their lost tree diversity. Therein lays the importance of possible domestication of timber yielding species. Adoption of tree farming by farmers should be supported by government policies that should include the awareness of the contribution of homegardens to not just timber, but also food, fuelwood and medicine, and take into account their ecological and economic sustainability along with incentives for tree integration on farmlands. Practical support for sustaining the tree-dominated homegarden system should include the production and supply of quality seedlings of native trees. One of the strategies to relieve homegardens from the clutches of market demands is adding more value to homegarden products through organic certification. Therefore, ecologically rich and economically sustainable homegardens that can function as loci for experimenting with new tree domestication programs can be considered as a model for agroforestry extension that seeks alternatives for agricultural development. The revitalization of the Kerala homegardens with deliberate integration of the right amount of economically viable tree species such as bamboos which are important for economic benefits and ecological security is considered as the need of the hour. However, demonstrable models of homegardens for small and large farmers are in dearth now. Though homegardens are facing a lot of challenges, still they have the potential to meet the considerable timber demands of society.

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Reviewing the Adaptability of Pure and Mixed Norway Spruce Forests to Climate Change in Central Europe

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Climate change is an inevitable challenge to forest managers around the world. Adaptive forest management allows forests to cope with the changing climate. Norway spruce is an important tree species with significant production and economic value in Central Europe. However, climate change resilience of the species is doubted nowadays especially after severe wind damages and bark beetle infestation in many parts of Europe. This review aims at comparing monoculture Norway spruce forests to mixed Norway spruce forests in terms to their performance against climate change and resulted disturbances. The studies from different parts of Central Europe followed different techniques such as tree ring studies, forest damage surveys, survival analysis. All the studies reviewed here suggest that mixed Norway spruce forests outperform monocultures during droughts, storms, or bark beetle infestations. Thus, we suggest that mixed forests as a silvicultural solution for better climate change adaptation.

Keywords: Climate change, Adaptation, Monocultures, Mixed forests, Native species

INTRODUCTION

Unforeseen natural events which are severely increasing in many regions of the world are threatening the survival of many native species (Bottero *et al.,* 2012). The ability of a species to maintain fundamental ecosystem processes under disturbances such as changing climate is its resistance. Managing the forests to improve its resistance and thus better adapt to varying environments is of utmost importance considering the ecosystem services provided and their role in the carbon cycle (Rai *et al*., 2021). Considering its extended time frame, all decisions in forest management will have a different outcome in future climate. The forestry sector has significant roles in the national and rural economy, providing jobs and income for forest owners, forest workers, logging firms, and various forestry-related services and industries. Projected climate change changes the mean climate parameters, such as temperature or precipitation, and results in changes in the frequency and magnitude of extreme weather events (Kjellström, 2004). Forest adaptability to climate change can be achieved through a variety of silvicultural measures such as changing the species composition (pure versus mixed), changes in forest structure (even versus uneven aged, coppice versus high forests, single strata multiple strata), intensified thinning or reducing rotation length (Yousefpour *et al.*, 2017).

Natural distribution of Norway spruce (*Picea abies*) ranges from Serbia to Fennoscandia through the Baltic countries all the way to the mountain ranges of Central Europe (de Vries *et al*., 2015). To a large degree it is an introduced species in Central Europe and due to its high economic value, it is a dominant tree species. Norway spruce is generally intensely managed and raised as monocultures or pure stands. When a single species constitutes 80 % of the stand, they are called pure stands. Climate change is affecting the viability and survival of Norway spruce throughout its range. Studies report that in the past decades, the vulnerability of Norway spruce forests to drought stress and storm damages has increased (Zang *et al.,* 2014; Seidl *et al.,* 2014a). Major storm and drought damages in turn have triggered more European spruce bark beetle (*Ips typographus* L) infestations. Climate change also directly affect bark beetles by increasing their generations, reducing winter mortality and reducing the fitness of host trees (Huang *et al.,* 2019). Norway spruce is generally looked upon as a failure in climate change and this review is a way to figure out if converting pure spruce forests to mixed forests would help address this issue. Change in tree species composition or managing forests for biodiversity is widely accepted as an effective silvicultural management strategy to adapt to climate change. This literature review aims to understand if mixed Norway spruce forests are more resilient to climate change than monocultures. The goal of this review literature is to collect information about the climate change adaptation of Norway spruce forests in pure and mixed stands. The hypothesis is that Norway spruce in mixed forests is less affected by climate change than in pure stands. The review tries to address climate change induced droughts, storms, and insect damages and their effects.

MATERIALS AND METHOD

The literature review of understanding the vulnerability of pure and mixed Norway spruce forests to climate change was carried out using Scopus as the search engine. The following keyword combination were used during the process; "climate change" AND “adaptation" AND "Norway spruce" AND "Europe" AND "mixed" OR "mixture" OR "pure" OR "monoculture". This gave 1587 document results. We thought to focus on climate extremes like storm damage, droughts, and secondary damages caused due to insect special focus in the review. With this in mind we created an additional keyword search for Title and abstract. These are the keyword combinations we used; "Norway spruce" AND "storm" OR "wind" OR "insect" OR "beetle" OR "drought". This search yielded 104 research papers. These publications were then screened through and many publications focused on forest management, yield, and mortality, climate change adaptability of tree species without comparing pure and mixed stands. This was selected as other criteria to screen through and later we chose the publications from Central European region. Not all papers identified in this search are referenced. Four publications dealing with drought, wind damage, and bark beetle attack of Norway spruce and how the effects vary in pure and mixed stands were finally selected after scanning the abstracts and results of all relevant papers.

RESULTS AND DISCUSSION

Cosofret and Bouriaud (2019) in a literature review of silvicultural measures recommended to adapt forests to climate change identified 12 options of adaptive silvicultural practices and measures. The two most frequent practices reported by them were “mixed tree species composition” and “increase thinning intensity” (Figure 1). Neuner *et al*. (2014) studied the effect of climate change on production risks of Norway spruce and how it varies in mixtures and pure forests. The study accepts the hypothesis and reports that a 24% decrease in survival probability of Norway spruce at age 120 in a pure stand compared to a 7 % decrease in survival probability in species admixtures when unfavourable climate conditions were assumed. The study used forest damage survey (FDS) assessment and observations recorded from 2334 plots between 1995 and 2005. Monthly precipitation and mean temperature were the climate variables considered. Kaplan Meier survival analysis (Kleinbaum and Klein, 2012) also showed that rotation periods in pure stands would have to be shortened to 85 years or 90 years (under unfavourable and favourable conditions, respectively) to achieve survival probabilities like mixed spruce stands at age 120.

