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Disease management system of potato diseases in storage rooms through proper ventilators and sanitation

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Analysis of fungal airspora of three potato storage rooms in Imphal West District was carried out for two years (January - December, 2017 and January – December, 2018) by adopting Petriplate exposure method. A total of 20 fungal types were isolated from the potato storage rooms. During the investigation period, *Fusarium solani (*9.61S_I PSR_I, 6.19S_1PSR_{II}, 6.84.$S_IPSR_{III}$and 9.46$S_{II}PSR_1$, 7.93$S_{II}PSR_{II}$, 6.64$S_{II}PSR_{III}$) *Aspergillus niger* (6.69S_IPSR_I, 8.26S_IPSR_{II}, 5.34S_IPSR_{II} and 6.33$S_{II}PSR_I$, 7.93$S_{II}PSR_{II,}$ 3.59S_IPSR_{III}) and *Penecillum citrinum* (6.30$S_IPSR_{I,}$ 7.31S_I PSR_{II}, 6.30S_I-$PSR_{III-}$and 5.89$S_{II}PSR_I$, 6.80S_{II}, 6.55$S_{II}PSR_{III}$)were the dominant fungal species. The highest fungal population were found in the godown of shop number III which was without ventilators and sanitation.

Key words: Dominant air spora, *Fusarium solani,* godown, potato storage room

INTRODUCTION

Potato (S*olanum tuberosum L.)* is one of the most important food crops of the world. It belongs to family Solanaceae. The plant is an annual herb vegetatively propagated by tubers, which are underground stems. Potato has a high content of carbohydrates, significant amounts of quality protein and substantial amounts of vitamins, especially vitamin C (FAO, 2008). The total world potato production was estimated to 368 million tons, in 2018 (FAO, 2019). Storage is a vital process to ensure year round supplies for the fresh market and processing potato industries. Post harvest losses are mainly caused by different physical, environmental and biological factors which include mechanical injuries, extreme temperatures and pathogens (Clark *et al*. 2004).

The outermost layer of potato tuber is the periderm that protects potatoes from weight loss and pathogen attach (Barel and Ginzberg, 2008). The periderm is subject to wounding, which is common during potato harvest and handling. Wounds can be in the form of cuts, punctures, abrasions, broken knobs, shatter-bruised areas, or any area that has a break in the periderm. Good level of care is needed during harvesting and handling operations to minimize damage caused on tubers. The damaged tuber always has a shorter post-harvest life than the undamaged tubers (Pinhero, 2009).As potatoes are seasonal, high-quality storage of potatoes is essential to provide a good quality product throughout the whole year (Singh and Kaur, 2016). Tubers that are stored at relatively higher temperature lose their moisture after sometime and become unfit for consumption or for prolonged storage as seed for the coming season planting (Degebasa, 2020). The purpose of storage is to maintain tubers in their most edible and marketable condition and to provide an uniform flow of tubers to market and processing plants throughout the year. Storage losses are mainly caused by the processes like respiration, sprouting evaporation of water from the tubers, spread of diseases, changes in the chemical composition and physical properties of the tuber and damage by extreme temperatures (Eltawil *et al*. 2006). Fungi associated with diseased fruits have manifold effects on the stored products of the host. The significant biochemical changes are reduction in their nutritive value both qualitatively and quantitatively and thus rendering them unfit for human consumption. Thus, considerable

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quantitative of vegetables and fruits are lost due to many storage diseases of fruits and vegetables caused by fungi in storage and markets.

In view of these above facts, investigations have been carried out to detect the pathogenic fungal species from the potato storage rooms, to study the correlation of fungal population and meteorological parameters records, as well as to study the significance of ventilators and sanitation to control the disease in storage rooms.

$$r = \frac{N\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{[N\Sigma x^2 - (\Sigma x)^2][N\Sigma y^2 - (\Sigma y)^2]}}$$

Where:

N = number of pairs of scores

Σxy = sum of the products of paired scores

Σx = sum of x scores

Σy = sum of y scores

Σx^2 = sum of squared x scores

Σy^2 = sum of squared y scores

MATERIALS AND METHODS

The present study deals with 2 years (Jan-2017 - Dec. 2018) investigations of fungi in the air of potato storage rooms in Imphal West District. The petriplates were exposed horizontally to the atmosphere of potatoes storage rooms keeping one m. above ground level. The air samplings were taken 3 (three) times a month for 2 years.

