RESEARCH ARTICLE

Seasonal diversity of seed borne micro-fungal flora in storage on *Solanum melongena* L.

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ABSTRACT

Environmental seasonal variation pattern, vegetation diversity, pre- and post-harvest climate determine periodic distribution and concentration of microfungal propagules on seed coats in any geographic area. The seeds play crucial role in crop productivity on the globe and are vulnerable to attack by diverse group of fungal pathogens and spread of diseases, in turns adversely affect the global agricultural economy. Prevalence of enormous, high concentrations of diverse microfungal propagules on stored seeds of *Solanum melongena* L., widely considered as some pathogenic, phytotoxic and few carcinogenic, have been investigated in a set of storage climate for a year employing standard blotter paper technique, screening four hundred seeds from mixed samples of diverse geographic location of Vidarbha Region (M.S.) and incubating them for seven days. It has been proposed for an establishment of seasonal variation patterns as well as its possible correlation with climatological factors. Results revealed that out of a total fifty fungal isolates fall under thirty genera, eleven species of *Aspergillus* are among the most predominant components of mesophilic seed mycoflora. *Deuteromycota* contributed greater count of isolates followed by *Ascomycota* while *Basidiomycota* had least count. Winter season dominated by nearly half of a total population of isolates while summer season had 14 per cent count. Nearly 28 per cent population remained throughout in storage period while 10 per cent isolates occurred frequently. The storage period of winter season belonged to the months of *December, January* and *February* was seemed to be supportive for fungal infestation, rapid proliferation and sporulation, exhibiting greater level of percent incidence. Level of infestation for mesophilic isolates declined while it was enhanced for thermo-tolerants in summer season. Fungal count and per cent incidence varied periodically during storage. Report on seasonal diversity provides a basis for estimating functional role of fungal organism in an ecosystem.

Key Words: *Solanum melongena* L, *seasonal diversity, incidence, infestation, mesophiles, thermo-tolerant*

INTRODUCTION

The seeds are known containers of embryos of a new generation, vehicle for spread of new life as well as most critical input for substantial agriculture hence pathogen free healthy seeds play a vital role for desired plant population and serve as backbone for good economic harvest. Environmental climate of high relative humidity, moderate temperature,

cloudy weather, seed nutritive content and high level of seed moisture content of post-harvest crop are proved supportive measures for seed contamination with diverse group of fungal micro-propagules (Ramesh et al, 2013). Some fungal pathogens attack matured pre-harvested seed in standing crop, penetrate deep contaminating internal seed coats, tissues of embryo, endosperm while others contaminate external seed surface in storage as a result of favourable storage environment (Bhajbhuje, 2013). It is premised on the hypothesis that infested seeds are considered highly effective means for transporting diverse pathogenic fungal micro-propagules over long distance (Archana and Prakash, 2013). Literature review suggest for international spread of diseases as a result of importation of seeds that were infested or contaminated with viable propagules of plant pathogens and are often difficult to identify as their typical symptoms being rare on seed surfaces, and their economic impact has increased in recent years with concern to many kinds of crop worldwide (Lew-Smith, 2013). The fungal population associated with seed coats as surface contaminants elicits response causing seed abortion, seed rot, seed necrosis, reduction or elimination of seed viability as well as seedling damage resulting disease development at later stages of plant growth by systemic or local infection (Gupta et al, 2012). Planting infected seeds leads to a widespread distribution of diseases within crop, and an increased count of initial infection sites from which disease can spread. High rate of seed-to-seedling transmission of pathogens create alarming situation, even a small percentage of infected seed can result in significant seedling infection in the field (Saskatchewan, 2013). Seed mycoflora limits an ability of plants to produce healthy fruit bearing shoots, causing damping-off, collor rot, stem canker, leaf blight and fruit rot leads to premature defoliation, reduction in size & quality of fruits, thereby adversely reducing yield potential to the extent of 20-30% (Lew-Smith, 2013).