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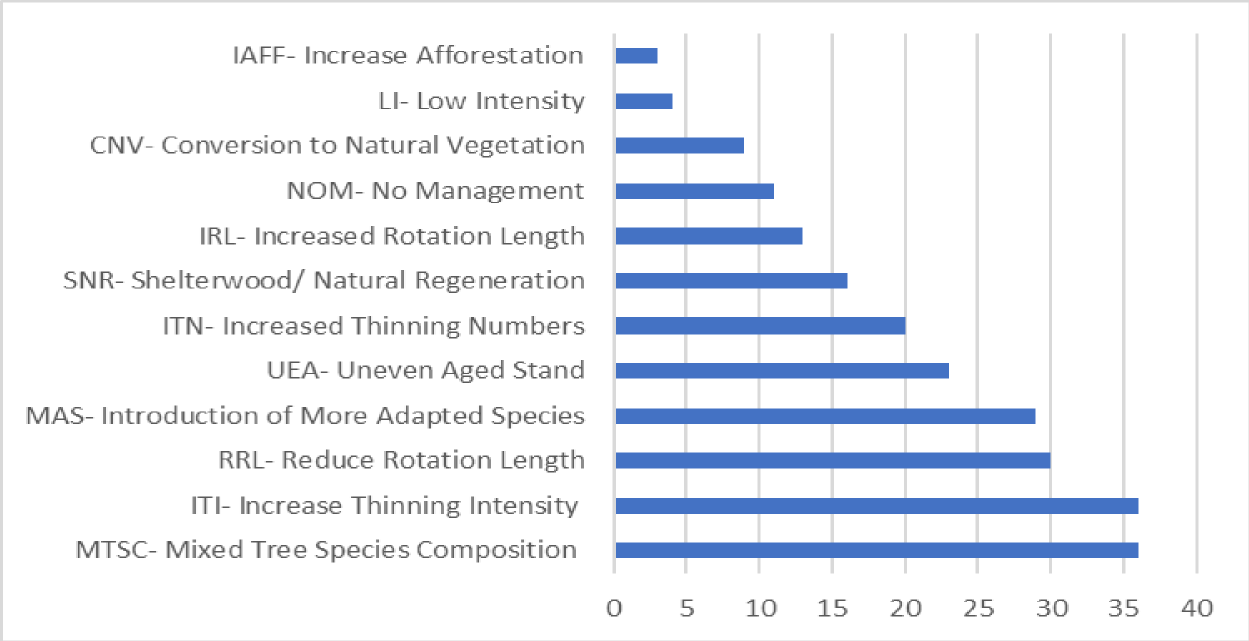

Figure 1. Recommended silvicultural practices for climate adaptation (The number to the right indicates the number of articles which recommended that particular practice; Cosofret and Bouriaud, 2019)

In another study conducted in South Germany, tree ring measurements from increment borings of mixed and pure stands of Norway spruce was used to understand tree growth reactions to episodic drought stress in 1976 and 2003. The spruce mixture performed better than spruce monoculture in terms of indices of resistance and resilience (Pretzsch *et al.*, 2013). The study also reports that the species choice for mixtures also affect the performance against drought. In this work they found that beech and oak mixtures of spruce perform differently. Dobor *et al*. (2020) studied the vulnerability of pure and mixed Norway spruce forests to wind damages and beetle disturbances in Central Europe. The study says that as climate change amplifies pure stands of Norway spruce in Central Europe would not sustain without changing the management strategy. The iLand ecosystem model was adopted to understand the interplay between species composition of the forest and forest disturbance dynamics affected by climate change through simulation. Sharp decline in Norway spruce throughout the simulation period was recorded even with moderate climate change. The study also points out the importance of active management of forests in light of climate change. Juha *et al*. (2020) also verified the hypothesis by reporting that dispersing Norway spruce throughout the landscape in mixed stands resulted in the highest levels of climate resilience. The study also focussed on how adaptation measures focus largely on the stand level, and why we should focus on modifying landscape composition and configuration to foster Norway spruce resilience. The study also reported that reducing the percentage of Norway spruce in that landscape increased the resilience of the remaining trees to climate change and natural disturbances.

Neuner *et al*. (2014) clearly demonstrated that spruce in mixed stands was much less affected by adverse climate than in pure stands, thus can be adopted as a climate change adaptation measure. The higher variation in tree ages must have also contributed in higher stand resistance (Hanewinkel *et al.*, 2014) as beech are regenerated earlier when in mixtures than spruce as beech grows slower. Also considering the production risks, mixtures are preferred over pure spruce stands as provisions for other ecosystem services such as recreation and protection will increase in a near-natural, mixed and longer-living forests (Edwards *et al.*, 2012). Another reason why pure Norway spruce is adversely affected by droughts and warmer weather can be attributed to its shallow root system. In such pure stands the water uptake and roots concentrate in the upper soil layers compared to deep roots in beech. This results in lesser competition between the two species in mixtures as they do not share the same root space. When multiple species interact, they also tend to have positive effects by hydraulic lift of one species (Dawson, 1993).

Drought events and soil nutrient limitations will be accelerated with climate change (IPCC, 2007) and thus such multiple species interaction can be beneficial especially in nutrient poor and dry soils. This was reported with multiple species mixtures of Norway spruce which responded differently (Pretzsch *et al*., 2013). Monoculture spruce plantations are very vulnerable to wind and beetle disturbances and the contrast in vulnerability between pure and mixed forests is further amplified by climate change. This is reported by studies from Slovakia (Dobor *et al*., 2020) and eastern Austria (Juha *et al*., 2020). Climate change has resulted in increased instances of bark beetle outbreaks in Europe and has caused more damage than wind or wildfires (Seidl *et al*., 2014$_b$). Also, the wind and bark beetle damages are expected to increase in the future as the structural composition of forests change in climate change. Droughts also will result in increased cases of bark beetle disturbances as the drought stressed trees would lack the capacity to defend themselves against bark beetles. A silvicultural practice adopted to reduce the beetle infestation is to reduce the number of host trees, which can be achieved by mixed forests. Removing substrates for beetle breeding, thinning, harvesting vulnerable trees are also practiced. This review has only focused on two situations- monocultures or mixed Norway spruce forests. The different species compositions possible, how the disturbance affect when the species in mixtures vary, how site conditions contribute to their performance against climate change, how does thinning regime and rotation lengths affect the outcomes are not addressed in this report. Studies comparing different mixed forests will have to be reviewed to understand which species combinations perform better in Central Europe under climate change.

CONCLUSION

`Choosing best silvicultural measures to manage monoculture Norway spruce forests are of paramount importance under climate change. This report reviews the outcomes of adopting the silvicultural practice of mix tree species composition instead of Norway spruce monocultures. The studies report a positive effect of using a range of different species for mixed stands are more resilient to disturbances. This makes it one way of adapting forests to climate change. Climate extremes and events caused by climate change such as droughts, storms and bark beetle infestations were analysed to find out how the Central European production forests respond to this management measures. These findings can result in effective management of Norway spruce monocultures under current and future climate change. The silvicultural conversion of monocultures to mixed stands can be achieved through rapid conversion by clear-cutting and subsequent planting or conversions maintaining a continuous cover. The adaptability of mixed stands also depends on the site conditions, species composition, regeneration, and competitions prevailing there.

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Nationalization of Non-Timber Forest Products

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Non-timber forest products (NTFPs) have been reported to be crucial for the livelihood development of forest dwellers socio-economically and culturally. The Forest Rights Act, of 2006 recognizes the "right of ownership, access to collect, use and dispose of minor forest produce." Yet, the indigenous and local people dependent on forests remain underprivileged and impoverished. The use of NTFPs has received attention due to their potential to address both poverty reduction and tropical forest conservation. Although non-timber forest resources were recognized as valuable for peoples' sustenance, their economic value is rarely considered in forest planning and or in accessing Gross Domestic Product. The potential economic value of NTFPs either in terms of utilization or their market value is often underestimated or unknown. NTFP certification may be a step forward in this direction and is being suggested and explored in India as well. Strategies such as value-added markets through certification or eco-labeling have shown to be successful in developing countries of Latin America and Africa resulting in increased income, security, stronger socio-economic status, and positive conservation outcomes. The minimum support price (MSP) for NTFPs will help enhance the income of collectors thereby improving the quality of forests. Resource mapping aids the policymakers to establish procurement and value-addition centers at minor market levels, improving income whilst encouraging sustainable harvesting. By acquiring a proper infrastructure and the latest marketing strategies, the net value realization of the forest dwellers can be improved remarkably, so they can also participate in the rising tide of country's economy.