The plates were exposed for 10 minutes from 11 a.m. to 11.10 a.m at different potato storage rooms (Shop No.I, Shop No.II and Shop No.III). The exposed petriplates were brought aseptically to the laboratory and incubated in an inverted position at 27°±1°C for 5 -7 days. The colonies developed were examined regularly, counted and identified with the help of published literatures. Meteorological data viz, temperature, relative humidity, rainfall and wind speed were recorded for the investigating period. The data were collected from the meteorological section., ICAR Research Complex for N.E.H. Region, Manipur centre, Lamphelpat, Imphal. Pearson's correlation coefficient (r)is calculated using the following formula (Yadav, 2018).

RESULTS AND DISCUSSION

During the investigation period, a total number of 20 fungal colonies were isolated from the three potato storage rooms in Imphal West District. A total number of 4868 (Potato storage room-I), 4828 (PSR-II) and and 5423(PSR- III) fungal colonies were isolated and identified for the first year working period.During the Second year working period, a total of 4753 (PSR-I), 4849 (PSR-II) and 5418 (PSR-III) fungal types were detected. *Aspergillus niger*(6.69S_IPSR$_I$, 8.26S_IPSR$_{II}$, 5.34S_IPSR$_{II}$ and 6.33S_{II}PSR$_I$, 7.93S_{II}PSR$_{II}$, 3.59S_IPSR$_{III}$), *Fusarium solani* (9.61S_1 PSR-I, 6.19S_1 PSR-II, 6.84S_1 PSR-III) and (9.46S_2PSR-I, 7.93S_2PSR-II, 6.64S_2 PSR-III) *Penicillium citrinum*(6.30S_IPSR$_I$, 7.31S_I PSR$_{II}$, 6.30S_I-PSR$_{III}$ and 5.89S_{II}PSR$_I$, 6.80S_{II}, 6.55S_{II}PSR$_{III}$)were the dominant fungal species recorded during the working period (Table1 and 2). The maximum concentrations of fungal colonies were recorded in the months of July, 2017 (581 fungal colonies with 10.71%) in shop-III (Table No.3). The godown of Shop number-III was without ventilators and sanitation. There was intensive activity during daytime due to loading and unloading and movements of the workers which generates a lot of dust. The corresponding meteorological parameters were temperature (Max. 29.0^0 C, Min, 22.6^0 C), relative humidity (92.8%), rainfall (12.8 mm) and wind speed (5.7 Km/h).The lowest concentrations of the fungal species were recorded in the month of October, 2018 (218 fungal colonies with 4.49%) in Shop-II. The corresponding meteorological parameters were temperature (Max. 27.4^0 C, min. 16.5^0 C), relative humidity (89.5%), rainfall (3.8 mm) and wind speed (1.8 Km/h) (Table No. 3 and 4).During the investigation periods, *Fusarium solani* was having the highest fungal population. The Fusarium diseases are among the most serious soil borne diseases responsible for economic losses worldwide (Larkin and Halloran, 2014), as they can affect potato at any growth stage by inducing Fusarium wilt on plants and Fusarium dry rot on tubers.Thirteen species of *Fusarium* have been implicated in causing dry rot of potato worldwide (Gachango *et al* 2012). *Fusarium sambucinum* and *Fusarium solani* are the most common pathogenic species in Egypt (El-Kot, 2008). Pathogenic species of *Fusarium* associated with dry rot of potato include *Fusarium coeruleum, Fusarium avenaceum, Fusarium culmorum, Fusarium oxysporum* and *Fusarium graminearum* (Peters *et al* 2008).These species of *Fusarium* produced trichothecene, including deoxynivalenol (DON), nivalenol (NIV), diacetoxyscirpenon (DAS) and T-2 toxin and non trichthecene including fusaric acid, sambutoxin, fumonisin, fusarin C and zearalenones (ZEA)mycotoxins in potato tuber

Table 1: Total Number of fungal species isolated from the potato storage rooms in Imphal West District, for 1st year (Jan.-Dec.2017) and their contribution (%) to the yearly total