Solanum melongena L., a warm-season, non-tuberous, low price, summer fruit vegetable of Southern Indian origin belongs to family *Solanaceae* is reported to be cultivated quite extensively throughout the continents on the globe including America, Europe and Asia for its fleshy fruit as it is a rich source of dietary fiber, vitamins, potassium and calcium; it has 92.7% water, 4% carbohydrate, 1.4% protein, 0.8% minerals, low fat, zero cholesterol, and very low calorie content hence make an integral part of a healthy diet and preferred food among weight-conscious consumers. It is a vital ingredient in numerous international dishes. In Indian cuisines, fruit can be boiled, stir-fried, deep-fried, steamed, roasted, or baked and used in preparation of "*baigun bhurta"*, curries, "*chutneys"* and other delicious dishes. Besides being used as food, the plant parts have great demand for medicine formulation in China, South-east Asia and Philippines. Roots are employed to cure syphilis and skin diseases. Decoction preparation from roots, dried stalk, and leaves is used as an astringent for haemorrhages. Leaves infusion is employed as an anodynes and remedy for throat and stomach troubles. Ripe fruit is bilious and excellent remedy for liver complaints. Burnt fruit is light in digestion, purgative, slightly bilious and proved beneficial in phlegm and obesity. Long fruit is phlegmatic and generative of phthisis, coughs, and loss of appetite. Tender fruit is antiphlegmatic and alleviative of wind. Fruits bruised with vinegar cure abscesses and cracked nipples. Peduncle is used in intestinal hemorrhages, piles and toothache. Seeds are used as a stimulant but are apt to lead to dyspepsia and constipation (FTRNR, 2012).

In India, an eggplant is first renounced vegetable cash crop of poor farmers and second highest consumed vegetable after potato, grown throughout the country except at higher altitude & strengthens the economy by providing a stable income round a year. A population of 1.6 million Indian farmers cultivates eggplant on an area of 6.8 lac hectares producing 118.96 lac metric tons yield annually, equivalent to one quarter of the global production. India ranks second leading producer contributing around 27.6% of the global annual harvest after China (IHD, 2012). Over the past decades, the yield potential has increased but existing annual productivity unable to satisfy domestic demand of growing mouths in India. Vidarbha is the eastern region, occupies 31.6% of total area and holds 21.3% of total population of Maharashtra. Vidarbha's economy is primarily agricultural. Apart from growing seasonal cotton and soya beans as main cash crop, the poor farmers cultivate eggplant as vegetable cash crop round a year. Among various constrains, an availability of poor quality seeds and fungal diseases are responsible for low yield and major economic losses. Vidarbha's climate support fungal diseases in field that adversely affect fruit productivity to a greater extend.

Solanum melongena L. is prone to attack by several fungal pathogens that cause enormous losses both to pre- and post-harvest crop (Kuri et al, 2011). Deterioration of seeds as substrate under supportive storage climate is an inexorable, continuous and irreversible process, under storage involves succession of fungal flora resulting in loss of seed nutrients, alteration of physiochemical properties of seeds, loss the seed weight, seed viability & vigour, medicinal properties, aesthetic changes including discoloration, heating & mustiness, cracking and abnormal odours contributing losses of seeds to the extent of 24% (Ismael, 2010). The consequences of deterioration leading to series of deteriorative changes include membrane degradation, accumulation of toxic

metabolites, decreased enzymatic activity, lipid autoxidation, failure of repair mechanisms, genetic degradation, reduced yield, finally loss of seed viability or death of seed (Jyoti and Malik, 2013). Fungal population of some isolates may bring about unexpected biochemical changes and toxic metabolites (mycotoxins) that elicit a toxic response such as immunosuppression, carcinogenicity, genotoxicity, terrotogenicity, hepatotoxicity, etc. Secondary fungal metabolites are reported to be toxic to man, animals and pose serious health hazard (Brakhage and Schroeckh, 2011).