Keywords: NTFP, Minimum support price, Economy, Livelihood, Value addition, Market

INTRODUCTION

Non-Timber Forest Products (NTFPs) are the biological products and services collected mainly from forests, and other associated tree-based land use systems (Bauri *et al*., 2015). About 40 % of the poor people, mostly the indigenous communities reside in and around forests of India and are dependent on NTFPs for their livelihood (Pandey *et al*., 2016). NTFPs were reported crucial for the livelihood development of forest dwellers socio-economically and culturally (Bhatia and Yousuf, 2013; Lepcha *et al*., 2018, 2020). The Forest Rights Act, of 2006 recognizes the "right of ownership, access to collect, use and dispose of minor forest produce," yet the indigenous and other local people dependent on forest remain underprivileged and impoverished (Sharma *et al*., 2018). The use of NTFPs has received attention due to their potential to address both poverty reduction and tropical forest conservation (Chilalo and Wiersum, 2011). However, their value still remains underestimated or unknown (Wickens, 1994). Moreover, most of the research on NTFPs is on medicinal plants but very less on other forms of NTFPs (Basumatary *et al*., 2014; Lepcha *et al.,* 2018).

Information about markets, together with the capacity to act upon them, is an important prerequisite for entering and maintaining a hold in new markets. Regardless of the governance in the value chain, the ability to negotiate prices and define the rules of trade is vital in determining the satisfaction levels of the poor producers, processors, and traders in the NTFP value chain (Marshall *et al*., 2006). A small volume of NTFP collection is a problem leading to small market sales thereby leading to a low market surplus (Yadav and Misra, 2010). The NTFP market being unorganized and uncertain market demands make it difficult to thrive with just one or two items only.

The local market being geographically limited, collector's access to direct consumers is always limited to sales in nearby villages or weekly markets, therefore a major portion of the collection is taken by the middlemen of the area who sell it to wider markets and big-scale sectors (Yadav and Misra, 2010). Lack of value addition at the primary level causes the primary supplier and collectors to lose a substantial part of the possible income (Lahiri, 2018). Modernization and unethical development in the sector have shown a steady decline in the market which in the end affects the rural community (Gharai and Chakrabarti, 2009). The already small market of NTFP is split into numerous smaller markets aiding specific local areas and availability (Vidale *et al.,* 2014). This makes the business more susceptible to failure (Belcher and Schreckenberg, 2007).

About a quarter of the world's population are indigenous forest communities directly or indirectly depend upon forests for their day-to-day needs due to their poor economic conditions (Alex *et al*., 2016; Lepcha *et al*., 2018; Shackleton and Pullanikkatil, 2018). About 150-200 million people belonging to indigenous groups in over 70 countries, mostly in the tropics, depend on NTFPs to sustain their way of life, including their culture, religious traditions and for commercial purposes (Dey and De, 2010; Bauri and Mukherjee, 2013). India has an indigenous population of 42 million of which some 60 % live in forest areas and depend on forests (Yeshodharan and Sujana, 2007) and it is estimated that in India about 800 species are consumed as wild, edible plants, chiefly by these indigenous communities (Bandyopadhyay and Mukherjee, 2009; Dolui *et al*., 2014; Lepcha *et al*., 2018). Non-Timber Forests Produces (NTFPs) are key resources of livelihood for indigenous/fringe communities as they generate employment, provide income, reduce poverty and grant a dignified living while also insurance to them during scarcity periods (Suresh *et al*., 2014; Bauri *et al*., 2015; Verma and Paul, 2016) and its resource potential for future generation through associated traditional knowledge (O'Neill *et al*., 2017).

NTFP acts as a complementary or a primary alternative to timber harvesting and industries of similar resources (Nguyen *et al*., 2020). Although non-timber forest resources were recognized as valuable for peoples' sustenance, their economic value is rarely considered in forest planning and or in accessing Gross Domestic Product (Van Andel, 2000). The potential economic value of NTFPs either in terms of utilization or their market value is often underestimated or unknown (Murthy *et al*., 2005). Unfortunately, cash generated from the sale of non-timber forest products may vary tremendously, even for the same resource category (Tewari and Campbell, 1996). These omissions and misfortunes need to be corrected, as NTFPs make significant contributions to rural household incomes and a nation's productivity. At the same time, it is essential to exercise great care in valuing non-timber forest resources to avoid over-optimistic assessments (e.g., the value of NTFPs is significantly greater than the value of timber) or over-pessimistic estimations (e.g., NTFPs only have real economic value in domesticated extensive context). Objective valuation studies involving and based on the preferences of local users probably is a first step in correcting omissions and misfortunes about NTFP values (Shiel and Wunder, 2002).

Research related to NTFPs and their impact on livelihood were primarily been carried out in the Reserved forests of tropical and temperate regions (Mahapatra and Tewari, 2005; Lepcha *et al*., 2018, 2020). The potential economic value of NTFPs either in terms of utilization or their market value is often underestimated or unknown as its commercial importance has rarely been carried out (Roy, 2003; Murthy *et al*., 2005). The importance of NTFPs is now increasingly gaining global academic and policy attention due to their contribution to marginal household economies providing them empowerment (Sawian *et al*., 2007; Jhonson *et al*., 2013; Chakravarty *et al*., 2016). The available studies on NTFPs mostly reported general statements on the use to quantify its value comparing across collections and locations but rarely on its economic importance or market value and its marketing mechanisms (Dawson *et al*., 2014).

CLASSIFICATION AND UTILIZATION

There is no universal standard system of classification for NTFPs and thus were classified differently in different regions based on the end use of the products like medicine, food and or any other thing or on the parts used like root, bark, and flower (Shiva and Verma, 2002). NTFPs were generally collected by rural and forest fringe communities in African, Asian, and other developing countries for food, fuel, medicines, decorative purposes, construction materials, fodder, industrial raw materials, and spices (Faye *et al*., 2010; Heubach *et al*., 2011). NTFPs documented from the moist deciduous forest zone of West Bengal were classified into 23 major categories which included dyes, grasses, oil, wax, honey, gum, resin, food items (leaf, fruit, seed, herb, stem), bamboo, broom, basket, cotton and leaves of Sal and Kendu (Bauri *et al*., 2015). Moreover, a thin line of difference exists between NTFPs collected from natural forests and those from human-influenced systems (Ahenkan and Boon, 2010).

The utilization of NTFPs varies from region to region based on their availability and traditional knowledge associated with it and was utilized both for domestic and commercial purposes (Bauri *et al*., 2015). NTFPs of both plant and animal origin were generally utilized for food, medicine, handicraft, and construction in Asia (Dattagupta *et al*., 2010) where about 800 plant species were reported edible (Bandyopadhyay and Mukherjee, 2009). In India 20 % of the recorded 15 thousand plant species have NTFP uses (Bauri *et al*., 2015) but only 126 species (8 %) were reported to have commercial value as NTFP (Maithani, 1994). Indigenous communities in India were reported to use over 500 plant species as food, fodder, dyes, medicinal, drinks, house construction, decoration, and small implements (Chaudhury, 1986; Uprety *et al*., 2016).

A recent study from Himachal Pradesh reported 811 NTFP species with significant potential for the State and was categorized into 18 use types (Masoodi and Sundriyal, 2020). The forest dwellers of Himachal Pradesh were reported to use these NTFPs as whole plants, roots (including rhizomes and tubers), leaves, flowers, fruits, seeds, stems, and barks. NTFPs were prominently collected from the warm temperate zone of Himachal Pradesh followed by temperate, sub-alpine, sub-tropical, and alpine zones. Most of these collected NTFPs were utilized as folk medicine (61 %), while others were used as food or as fodder. In North-East India, out of 129 species of NTFPs reported, 39 species were edible, 46 were medicinal plants and brewing herbs, 24 species were used for building materials and 13 species were animal-based NTFPs (Tiwari, 2000). Indigenous communities of Inner Line Reserve Forest (ILRF) Cachar, Assam used 28 species of plants and animals as food for domestic consumption, 26 plant species as traditional medicine, 14 plant species for house construction, 13 plant species as firewood, and 10 species as a trophy (Dattagupta *et al*., 2010). In Arunachal Pradesh, six bamboo species were used for house construction, while fruits and other plant parts of 60 wild species were edible and 40 plant species were used for worship (Tiwari, 2000). Similarly, another study from Arunachal Pradesh reported the utilization of leaves from 54 plant species, stems of 30 species, fruits of 22 species, rhizomes/roots/tubers of 13 species, seeds of eight species, flowers of five species, shoots of four species and bark of three species (Sharma *et al*., 2015). Among these documented NTFP species, 41 % were medicinally utilized, 35 % were utilized as food, 10 % for construction purposes, and 6 % were used as firewood. In Mizoram wild fruits of 44 plant species were edible, 39 species were used for making furniture and 89 species were used for other purposes (Lalfalzuala *et al*., 2007; Bhardwaj and Gakhar, 2008).