	Total No. of Fungal Spore Types			Percentage Contribution to yearly total		
	Jan'17 - Dec'17			Jan '17 - Dec'17		
Fungal Types	Shop I	Shop II	Shop III	Shop I	Shop II	Shop III
A. Zygomycotina						
Mucor racemosus	165	177	295	3.38	3.66	5.43
Rhizopus stolonifer	240	180	308	4.93	3.72	5.67
B. Deuteromycotina						
Aspersillus niger	326	399	290	6.69	8.26	5.34
Aspergillus clavatus	295	313	360	6.05	6.48	6.63
Aspergillus flavus	273	288	270	5.60	5.91	4.97
Alteniaria solani	301	317	291	6.18	6.56	5.36
Botrytis cinerea	128	190	200	2.62	3.93	3.68
Cladosporium herbarum	175	312	272	3.59	6.46	5.01
Curvuiaria lunura	157	119	60	3.22	2.46	1.10
Fusartum solani	468	299	371	9.61	6.19	6.84
Fusarium roseum	257	291	345	5.27	6.02	6.36
Fusarium oxysporum	300	351	401	6.16	7.27	7.39
Penicillium citrinum	307	353	342	6.30	7.31	6.30
Gliocladium rosum	167	107	216	3.43	2.21	3.98
Cercospora concors	251	151	275	5.15	3.12	5.07
Penicillium digitatum	302	200	398	6.20	4.14	7.33
Fusarium radicicola	314	271	271	6.45	5.61	4.99
Helminthosporium solani	297	272	80	6.10	5.63	1.47
Cladosporium fulvum	78	168	278	1.60	3.47	5.12
Colletotrichum falcatum	67	70	100	1.37	1.38	1.84
Grand total	486	4828	5423			

tissue (Gachango *et al* 2012).Fusarium dry rot (*Fusarium*spp), bacterial soft rot (*Pectobacterium* spp) and Pythium Leak (*Pythium* sp) which are the three major potato storage diseases in Wisconsin. A tuber is considered to have a disease incidence if decay area on the cut surface caused by any of the three pathogens is lager than 5% (Brandt *et al.* 2016). Elsherbiny *et al.* (2016) indicated that the methanol extract of Pomegranate peels had a significant antifungal activity on the mycelial growth and spore germination of *Fusarium sambucinum*, as well as a high potential source of natural antifungal agents to control dry rot on potato tubers both in curative and preventive applications. Khedher *et al.* (2021) revealed that *Bacillus subtilis* V26 has great potential to be used as bio control agent for management of Fusarium species causing dry rot on potato tuber as well as Fusarium wilt onpotato plants.Wang *et al.* (2020) investigated that higher would healing temperatures may have the potential benefits of improving potato storage quality while reducing the economic penalty associated with weight loss for specific varieties, but tubers should be healthy at harvest for better benefits. The higher the ambient air temperature, the more water loss from the tuber. Degebase (2020) reported that storing potato on the ground under beds exposes the tubers and leads to rapid sprouting colour and taste changes within few days. It seems that the introduced improved seed and ware potato storage were the only effective option for potato grower farmers. Heltoft *et al.* (2016) revealed that ventilation management and the tuber maturity at harvest are essential factors in maintaining potato quality during long term storage. Nasar (2006) reported that *Fusarium sulphurium, Fusarium solani* and *Fusarium oxysporium* were the causal agents of typical dry lesions in inoculated potato tubers. The present investigation is in agreement with these previous workers.Guchi (2015) reported that late blight of potato can be managed by using control measures such

Table 2: Total Number of fungal species isolated from the potato storage rooms in Imphal West District, for 2nd year (Jan.-Dec.2018) and their contribution (%) to the yearly total.