Variable distribution of diverse seed borne fungal flora differs from region to region attributed to diversity in vegetation, climatic fluctuation and storage environment. Attempts have been made by uncountable researchers on prevalence of seed mycoflora of *Solanum melongena* L from various geographic regions on the globe with concern to spoilage of stored seeds in a set of environment (Ismael, 2010; Kuri et al., 2011; Bhajbhuje, 2013). Literature review revealed that a little is known from Vidarbha concerning to seasonal diversity of seed borne fungal flora on *S. melongena* L. A report on survey of seasonal distribution of seed borne pathogens in fluctuating climate of Vidarbha might be of some significance in establishing correlation between fungal sensitization and bio-deteriorative prevention of post-harvest crops. Since biodeterioration of post-harvest crop in storage climate attributed to seasonal fungal diversity is a common problem in Vidarbha, has not so far been highlighted, it seemed to be worthwhile to undertake a more comprehensive & systematic study to assess prevalence and report seasonal diversity micro-fungal flora on seeds of *S. melongena* L. originating from diverse geographic locations of Vidarbha in set of storage environment.

MATERIALS AND METHODS

In an initial step, a total of twenty seed samples of commonly grown cultivars of *Solanum melongena* L were collected in polythene bags from various cultivators of diverse geographic regions of Vidarbha (M.S.), brought to laboratory, immediately transferred aseptically to small cloth bags after mixing together and maintained under laboratory climate for a period of one year.Prior to this, seeds from collected samples were preliminary screened for prevalence of apparent deformities or discoloration employing dry examination technique (Bhajbhuje, 1989). At the end of periodic interval for a month, randomly selected 400 seeds were screened for prevalence of seed surface contaminants following standard blotter paper test (ISTA, 2012). Three folds of filter papers were sterilized with aqueous 1% mercuric chloride solution for 5 minutes, thereafter rinsed with sterile distilled water for five consecutive times. Twenty five seeds were laid down aseptically on three layered sterilized moistened filter papers in sterilized petri dishes without pretreatment for isolation of seed surface fungal contaminants. The moisture content of blotter paper containing seeds has been maintained by addition of sterile distilled water when required. After incubation for seven days in B.O.D incubator at 25±1°C under alternating cycles of 12 hours light and darkness, these plates containing seeds were examined directly for fungal growth under stereoscopic microscope. Identification by habit character such as colony colour and sporulation type was supplemented by microscopic examination of spores and fruiting bodies. Fungal isolate count and infection levels have been recorded as a percentage of infected seeds in a sample following a technique reported earlier (CMI, 2010). Purified fungal isolates were propagated and maintained on Czapek's Dox agar nutrient medium in sterile slants. Seed viability was determined at an interval of a month employing rolled towel method (Bhajbhuje, 1989).

RESULTS AND DISCUSSION

Microfungal propagules survive as a single unit, spores rarely as hyphal fragments, conidiophores, associated with seed surface and their distribution differs with respect to count and type, vary with time, weather, and also geography may attributed to variation in surrounding climate, seasonal fluctuation, changing vegetation and storage condition (Stephan, 2013). Preferably environmental seasonal fluctuating temperature in combination with moisture content determines a periodic distribution of diverse microfungal flora on various components of viable seeds and their propagules elicited varying response to fluctuating temperature and humidity leads to deterioration of seed nutritional components at differential rates (Jyoti and Malik, 2013). They are implicated in spoilage of stored grains, deterioration of organic material and their high concentration of mycotoxins may cause health hazards (Brakhage and Schroeckh, 2011). The chemical constituents of seeds are known for sporistatic, fungistatic and fungicidal activities possibly helps in variable reduction of level of fungal spore population in a set of storage environment. Raising of seedlings from infected seeds favours pathogen transmission of "*seed-to-seedling*" leads to a widespread distribution of diseases; emergence of diseased unhealthy fruit bearing shoots, premature defoliation, limits ability to anabolism and reduced yield potential of crop (Saskatchewan, 2013).