In West Bengal, NTFPs were categorized into 23 major forms which include different types of dyes, grasses, oil, wax, honey, gum, resin, food item (leaf, fruit, seed, herb, stem), leaves (like Sal and Kendu), bamboo, broom, basket, and cotton which were utilized both for domestic and commercial purpose as medicine, food, fuel-wood, fodder, cottage industries (handicrafts), construction, industrial materials and different religious and rituals (Behera and Nath, 2012). Indigenous communities of Midnapur forest, West Bengal prominently used NTFPs as food (44 plant species) followed by fuel-wood (39 species) and only 18 plant species as traditional medicine (Malhotra *et al*., 1991). Another study from Paschim Midnapur district of West Bengal documented the utilization of 39 NTFP species for self-consumption and 27 commercial NTFP species like Sal leaves and seeds, Kendu leaves, Mahua flowers and seeds, mushrooms, and tubers, while 47 species were used as traditional medicine (Shit and Pati, 2012). Fringe communities of Gorumara

National Park were reported to utilize 209 plant species as traditional medicine including 45 as veterinary medicine, 57 plant species as food, 20 plant species for religious purposes, 19 plant species as poisonous substances, 54 plant species as fuel-wood, and 260 plant species as fodder (Saha *et al*., 2014).

MARKET AND ECONOMICS

Traditional markets are a hub of the indigenous community to earn hard cash for the NTFP produce and collections through sales, and also an important place to share traditional knowledge on the usage of plants and their conservation (Williams *et al.,* 2000; Mertz *et al.,* 2001). The process for NTFP trading still remains traditional with negligible trading where few collectors are involved and generally don't worry about the extracted quantity of their produce (Wagh *et al*., 2010). Although NTFPs were recognized as a valuable resource of livelihood for rural and indigenous communities, their economic value is rarely taken into account in forest planning and or in accessing Gross Domestic Product (Cunningham, 2011). Forests in India were recognized only as a social and environmental resource but not as a commercial resource (Sharma *et al.,* 2018).

NTFPs provide a variety of products for local, national (Table 1), and international markets that are growing rapidly and steadily (Wilkinson and Elivitch, 2000). Fortunately, academic interest in the commercialization of NTFPs has increased in the past few decades due to its potential in empowering the rural and forest fringe communities to fight poverty while providing a dynamic business opportunity but might be risky as it could accelerate unsustainable resource use practices and environmental negligence (Wynberg and van Niekerk, 2014).

Table 1. Economically important NTFPs of India given seasonally

Season	Collection	Economy
Jan- Mar	Lac, mahua, tamarind	Over 75 % of tribal households in Orissa, Madhya Pradesh, and Andhra Pradesh collect mahua flowers and earn INR Rs. 5000 a year. 3 million people are involved in lac production.
Apr-Jun	Tendu, Sal seeds, chironji	30 million forest dwellers depend on seeds, leaves, and resins from Sal trees; tendu leaf collection provides about 90 days of employment to 7.5 million people, and a further 3 million people are employed in bidi processing.
Jul-Sept	Chironji, mango, mahua fruits, silk cocoons, bamboo	10 million people depend on bamboo for livelihood; 1,26,000 households are involved in Tussar silk cultivation only.
Oct-Nov	Lac, Kullu gum, resins	3 lakh person/days of employment from the collection of gums.

(Source: TRIFED, Government of India- https://trifed.tribal.gov.in/non/timber/msp-mfp)

In some cases, revenues earned from NTFP commercialization were the only source of income for rural people (Van Andel, 2000). Earning reasonable income requires a high volume to be traded but a lack of capital for investment and poor or no infrastructural facilities like storage and transport results in less income even though collected volume is high (te Velde *et al.,* 2006). Farmers, local processors, and traders of NTFPs do not get a fair market for their product/produce due to inadequate quantity, poor market access, poor or lack of road communication and transport, lack of awareness, corruption practices, and human animal conflict thus making NTFP trade less remunerative (Awono *et al.,* 2010; Nkem *et al.,* 2010)., The primary producers and collectors get very low prices and the bulk of the value goes to the middlemen in tamarind trade (Rao and Rao, 2022). Collectors forced to sell the fruit at an alarmingly low price to the traders. Shown below (Table 2), is the price difference observed in the marketing channels of tamarind in Andhra Pradesh.

Table 2. Price gap in the tamarind market

Purchase point	Rs/Kg
Farmer selling his tamarind at flowering stage	10
Collectors selling to GCC (improperly graded/ unprocessed)	16-18
Collectors selling to private traders (graded/ processed)	25
Consumers buying from fair-price shops	70
Consumers buying from Raytu Bazar	90
High street grocery shops	90-100
Supermarkets in major cities	120

(Source: Rao and Rao, 2022)

NTFP prices were mostly subjected to external market forces (Malleson *et al.,* 2014). Studies had reported that NTFP consumers were generally not bothered by its quality and hence pricing NTFPs high due to quality often leading to its poor sale (Kilchling *et al.,* 2009). Moreover, the types of market and its influence in prices were also reported as a common challenge to NTFP traders in countries like India, South Africa, Bolivia, and Mexico (Saha and Sundriyal, 2012). NTFP collectors were mostly found unaware of the latest policies and often were poorly organized which caused them difficulty in selling their collections or products even at their local markets (Kala, 2013). Moreover, lack of adequate knowledge regarding the value addition of their products and their minimal forward and backward market linkages which otherwise would have empowered them to sell their goods at a sustainable price were generally found either obliged or forced to sell their collections at a very low price even if unsustainable (Saxena, 2003).

For instance, the NTFP market in India has reported oligopoly with opaque market structures where innocent and misinformed sellers were less in number as compared to well-informed buyers. Such markets in India were found disadvantageous to the collectors and cultivators as the absence of reliable and accurate market knowledge causes over-harvesting of the natural resource which in turn reduces the income generation of the collectors/cultivators (Yadav and Misra, 2010). Further, a very less market of NTFPs near the forest fringe areas causes market saturation of NTFPs which also influences price fluctuation in NTFPs (Adam *et al.,* 2013). NTFP collectors who were generally located in remote areas were also reported cheated by the middlemen who facilitate the collectors in processing and selling the collection or produce (Kala, 2013).

Additionally, NTFP management comes with many new challenges and opportunities because of past malpractices and challenges regarding their harvest and processing (Yadav and Dugaya, 2013). Unscientific method of collecting and excessive use of NTFPs was the major reason for losing a variety of products and the rarity of plant species (Solomon, 2016). Climate change in form of extreme drought or extreme flooding also affects the production of many NTFPs (Bhattacharya, 2013). Multiple levels of outsiders such as processors, traders, manufacturers, and exporters and their roles result in market complexities rendering very low data reliability (Yadav and Misra, 2012). The NTFP's value chains are a network of complicated stages and participants involved in the process of collection from the first point i.e., forest to the last stop, the consumer (Figure 1; Jhonson *et al*., 2013; Pandey *et al*., 2016). They can be uncertain with changing times and situations. Hence, information about the product, price, and current market status is of great importance (Pandey *et al*., 2016).