	Total No. of Fungal Spore Types			Percentage Contribution to yearly total		
	Jan'17- Dec'17			Jan '17 - Dec'17		
Fungal Types	Shop I	Shop II	Shop III	Shop	Shop II	Shop III
A. Zygomycotina						
Mucor racemosus	170	160	300	3.57	3.29	5.53
Rhizopus stolonifer	250	195	320	5.25	4.02	5.90
B. Deuteromycotina						
Aspersillus niger	301	385	280	6.33	7.93	3.59
Aspergillus clavatus	309	295	385	6.50	6.08	7.10
Aspergillus flavus	260	300	260	5.47	6.18	4.79
Alteniaria solani	312	309	280	6.56	6.37	5.16
Botrytis cinerea	131	185	190	2.75	3.81	3.50
Cladosporium herbarum	180	295	280	3.78	6.08	5.16
Curvuiaria lunura	160	134	100	3.36	2.76	1.84
Fusartum solani	450	385	360	9.46	7.93	6.64
Fusarium roseum	163	300	365	3.42	6.18	6.73
Fusarium oxysporum	250	360	390	5.25	7.42	7.19
Penicillium citrinum	280	330	355	5.89	6.80	6.55
Gliocladium rosum	180	[12	205	3.78	2.30	3.78
Cercospora concors	301	147	280	6.33	3.03	5.16
Penicillium digitatum	315	185	400	6.62	3.81	7.38
Fusarium radicicola	320	285	293	6.73	5.87	5.40
Helminthosporium solani	270	267	112	5.68	5.50	2.06
Cladosporium fulvum	70	170	288	1.47	3.50	5.31
Colletotrichum falcatum	81	50	60	1.70	1.03	1.12.
Grand total	4753	4849	5418			

biological control agents, resistant varieties, inter cropping and selective fungicides. Obidiegwu *et al.* (2014) suggested that identifi-cation of resistance genes to potato wart disease caused by *Synchytrium endobioticum* is the key for developing diagnostic markers for breeding resistant cultivars. Hadizadeh *et al.* (2019) revealed that potato endophyte *Serratia plymuthica* A30 protected potato plants by reducing black leg development on average by 58.5% and transmission to tuber progeny as latent infection by 47.75%. These results suggest that treatment of potato tubers with biocontrol agents after harvest can reduce the severity of soft rot disease during storage and affect the *transmission* of soft rot bacteria from mother tubers to progency tubers during field cultivation.For 2017 data (Table N5), only wind speed of Shop-III shows moderately positive correlation with fungal spores at $p < 0.10$ significance level. Other meteorological factors such as temperature, relative humidity and rainfall are weakly correlated and are not significant.For 2018 data (Table 5), only temp. (max.) and temp. (min.) of Shop 3 shows moderately positive correlation with the fungal spores at $p < 0.10$ significance level. Other meteorological factorssuch as relative humidity, rainfall and wind speed are weakly correlated with the occurrence of fungal spores and are not significant.In the present study, the nature of the correlation

Table 3: Month-wise percentage contribution of the fungal types and metrological parameters records (Jan 2017 – Dec2017)

Metrological Parameters Jan. – Dec. 2017						Total number of Fungal Types and their contribution Jan. – Dec. 2017					
Month	Temp. (Max)	Temp (Min)	R.H. (%)	Rainfall (mm)	Wind Speed (Km/hr)	Shop-1	Shop-II	Shop-III	Shop-I	Shop-II	Shop-III
Jan.	23.3	6.0	89.3	0.1	2.7	438	426	418	8.99	8.82	7.70
Feb.	24.7	8.6	86.3	0.4	3.7	460	358	350	9.44	9.11	6.45
March	24.0	11.7	83.9	8.1	4.7	371	358	446	7.62	7.41	8.22
April	25.8	17.4	85.0	9.1	4.6	298	278	486	6.12	5.75	8.96
May	24.7	8.6	86.3	0.7	4.1	330	472	520	6.77	9.77	9.58
June	29.4	22.3	91.9	10.7	4.2	540	508	480	11.09	10.52	8.85
July	29.0	22.6	92.8	12.8	5.7	568	540	581	11.66	11.18	10,71
Aug.	29.1	23.3	93.9	7.1	4.1	431	427	505	8.85	8.84	9,31
Sept.	29.3	21.8	93.6	12.0	3.2	345	348	470	7.08	7.20	8.66
Oct.	28.1	19.4	92.5	7.8	3.1	228	220	267	4.68	4.55	4,92
Nov.	26.6	13.5	93.3	0.3	2.8	422	378	496	8.66	7.82	9.12
Dec.	22.4	9.7	93.8	3.8	3.2	437	433	404	8.97	8.96	7.44
						4868	4828	5423			