An isolation of fungal flora associated with seed surface was made at an interval of a month from seeds of mixed samples of *Solanum melongena* L from diverse geographical locations of Vidarbha following standard blotter test for a period of *October* 2012 to *September* 2013. Mycological analysis revealed an existence of a fungal population of 50 species belongs to 30 genera in varying degree of incidence. *Deuteromycota* are predominant ones, contributed greater count, 22 species of 14 genera followed by *Ascomycota* with 19 species of 8 genera. *Zygomycota* contributed 6 species of 5 genera while *Oomycota* are represented by 2 species of 2 genera. *Basidiomycota* had single species. An individual genus, *Aspergillus* dominated with 11 species. Three species each of *Curvularia, Helminthosporium, Fusarium*; two of *Alternaria, Penicillium, Rhizopus*, *Trichoderma* have been confined to seed testa as seed surface contaminants with diverse frequencies while others had single species (Table 1).

The standard blotter test proved superior over others was used for periodic detection of seed surface contaminants to record seasonal diversity in storage climate. Considering diverse fungal population count and variable infection level in monthly period of season, the fungal isolates may be categories into *four* types viz., prevailing (a) throughout a year; (b) in winter only; (c) in summer only and (d) rare without showing any specificity to a time of recurrence. A fungal population of fifty diverse isolates was seemed to be prevailing on seed surface in storage. Of these, a population of 14 species of 11 genera, *Absidia corymbefera*, *Alternaria tenuis, A. pori, Aspergillus flavus, A. fumigatus, A. niger, Colletotrichum dematium, Curvularia lunata, Drachslera rostrata, Fusarium miniliformae, Nigrospora sp., Penicillium oxalicum, Phytophthora infestans* and *Rhizopus stolonifer* were encountered throughout a year of storage representing category-(a). Among these, *Aspergillus fumigatus* was appeared to be predominant with 234.5 per cent total incidence followed by *Rhizopus stolonifer* (207.25%); *Aspergillus flavus* (172.75%); *Colletotrichum dematium* & *Drachslera rostrata* (146.0%); *Absidia corymbifera* (123.25%) and *Alternaria porri* (104.25%). Little infestation was recorded for *Nigrospora* sp while others had 40.0-93.25 per cent cumulative incidence. Significant level of infestation has been observed in a month of *January* (Table 1).

The seed surface contaminants confined to seeds in the winter season (*October* to *March*) representing category-(b), contributed a population comprising total of 10 species of 10 genera, *Aspergillus parasiticus, Botrytis cinera. Cladosporium fulvum, Curvularia intermedia, Fusarium oxysporum, Helminthosporium tetramera, Mortierella sp, Rhizopus nigricans, Stachybotrys atra* and *Verticillium albo-atrum* in varying level of infestation. An isolate of *Zygomycota*, *Rhizopus nigricans* was seemed to be major components in the winter season, contributing cumulative 53.5 per cent incidence followed by *Helminthosporium tetramera* (33.0%) and *Stachybotrys atra* (28.5%). Incidence level ranged between 19.0 to 23.5 per cent has been detected for *Botrytis cinera, Fusarium oxysporum, Cladosporium fulvum* and *Curvularia intermedia* while it was 14.5 per cent for *Aspergillus parasiticus* and *Mortierella* sp. *Verticillium albo-atrum* had little infestation. Similar trend for infestation level to seeds was confined to a month of *January* as recorded for category-(a). It is premised on the hypothesis that climate of winter season between *January* and *February* favors propagation of majority of propagules. Results revealed that a population of a total of 14 species belong to 12 genera, *Aspergillus amstelodomi, A. sydowi, Aureobasidium pullulans, Botryodiplodia theobromae, Curvularia ovoidea, Fusarium semitectum, Helminthosporium anomalous, H. spiciferum, Penicillium pallidum, Phoma glomerata, Pythium sp., Stemphylium botryosum, Trichoderma lignorum* and *Trichothecium roseum* were appeared in the months of *January*, *February* and rarely in *March* of the winter season. Both the species of *Helminthosporium* and *Pythium* sp. were seemed to be predominant with greater, 8.0 -11.5 per cent incidence. Little to mild incidence level varying between 1.0-4.75 per cent has been detected for *Aureobasidium pullulans, Botryodiplodia theobromae* and *Trichoderma lignorum* while others had moderate level of infestation (Table 1).