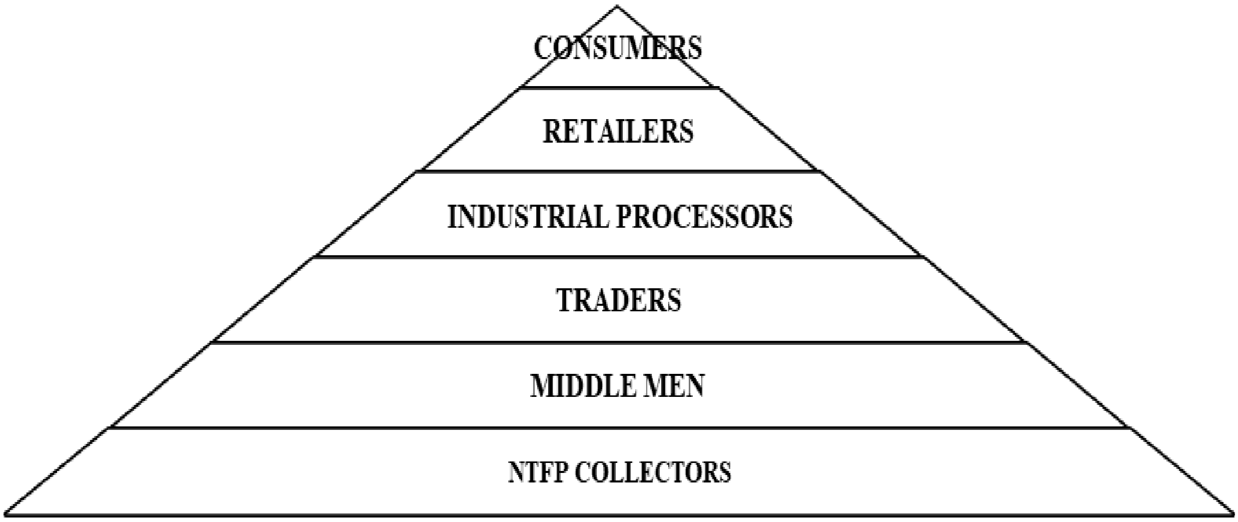

Figure 1. Typical marketing channel of NTFPs

The above-discussed omissions and misfortunes also need to be corrected, as NTFPs were reported to contribute significantly to rural household incomes and a nation's productivity like in the Indian states of Madhya Pradesh, Chhattisgarh, Orissa, Maharashtra, and Andhra Pradesh where more than 75 % of NTFPs collected or produced was traded which supported a number of small to large scale enterprises in processing and/or trading of species (Saxena, 2003). Studies had recommended the need for management and marketing arrangements for NTFPs (Shylajan and Mythili, 2012; Yadav and Dugaya, 2013). NTFP certification may be a step forward in this direction and is being suggested and explored in India as well (Krishnakumar *et al.,* 2012; Yadav and Dugaya, 2013). Strategies such as value-added markets through certification or eco-labeling have shown to be successful in developing countries of Latin America and Africa resulting in increased income, security, stronger socio-economic status, and positive conservation outcomes (Laird *et al.,* 2010; Lilieholm and Weatherly, 2010).

There would be higher economic benefits from the collection of NTFPs in the tropical regions than logging (Peters *et al.,* 1989; Miina *et al*., 2020) but unfortunately there exist conflicts between conservation policies and livelihood opportunities of rural and forest fringe people and the role of Forest Rights Act, 2006 in securing their rights (Chatterjee, 2018). Setting up of protected areas for conserving biodiversity makes forests into 'people-free' tracts stripping the indigenous and forest dependent communities of all the opportunities for NTFPs collection, limiting the scope of both sustenance and commercial opportunity (Kabra, 2003). With the promulgation of the Wildlife Protection Act, access to the collection of NTFP and fishing was restricted in most states causing a deteriorating relationship between the forest department and forest user's group while, the collection of specific items was permitted under circumstances that will not harm the forest ecology (Sarin *et al.,* 1998).

Several issues related to ownership, pricing, value addition, and sustainability of the NTFPs exist but have been dealt with limited success (Sharma *et al.,* 2018). Minimum Support Price (MSP) is an innate component of the Agriculture Price Policy of India securing the farmers' support while delivering affordable prices to consumers through the public distribution system (Parikh and Singh, 2007). This system was conceptualized during the pre-green revolution period as an institutional mechanism for incentivizing farmers to adopt new technologies (Deshpande, 2008). Govt. of India, between 2013-2014, instigated the scheme of "Mechanism for Marketing of Minor Forest Produce (MFP) through Minimum Support Price (MSP) and development of value chain." The venture targeted social safety net for the betterment of the livelihood of MFP gatherers by listing fair prices for the MFPs they collect (Singh *et al*., 2020). The Scheme gives importance to the NTFP gatherers, the majority of whom are people belonging to various Schedule Tribe groups. It has been designed to insure social protective measures for the said group. The nodal Ministry for managing the scheme is the Ministry of Tribal Affairs (MOTA), Government of India. The state government is in charge of implementation, supervision, and monitoring (Anon., 2014).

Main objectives:

- Provision of fair prices to the gatherers to improve their finances.
- To practice sustainable harvesting of all NTFPs.
- To ensure a huge social dividend for MFP gatherers, majority of them belonging to the tribal community.
- As per the guidelines issued for the implementation of the scheme, the Centre should provide 75% of the working capital in the form of revolving funds in the initial two years and share losses, if any, in the ratio of 75:25 between the Centre and the state.
- To add maximum number of items in the list. The scheme started with 10 important MFPs in 9 States.
- To emphasize the development and improvement in the value chain for the collection which includes the creation of cold storage facilities, clean warehouses, proper processing units, and modernization of haat bazaars (Singh *et al*., 2020).

Farmer has the freedom to refuse to settle for a price below MSP if he is aware of the support price. Exploitation by traders and middlemen can in turn be prevented (Anon., 2016). Most of the states have not been able to fix the MSP for NTFPs due lack of appropriate methodology for fixing it. As a result, the collectors are at a mercy of the state government agencies and private traders offering unfair prices to collectors. The price offered does not commensurate with either the prevailing statutory minimum wage or even the wage rate provided by the Mahatma Gandhi National Rural Employment Generation Act (Lahiri, 2018). The most recent list of NTFP items added by the Ministry of Tribal Affairs, Government of India includes 14 carefully selected species as of November 2020 (table 3).

Table 3. List of MSP Proposed for New MFP items

Sn	Minor Forest Produce (MFP)	MSP	State
1	Tasar cocoon; reeling class grade- I	3200*	Jharkhand
	Tasar cocoon; unreeling class grade- I	1500*	
2	Cashew kernel *(Anacardium occidentale)*	90	All India
3	Elephant apple dry *(Dillenia indica)*	120	North Eastern States
4	Bamboo shoot *(Phyllostachys edulis)*	70	North Eastern States
5	Malkangni seed *(Celastrus paniculatus)*	100	All India
6	Mahul leaves *(Bauhinia vahlli)*	15	Odisha, Chhattisgarh, MP, WB
7	Nagod *(Vitex negundo)*	20	All India
8	Gokhru *(Tribulus terrestris)*	60	All India
9	Pipla/ Uchithi *(Piper pedicellatum)*	120	All India
10	Gamhar/Gamari *(Gmelina arborea)*	20	North Eastern States
11	Oroxylum indicum *(Oroxylum indicum)*	40	North Eastern States
12	Wild mushroom dry *(Agaricussp)*	400	North Eastern States
13	Shringraj *(Eclipta alba)*	18	All India
14	Tree moss *(Bryophytes)*	350	Karnataka

MSP: Minimum support price (INR ₹; *INR/1000 numbers); MP: Madhya pradesh; WB: West Bengal; (Source: TRIFED, Government of India- https://trifed.tribal.gov.in/non/timber/msp-mfp)

(Source: TRIFED; MOTA (Livelihood division) 2020)

The MSP for NTFPs will help enhance the income of collectors thereby improving the quality of forests. Resource mapping aids the policymakers to establish procurement and value-addition centers at minor market levels, improving income whilst encouraging sustainable harvesting. Apart from this, mitigation of climate change, contribution towards Nationally Determined Contributions (NDCs) targets from the forestry sector, and improving the quality of forests will be incorporated (Sharma *et al.,* 2018). By acquiring a proper infrastructure and the latest marketing strategies, the net value realization of the forest dwellers can be improved remarkably, so they can also participate in the rising tide of the economy of India (Yadav and Misra, 2010).