between the meteorological factors and number of fungal spores varied. In 2017, only Shop II shows negative correlation in case of temperature (min.) and rainfall. In 2018, Shop I and shop IIIshows negative correlation for temperature (max.) and relative humidity respectively. By observing both 2017 and 2018 correlation coefficient, it can be concluded that disease incidence of shop-III can be regulated by means of two factors, viz., temperature and wind speed. Both these factors are positively and moderately correlated. By providing the temperature of the shop at a medium level (not very low nor very high) and making the wind speed calm, fungal diseases of the stored crops could be reduced significantly.During the investigation period, the pathogenic fungi namely *Alternaria solani, Fusarium solani, Helminthosporium solani* were isolated from the air of potato storage rooms. So, it is necessary to identify the pathogenic fungi from the different potato storage rooms to build the know edge of disease management systems to save tuber losses in potato storage rooms. Foods being rich in carbohydraes, proteins and lipids are very nutritious both for microbes and humans. A small number of microorganisms are often responsible for loss of quality based on food. It is essential to protect the quality of potato tubers in storage houses through the management systems of sanitation and selection of healthy potato seeds. Proper ventilation provides fresh air and helps maintain the proper temperature and relative humidity. Fresh air allows the potato tubers to function normally during the storage period.

CONCLUSION

The foundation of storage management is to provide dark conditions with proper ventilation, humidity and temperature to maintain quality. Crop-loss assessment relating productivity to all yield-forming and reducing factors would benefit organic production and sustainability evaluation. Plants wounded before inoculation become more susceptible to pathogens since injury provides avenues of entry for tubers pathogens so wounded tubers should be avoided.

Table 4: Month-wise percentage contribution of the fungal types and metrological parameters records

Metereological Parameters Jan – Dec. 2018						Total number of Fungal Types and their contribution Jan – Dec. 2018					
Month	Temp. (Max)	Temp (Min)	R.H. (%)	Rainfall (mm)	Wind Speed (Km/hr)	Shop-I	Shop-II	Shop-III	Shop-I	Shop-II	Shop-III
Jan.	21.8	6.5	89.4	0.3	2.7	420	438	400	8.83	9.02	7.38
Feb.	24.8	9.0	88.0	0.4	4.1	430	441	312	9.04	9.09	5.75
March	27.0	12.1	87.2	2.3	4.7	361	353	479	7.59	7.27	8.84
April	27.7	15.7	86.6	3.1	4.2	275	282	499	5.78	5.81	9.21
May	28.0	19.0	85.4	6.8	3.8	340	469	512	7.15	9.67	9.44
June	29.4	21.9	88.4	12.2	3.9	500	527	468	10,51	10.86	8.63
July	30.0	22.6	88.6	6.9	3.3	523	542	579	11.00	11.17	10.68
Aug.	29.7	22.1	92.3	5,.8	2.9	451	423	510	9.48	8.72	9.41
Sept.	30.3	20.9	90	0.9	3.6	350	352	482	7.36	7.25	8 89
Oct.	27.4	16.5	89.5	3.8	1.8	233	218.	290	4.90	4.49	5.35
Nov.	25.7	9.4	86.4	0.0	1.6	412	362	485	8.66	7.46	7.11
Dec.	22.9	7.4	89.5	0.8	2.9	458	442	402	9.63	9.11	7.41
						4753	4849	5418			

Table 5: Pearson's correlation coefficient (r) values between meteorological parameters and total fungal spores from three different shops during 2017 and 2018.

	Pearson's correlation coefficient (r) of total fungal spores					
	2017 (Jan-Dec)		2018 (Jan-Dec)			
Meteorological parameters	Shop I	Shop II	Shop III	Shop I	Shop II	Shop III
Temp. (Max.) (°C)	0.1379	0.0277	0.2808	-0.02	0.0464	0.5563*
Temp. (Min.) (°C)	0.106	-0.0552	0.2926	0.0648	0.1878	0.5398*
R.H. (%)	0.2505	0.1202	0.0518	0.2555	0.0227	-0.1661
Rainfall (mm)	0.081	-0.0662	0.2725	0.291	0.4667	0.3885
Wind speed (km/hr)	0.3284	0.3642	0.5675*	0.0505	0.2481	0.2609

Significant at $P < 0.10$

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