Fungal population of seed surface contaminants survived in storage throughout warmer summer season (*April* to *September*) representing category-(c). Of the total isolates, a population of 7 species of 5 genera, *Aspergillus candidus, A. ochracious, A. terreus, Chaetomium glabosum, Myrothecium roridum, Paecilomyces varioti* and *Sporotrichum pulverulentum* has been detected in varying degree of infestation. *Chaetomium glabosum* was appeared to be predominant with total 93.25 per cent incidence followed by *Sporotrichum pulverulentum* (39.25%); *Aspergillus terreus*(32.0%); *A. ochracious* & *Myrothecium roridum* (27.0%); *A. candidus* (26.5%) while *Paecilomyces variotii* had 21.5% total incidence (Table 1).

A few fungal isolates detected as seed surface contaminants, but did not exhibit any consistence of their recurrence in relation to changing and fluctuating climate, representing category-(d) included only a population of 5 isolates representing 4 genera, *Aspergillus nidulans, A. sulphureus, Cunninghamella elegans, Syncephalastrum racemosus* and *Trichoderma viride. Cunninghamella elegans* was seemed to be most predominant while others had mild to moderate infestation to the seed coat (Table 1).

Table-1: Periodic diversity of seed surface fungal contaminants and their level of infestation in storage on seeds of *Solanum melongena* L..