LIVELIHOOD

The poor economic condition of indigenous forest people compels them to depend on forest products (Alex *et al*., 2016; Masoodi and Sundriyal, 2020). The income that the gatherers receive from the collection and selling of NFTPs helps these rural people in various ways. Be it for their own in-house consumption, as a gap filling means during times when they do not have enough grains to survive on, and also to raise their household income. Rich households collect NTFPs as an additional source of their income, while poor households collect NTFPs for their subsistence survival (Ahenkan and Boon, 2011). The households which earn profit more from NTFPs were found with bigger land holdings than those who collect it for mere survival. The rural populace especially forest dwellers in India depend on the forests not only to supplement their domestic requirements but also to supplement their incomes by selling part or all of their collection in local markets (Das, 2005). Women were prominently involved in NTFP gathering, processing, and commercialization which indicates its potential for women empowerment to raise their status in the household and in the community at large (Bauri *et al*., 2015).

CONCLUSION

Domestication and commercialization of NTFPs in participatory mode is recommended. Research support is required for proper identification, documentation, and collection of NTFP along with their silvicultural requirements is vital to develop a suitable marketing channel. Traditional value addition techniques need to be advocated and recognized for improving market value. Nationalization of NTFPs can be crucial for the welfare of the forest fringe communities by ensuring better returns. The traditional and ecological knowledge of the forest communities can be utilized scientifically to achieve sustainable NTFP production in the future.

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Seasonality of Predaceous Ladybird beetles *Micraspis* spp. (Coccinellidae: Coleoptera) in Rice-based Cropping Systems of Terai Region of West Bengal

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The population fluctuation of *Micraspis* spp. was monitored through fixed plot survey in rice and mustard with a study on the role of weather factors influencing their occurrence. It was clear that, during Kharif season of 2021 the abiotic factors were responsible for quite a significant extent in impacting the population fluctuation of *Micraspis* population in rice fields. But during Rabi season of 2021-22 in mustard, the *Micraspis* spp. was found to be less impacted by the weather parameters. However, long term study on the population dynamics of the coccinellids in agroecosystems is necessary to settle for a concluding remark on the role of abiotic factors in manipulating the coccinellid population in the agroecosystems towards formulation of weather-based forecasting model for their fruitful utilization in applied pest management of crops.

Keywords: *Micraspis* spp., Seasonality, Rice, Mustard, Weather factors, Correlation, Regression

INTRODUCTION

In agricultural and horticultural crop ecosystems, coccinellids happen to be an important group of predators that are preserved and augmented in order to achieve both conservation and applied biological pest control. They are extremely valuable economically because they prey on a wide range of important crop pests, mainly homopterans including aphids, coccids, and other soft-bodied insects, in both their larval and adult stages (Hippa *et al*., 1978; Kring *et al*., 1985). Coccinellid predators typically congregate in areas of high prey abundance, but because of the unpredictable nature of extrinsic and intrinsic causes, their relative abundance frequently changes throughout time and place (Majumder *et al*., 2013). Several species of ladybird beetles are regarded as a crucial part of biological control programmes because of their great predatory efficacy (Gurney and Hussey, 1970). The growth and reproductive success of the predatory insects are ultimately affected by how effectively they use the nutrients and energy from their prey (Sanjeev Kumar *et al*., 2016). There is a great need to work on coccinellid predators to find solutions for farming communities, public health, and to make the environment safe because the widespread use of agrochemicals has led to insect pest resistance and environmental pollution that is too dangerous for human and animal health (Bukero *et al*., 2015). For many of the beneficial coccinellids, field predation has not been really documented. According to numerous studies, coccinellids are opportunistic feeders who consume a variety of foods in addition to their preferred prey. Due to their capacity to survive on different food sources during non-crop months and when the pest population is low, coccinellids have attracted a lot of attention in biological control programmes. In rice ecosystem *Micraspis discolor* is the dominant coccinellid beetle (Kandibane *et al*., 2006; Gangurde, 2007; Rekha *et al*., 2009) and it is recognized as a potential biocontrol solution for brown plant hopper (BPH), a key pest of rice. Thirteen species and seven genera of coccinellids have been reported in rice habitats globally (Barrion and Litsinger, 1994). Being a dominant predator in field crop ecosystems the study of seasonal fluctuations of *Micraspis* spp. in relation to the weather factors is very much important towards its conservation and utilization in IPM.

MATERIALS AND METHOD

Under the ecological conditions of the sub-Himalayan Terai region, the seasonal incidence of the *Micraspis* spp. complex i.e., *Micraspis discolor* (Fabricius) and *Micraspis yasumatsui* (Sasaji) was studied. Population fluctuation of *Micraspis* spp. was monitored weekly in an area of about one-acre land at the farm of UBKV, Pundibari in the rice ecosystem [crop variety: Swarna masuri (MTU-7029)] and the mustard ecosystem [crop variety: Agrani (B-54)] during the Kharif season of 2021 and the winter season of 2021-22, respectively. A total of 100 complete or return sweeps at 20 randomly selected locations (5 sweeps per location) were used to record the observations using the sweep net method.

Collecting Meteorological Data

The data on daily maximum and minimum temperatures, maximum and minimum relative humidity and total rainfall were collected from the Gramin Krishi Mausam Sewa (GKMS), Agro Meteorological Field Unit under Uttar Banga Krishi Viswavidyalaya (UBKV), Pundibari, Cooch Behar.

Statistical Analysis

Simple correlation coefficients (r) were derived between ladybug population on a date of observation and average maximum and minimum temperature, maximum and minimum relative humidity and total rainfall during the previous 7 days from that date of observation. To find out the individual as well as combined influence of the abiotic factors on the ladybeetle population, qualitative relationship between the weekly ladybird beetle population and weather parameters individually and collectively was worked out using simple and multiple regression and coefficient of multiple determinations (R^2) with abiotic factors as per Gomez and Gomez (1984). The multiple linear regression model used as follows:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$$

Where Y = Response or dependent variable i.e., ladybug population

a = Constant or Y intercept which signifies the value of Y when all value of all predictor variables is zero, b1-b5 = Regression coefficients for each predictor variable like X1 = average maximum temperature, X2 = average minimum temperature, X3 = average maximum relative humidity, X4 = average minimum relative humidity, X5 = total rainfall

The ‘F’ test and student ‘t’ test (Fischer and Yates, 1938) were applied to test the significance at 5 and 1% levels. The statistical analysis was done in computer using LINEST in excel and OPSTAT statistical package.

RESULTS AND DISCUSSION

Seasonality of Micraspis spp.