Sr. No	Name of fungus	Frequency (%) of fungal incidence												Total frequency	% over total
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.		
A	**Oomycota**	**3.0** (0.13)[1]	**7.0** (0.32)	**15.0** (0.68)	**19.0** (0.86)	**12.5** (0.57)	**5.0** (0.23)	**1.5** (0.07)	**1.75** (0.08)	**2.0** (0.09)	**1.0** (0.05)	**0.5** (0.02)	**2.5** (0.11)	**70.75** (3.20)	**3.20**
1.	*Phytophthora infestans* de Bary	3.0 (0.14)	7.0 (0.32)	15.0 (0.68)	14.0 (0.63)	6.0 (0.27)	5.0 (0.23)	1.5 (0.07)	1.75 (0.08)	2.0 (0.09)	1.0 (0.05)	0.5 (0.02)	2.5 (0.11)	59.25 (2.68)	2.68
2.	*Pythium sp.*	-	-	-	5.0 (0.23)	6.5 (0.29)	-	-	-	-	-	-	-	11.50 (0.52)	0.52
B	**Zygomycota**	**33.75** (1.53)	**34.0** (1.54)	**51.0** (2.31)	**57.0** (2.58)	**52.5** (2.37)	**4.5** (0.20)	**29.0** (1.31)	**21.75** (0.98)	**25.5** (1.15)	**21.0** (0.95)	**23.0** (1.04)	**30.0** (1.36)	**419.0** (18.94)	**18.94**
3.	*Absidia corymbifera* (Cohn) Sacc. & Trotter	2.25 (0.10)	2.5 (0.11)	2.0 (0.09)	2.0 (0.09)	9.0 (0.41)	13.0 (0.59)	16.0 (0.72)	18.75 (0.85)	17.0 (0.77)	14.0 (0.63)	13.0 (0.59)	13.75 (0.62)	123.25 (5.57)	5.57
4	*Cunninghamella elegans* Lendner	-	-	6.0 (0.27)	6.0 (0.27)	-	-	-	-	-	-	-	4.0 (0.18)	16.0 (0.72)	0.72
5	*Mortierella sp.*	1.0 (0.05)	1.0 (0.05)	5.0 (0.23)	3.0 (0.14)	2.0 (0.09)	1.0 (0.05)	-	-	-	-	-	1.5 (0.07)	14.50 (0.66)	0.66
6	*Rhizopus nigricans Demelius*	12.5 (0.57)	10.5 (0.47)	8.0 (0.36)	10.5 (0.47)	9.5 (0.43)	2.5 (0.11)	-	-	-	-	-	-	53.50 (2.42)	11.89
7	*Rhizopus stolonifer* Eh. Ex.Rr.)Lind.	18.0 (0.81)	20.0 (0.90)	28.0 (1.27)	34.0 (1.53)	32.0 (1.45)	24.0 (1.08)	12.0 (0.54)	3.0 (0.14)	8.5 (0.38)	7.0 (0.32)	10.0 (0.45)	10.75 (0.49)	207.25 (9.37)	
8	*Syncephalastrum racemosus* (Cohn) Schroet.	-	-	2.0 (0.09)	1.5 (0.07)	-	-	1.0 (0.05)	-	-	-	-	-	4.5 (0.20)	0.20
C	**Ascomycota**	**52.0** (2.35)	**74.5** (3.37)	**90.75** (4.10)	**114.75** (5.19)	**71.75** (3.24)	**57.25** (2.59)	**62.5** (2.83)	**72.25** (3.27)	**81.75** (3.70)	**77.5** (3.50)	**60.0** (2.71)	**56.0** (2.53)	**876.0** (39.6)	**39.6**
9.	*Aspergillus amstelodomi (Mang) Thom & Church*	-	-	-	3.0 (0.14)	4.5 (0.20)	-	-	-	-	-	-	-	7.5 (0.34)	29.47
10	*Aspergillus candidus* Link	-	-	-	2.0 (0.09)	-	-	8.0 (0.36)	9.0 (0.41)	4.0 (0.18)	3.5 (0.16)	-	-	26.5 (1.20)	
11	*A. flavus* Link.	14.0 (0.63)	20.0 (0.90)	24.0 (1.08)	24.5 (1.11)	18.0 (0.81)	10.0 (0.45)	7.0 (0.32)	6.75 (0.31)	7.0 (0.32)	12.5 (0.57)	14.0 (0.63)	15.0 (0.68)	172.75 (7.79)	
12	*A. fumigatus* Fres.	13.0 (0.59)	16.0 (0.72)	15.5 (0.70)	13.0 (0.59)	17.75 (0.80)	25.0 (1.13)	24.75 (1.12)	24.0 (1.08)	26.0 (1.18)	23.5 (1.06)	18.0 (0.81)	18.0 (0.81)	234.5 (10.60)	
13	*A. parasiticus* Speare.	7.0 (0.32)	7.0 (0.32)	8.75 (0.40)	9.0 (0.41)	6.0 (0.27)	3.0 (0.14)	-	-	0.75 (0.03)	-	-	-	41.5 (1.88)	
14	*A. nidulans* (Eidam) Winter	-	-	-	2.5 (0.11)	-	-	-	-	3.5 (0.16)	-	-	-	6.0 (0.27)	
15	*A. niger* Van Tieghen	4.5 (0.20)	7.5 (0.34)	15.0 (0.68)	14.0 (0.63)	13.0 (0.59)	6.0 (0.27)	4.75 (0.21)	4.0 (0.18)	4.5 (0.20)	5.0 (0.23)	3.0 (0.14)	3.5 (0.16)	84.75 (3.83)	
16	*A. ochracious* Wihelm	-	-	-	2.0 (0.09)	-	-	7.0 (0.32)	6.0 (0.27)	7.0 (0.32)	5.0 (0.23)	-	-	27.0 (1.22)	
17	*A. sulphureus* (Fres.)Thom & Church	-	-	6.5 (0.29)	2.0 (0.09)	-	-	-	-	-	-	1.5 (0.07)	-	10.0 (0.45)	
18	*A. sydowi (Bein. & Sartory) Thom & Church*	-	-	-	3.5 (0.16)	4.0 (0.18)	2.0 (0.09)	-	-	-	-	-		9.5 (0.43)	
19	*A. terreus* Thom.	-	-	-	4.0 (0.18)	-	-	-	7.0 (0.32)	9.0 (0.41)	7.0 (0.32)	5.0 (0.23)	-	32.0 (1.45)	
20	*Aureobasidium pullulans* Vala & Boyer	-	-	2.5 (0.11)	2.0 (0.09)	-	-	-	-	-	-	-	-	4.5 (0.20)	0.20

Table-1: Continued...

Sr. No	Name of fungus	Frequency (%) of fungal incidence												Total frequency	% over total
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.		
21	*Botryodiplodia theobromae* (Pat.) Griff, et Maub	-	-	1.0 (0.05)	3.75 (0.17)	-	-	-	-	-	-	-	-	4.75 (0.21)	0.21
22	*Botrytis cinerea* Pets.	4.5 (0.20)	3.5 (0.16)	4.5 (0.20)	6.5 (0.29)	-	-	-	-	-	-	-	-	19.0 (0.86)	0.86
23	*Chaetomium glabosum Kunze & Schm*	-	-	2.0 (0.09)	0.5 (0.02)	-	4.75 (0.21)	9.0 (0.41)	14.0 (0.63)	18.0 (0.81)	18.0 (0.81)	13.5 (0.61)	13.5 (0.61)	93.25 (4.22)	4.22
24	*Cladosporium fulvum* Cooke.	4.0 (0.18)	6.0 (0.27)	5.75 (0.26)	3.0 (0.14)	-	-	-	-	-	-	-	1.5 (0.07)	20.25 (0.92)	0.92
25	*Penicillium oxalicum* Currie & Thom.	5.0 (0.23)	6.0 (0.27)	7.75 (0.35)	9.0 (0.41)	8.0 (0.36)	7.0 (0.32)	2.0 (0.09)	1.5 (0.07)	2.0 (0.09)	3.0 (0.14)	5.0 (0.23)	4.5 (0.20)	60.75 (2.75)	
26	*Penicillium pallidum* (Cruick & Shank) Pitt.	-	-	2.5 (0.11)	3.0 (0.14)	-	-	-	-	-	-	-	-	5.5 (0.25)	3.00
27	*Phoma glomerata* (Corda) Wr. & Hocha	-	8.5 (0.38)	-	7.5 (0.34)	-	-	-	-	-	-	-	-	16.0 (0.72)	0.72
D	**Basidiomycota**	-	-	-	1.0 (0.05)	-	-	5.0 (0.23)	7.0 (0.32)	7.0 (0.32)	9.0 (0.41)	5.5 (0.25)	4.75 (0.21)	**39.25** (1.77)	**1.17**
28	*Sporotrichum pulverulentum* Nov Cain & Grover	-	-	-	1.0 (0.05)	-	-	5.0 (0.23)	7.0 (0.32)	7.0 (0.32)	9.0 (0.41)	5.5 (0.25)	4.75 (0.21)	**39.25** (1.77)	1.17
E	**Deuteromycota**	**57.25** (2.59)	**74.5** (3.37)	**116.75** (5.28)	**151.0** (6.83)	**104.0** (4.70)	**49.5** (2.24)	**32.25** (1.46)	**52.5** (2.37)	**48.75** (2.20)	**46.75** (2.11)	**38.0** (1.72)	**35.75** (1.62)	**807.0** (36.48)	**36.48**
29	*Alternaria porri* (Ells) Cif.	2.0 (0.09)	8.0 (0.36)	13.0 (0.59)	14.0 (0.63)	12.0 (0.54)	4.0 (0.18)	6.0 (0.27)	14.0 (0.63)	13.0 (0.59)	12.0 (0.54)	2.0 (0.09)	4.25 (0.19)	104.25 (4.71)	
30	*Alternaria tenuis* Nees.	3.5 (0.16)	4.5 (0.20)	9.5 (0.43)	10.0 (0.45)	3.5 (0.16)	3.5 (0.16)	3.0 (0.14)	3.0 (0.14)	3.0 (0.14)	4.5 (0.20)	2.0 (0.09)	2.5 (0.11)	52.5 (2.37)	7.08
31	*Colletotrichum dematium* But. & Bisby	13.0 (0.59)	14.0 (0.63)	18.0 (0.81)	22.0 (0.99)	18.0 (0.81)	14.0 (0.63)	7.5 (0.34)	7.5 (0.34)	8.0 (0.36)	6.0 (0.27)	13.0 (0.59)	5.0 (0.23)	146.0 (6.60)	6.60
32	*Curvularia lunata* (Wakker) Boedijn	7.75 (0.35)	8.0 (0.36)	10.0 (0.45)	9.0 (0.41)	7.5 (0.34)	7.0 (0.36)	1.75 (0.08)	3.0 (0.14)	3.0 (0.14)	2.5 (0.11)	7.0 (0.32)	5.0 (0.23)	71.5 (3.23)	4.48
32	*Curvularia lunata* (Wakker) Boedijn	7.75 (0.35)	8.0 (0.36)	10.0 (0.45)	9.0 (0.41)	7.5 (0.34)	7.0 (0.36)	1.75 (0.08)	3.0 (0.14)	3.0 (0.14)	2.5 (0.11)	7.0 (0.32)	5.0 (0.23)	71.5 (3.23)	
33	*Curvularia intermedia* (Tracy & Barle) Boedjin	8.5 (0.38)	-	7.5 (0.34)	6.5 (0.29)	-	-	-	-	-	-	-	-	22.5 (1.02)	
34	*Curvularia ovoidea* (Hirosa & Watan) Munt.	-	-	2.5 (0.11)	2.5 (0.11)	-	-	-	-	-	-	-	-	5.0 (0.23)	4.48
35	*Drechslera rostrata* (Drechsler) Rich. & Fraser	13.0 (0.59)	14.0 (0.63)	18.0 (0.81)	22.0 (0.99)	18.0 (0.81)	14.0 (0.63)	7.5 (0.35)	7.5 (0.35)	6.0 (0.27)	8.0 (0.36)	13.0 (0.59)	5.0 (0.23)	146.0 (6.60)	6.60
36	*Fusarium miniliformae* Sheldom	3.0 (0.14)	4.0 (0.18)	6.75 (0.31)	8.25 (0.37)	6.0 (0.27)	3.0 (0.14)	3.0 (0.14)	0.5 (0.02)	1.75 (0.08)	0.75 (0.04)	1.5 (0.07)	2.0 (0.09)	40.0 (1.81)	
37	*Fusarium oxysporum* Schlecht	-	4.5 (0.20)	2.5 (0.11)	7.5 (0.35)	6.5 (0.29)	-	-	-	0.5 (0.02)	-	-	2.0 (0.09)	23.5 (1.06)	3.21
38	*Fusarium semitectum* Berk & Rav.	-	-	-	3.5 (0.16)	4.0 (0.18)	-	-	-	-	-	-	-	7.5 (0.34)	
39	*Helminthosporium anomalus* Gilman & Abbott	-	-	2.5 (0.11)	2.5 (0.11)	3.0 (0.14)	-	-	-	-	-	-	-	8.0 (0.36)	2.28