The seasonality of *Micraspis* spp. on mustard crop during the Rabi season of 2021-22 has been presented in the Table 1 and graphically represented in the Figure 1. The lady bird beetle, *Micraspis* spp. first appeared in 49th SMW (i.e., 1st fortnight of December) (0.05/ 5 sweeps). In the flowering and podding stage, the highest population was observed on 1st week of January (0.9 adults/5 sweeps) when the average maximum temperature, average minimum temperature was 25.49 and 11.19℃, respectively. The average maximum relative humidity was 90.86 % and average minimum relative humidity was 53.86% during that period. After podding stage, the population of *Micraspis* spp. gradually declined. The results are in accordance with Rahman *et al.* (1991) who reported that peak population of the ladybird beetles attained at flowering stage. The findings were like those of Varmora *et al*. (2010) who reported that the ladybird beetle appeared from 1st week of January (0.22 beetle/plant) and highest population found in (1.20 beetle/plant) in 2nd SMW. Similarly, the population of ladybird beetles namely *Menochilus sexmaculata*, *Coccinella septumpunctata* and *Coccinella transversalis* was high at last week of January (20.00 coccinellid/plant) to 1st week of March

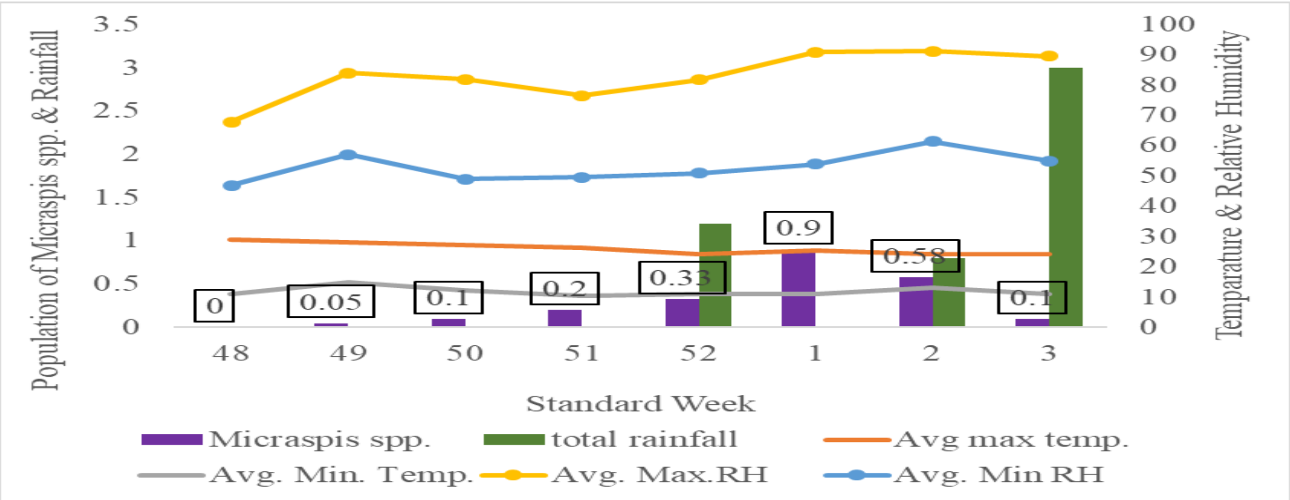
(Hugar *et al*., 2008). Furthermore, according to Mishra and Kanwat (2018) five species of lady birds were found on mustard of which *M. sexmaculatus* and *C. septempunctata* appeared in the 1st week of January while, the highest population was recorded in the last week of January coinciding with the peak aphid population.

Table 1. Seasonality of *Micraspis* spp. in mustard with respect to weather parameters during Rabi season (2021-22)

DAS	Crop stage	SW	Date	Ms	AT_{max}	AT_{min}	ARH_{max}	ARH_{min}	TR
30	Vegetative	48	05.12.21	0.00	28.94	11.12	67.86	46.86	0.00
37	Mostly Vegetative	49	12.12.21	0.05	28.21	15.04	84.00	57.14	0.00
44	Vegetative & Flowering	50	19.12.21	0.10	27.29	12.36	81.86	49.00	0.00
51	Flowering	51	26.12.21	0.20	26.44	10.49	76.57	49.57	0.00
58	Mostly Flowering	52	02.01.22	0.33	24.30	11.000	81.71	50.86	1.20
65	Flowering & Podding	1	09.01.22	0.90	25.49	11.19	90.86	53.86	0.00
72	Mostly Podding	2	16.01.22	0.58	24.36	13.07	91.14	61.43	0.80
79	Podding	3	23.01.22	0.10	24.26	11.03	89.57	55.00	3.00

DAS: Days after sowing SW: Standard week; Ms: *Micraspis* spp. (numbers/5 sweeps); AT_{max}: Avg. Max Temp.(°C); AT_{min}: Avg. Min. Temp. (°C); ARH_{max}: Avg. max. relative humidity (%); ARH_{min}: Avg. min. relative humidity (%); TR: Total rainfall (mm)

Figure 1. Seasonality of *Micraspis* spp. in mustard with respect to weather parameters during Rabi season (2021-22)



The correlation coefficients (r) between the population of *Micraspis* spp. in the mustard field and various weather parameters have been presented in the Table 2. It is clear from the table that the coccinellid population had non-significant associations with the abiotic factors. The maximum and minimum temperatures registered non-significant negative correlations with the predator population while, the maximum and minimum relative humidity (RH) registered non-significant positive correlation with the *Micraspis* spp. population. The coccinellid population showed very weak negative association with the weekly total rainfall. The results are in partial accordance with Pal and Debnath (2020) according to whom the abiotic factors showed a low order of association with Coccinellid population. The linear multiple regression equation of *Micraspis* spp. with weather parameters has been presented in the Table 3. The weather parameters together had non-significant influence on the *Micraspis* spp. population. Together all the weather parameters were responsible for 17.15 % variation in the coccinellid population fluctuation as evident from the R-squared value (0.1715).

Table 2. Correlation coefficients between *Micraspis* spp. in mustard and weather parameters

***Micraspis* spp.**	**Max temp^{0}C**	**Min temp^{0}C**	**Max RH (%)**	**Min RH (%)**	**Rainfall (mm)**
Correlation coefficients	-0.540^{NS}	-0.137^{NS}	0.621^{NS}	0.414^{NS}	-0.109^{NS}

NS: Non-Significant

Table 3: Multiple regression equation of *Micraspis* spp. in mustard with weather parameters

Regression equation	**Adjusted R-squared**
$Y = -0.8712-0.0261X_1-0.1585X_2 +0.0259X_3 +0.0326X_4 -0.2423X_5^{NS}$	0.1715

NS: Non-Significant

The seasonality of *Micraspis* spp. on rice crop during the Kharif season of 2021 has been presented in the Table 4 and graphically represented in the Figure 2. The lady bird beetle, *Micraspis* spp. complex first appeared in 41st SMW (i.e., 2nd fortnight of October) (0.33/ 5 sweeps). In the maturity stage, the highest population was observed on 1st week of November (1.17 adults/5 sweeps) when the average maximum temperature, average minimum temperature was 31.11 and 14.47℃, respectively. The average maximum relative humidity was 68.14% and average minimum relative humidity was 46.86% during that period. It was found that even after the harvest of the crop, the population of *Micraspis* spp. sustained a high population level as witnessed from the fact that lot of individuals were found taking refuge within the crop stubbles in the field.

Table 4. Population of *Micraspis* spp. (adults per 5 sweeps) in rice with respect to abiotic parameters during Kharif season

DAT	**Crop stage**	**SW**	**Date**	**Ms**	**T_{max}**	**T_{min}**	**ARH_{max}**	**ARH_{min}**	**TR**
50	Tillering	34	28.08.21	0.00	29.99	21.86	96.92	87.29	308.60
57	Tillering	35	04.09.21	0.00	30.51	21.71	94.00	83.85	253.00
63	Vegetative	36	11.09.21	0.00	33.80	22.29	87.00	68.14	52.80
70	Maximum tillering	37	18.09.21	0.00	34.60	22.31	82.86	69.86	71.80
77	Booting	38	25.09.21	0.00	33.40	22.44	86.00	69.43	19.40
84	Panicle	39	02.10.21	0.00	34.29	22.51	75.43	69.14	23.00
91	Milking	40	09.10.21	0.00	30.64	20.56	91.57	80.29	191.80
98	Grain filling	41	16.10.21	0.33	35.19	21.84	73.57	62.43	0.00
105	Grain filling	42	23.10.21	0.67	29.86	20.61	87.00	79.71	76.00
112	Maturity	43	30.10.21	0.83	31.31	17.21	78.57	62.14	0.00
119	Maturity	44	06.11.21	1.17	31.11	14.47	68.14	46.86	0.00

DAT: Days after transplanting; SW: Standard week; DAS: Days after sowing SW: Standard week; Ms: *Micraspis* spp.; T_{max}: Avg. Max Temp.(°C); T_{min}: Avg. Min. Avg. Min. Temp. (°C); ARH_{max}: Avg. max. relative humidity (%); ARH_{min}: Avg. min. relative humidity (%); TR: Total rainfall (mm)

The correlation coefficients (r) between the population of *Micraspis* spp. in the rice fields and prevailing weather parameters have been presented in the Table 5. It is clear from the table that the coccinellid population had significant negative associations with average minimum temperature (-0.908), average maximum (-0.621) and minimum (-0.653) relative humidity. The average maximum temperature and total rainfall registered non-significant negative correlations with the predator population. The linear multiple regression equation of *Micraspis* spp. in the rice field with the weather parameters has been presented in the Table 6. The weather parameters together had significant influence on the *Micraspis* spp. population.

Together all the weather parameters were responsible for 42.66% variation in the coccinellid population fluctuation in rice field as evident from the R-squared value (0.4266).

Figure 2. Population of *Micraspis* spp. in rice with respect to abiotic parameters during Kharif season

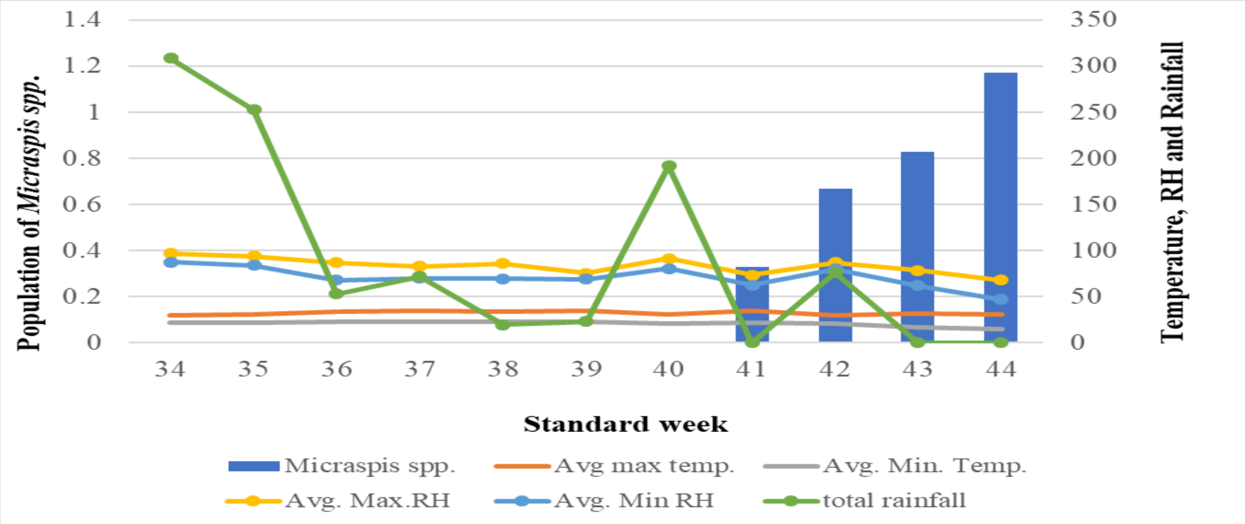


Table 5. Correlation coefficients between *Micraspis* spp. in rice and weather parameters

***Micraspis* spp.**	**Max temp⁰C**	**Min temp⁰C**	**Max RH (%)**	**Min RH (%)**	**Rainfall (mm)**
Correlation coefficients	-0.319^{NS}	-0.908**	-0.621*	-0.653*	-0.475^{NS}

**Significant at 1 % level of significance; *Significant at 5 % level of significance; NS: Non-significant

Table 6: Multiple regression equation of *Micraspis* spp. in rice with weather parameters

Regression equation	**Adjusted R-squared**
$Y = 1.966 - 0.024X_1 + 0.009X_2 - 0.038X_3 + 0.027X_4 - 0.0293X_5^{*}$	0.4266

*Significant at 5 % level of significance

The results are in accordance with Shankar et al. (2013) who reported, in November during the rainy season and in April during the dry season; *Micraspis* was reportedly seen numerous times during the blossoming phase of the rice crop, which lasted for around 30 days. This rise does not coincide with a rise in the availability of its insect prey. The preference of predators for specific food items present in an environment affects the effectiveness of alternative food in pest reduction (Frank *et al*., 2011). There is no reduction in GLH or BPH when there is increase in the population of *Micraspis discolor* showing that *M. discolor* populations are supported by alternative prey or food. According to prior observations by Shepard and Rapusas (1989) the maximal abundance of *M. discolor* correlated with the pollen availability during the reproductive period of the rice crop. The abundance of pollen and the preference for pollen eating over live prey in laboratory tests suggested that pollen was a more reliable source of food for *M. discolor* reproduction and survival than leaf and plant hoppers. Rahman *et al*. (1991) reported that *M. discolor* was found in the flowering stage of rice and number of adults were more than larvae. Among the three seasons the population of *M. discolor* was more abundant in *aus* (pre-Kharif) season. They observed that larvae and adult feed on the pollen grains of newly emerged panicles indicating that *M. discolor* might choose rice ears as alternate food source. Rattanapun *et al*. (2012) also reported that the highest population abundance of *M. discolor* was found at reproductive stage of rice.

CONCLUSION

The population of *Micraspis* spp., the dominant coccinellids of rice-based cropping system of Terai zone of West Bengal was found to be impacted significantly by the weather parameters during Kharif season in rice crop. The population attained the peak at the maturity stage of the crop coinciding with the onset of winter season even in the absence of their prey (mostly feeding on rice pollens). But during Rabi season the weather parameters couldn't influence the population fluctuation of the coccinellids in mustard crop.

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References should be given in alphabetical order according to the following examples:

Journal

Padukkage D, Geekiyanage S. 2017. Inheritance of Lemma and Palea Color in a Segregating Population Derived Through a Cross between Two Sri Lankan Rice Varieties (Traditional Rice *Inthian karuppa* and Improved Rice Bg 379-2). J Agri Technol. 4(1):7-9.

Roy KK, Hossain MS, Pramanik MEA. 2005. Effect of seed priming in zinc solutions on chickpea varieties in high Barind Tract of Bangladesh. J Agri Technol. 4(1): 10-14.

Books

Roy B. 2010. Synthetic Seed- A challenging technology for plant propagation, transportation and conservation. LAP Lambert Academic Publishing AG & Co. KG, Theodor-Heuss-Ring 26, 50668 Köln, Germany. 230p.

Articles or chapters in books

Roy B, Sarkar B. 2013. Achievement and let down in hybrid wheat. In: Breeding Biotechnology and Seed Production of Field Crops, Roy B, Basu AK, Mandal AB (eds). New India Publishing Agency, New Delhi. pp. 241-262.

Tables: Each table should have a brief title. Each column should have a heading; units should appear under the column heading(s). Some remarks may be written below the table, but they should not repeat details given in the Materials and Methods section.

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