Table-1: Continued...

Sr. No	Name of fungus	Frequency (%) of fungal incidence												Total frequency	% over total
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.		
40	*Helminthosporium* spiciferum (Bain.) Nicol	-	-	3.5 (0.16)	4.0 (0.18)	2.0 (0.09)	-	-	-	-	-	-	-	9.5 (0.43)	
41	*Helminthosporium tetramera* G & A	-	7.5 (0.34)	5.5 (0.25)	11.5 (0.52)	8.5 (0.38)	-	-	-	-	-	-	-	33.0 (1.49)	
42	*Myrothecium roridum* Tode ex Fr.	-	-	-	0.5 (0.02)	-	-	-	9.0 (0.41)	4.0 (0.18)	7.0 (0.32)	-	6.5 (0.29)	27.0 (1.22)	1.22
43	*Nigrospora sp.*	1.5 (0.07)	4.0 (0.18)	7.5 (0.35)	6.0 (0.27)	5.0 (0.23)	3.0 (0.14)	1.0 (0.05)	0.5 (0.02)	1.0 (0.05)	1.0 (0.05)	1.5 (0.07)	1.5 (0.07)	33.5 (1.61)	1.61
44	*Paecilomyces variotii* Bainier	-	-	-	1.5 (0.07)	-	-	2.5 (0.11)	7.5 (0.35)	6.5 (0.29)	3.5 (0.16)	-	-	21.5 (0.97)	0.97
45	*Stachybotrys atra* Corda	5.0 (0.23)	4.0 (0.18)	7.0 (0.32)	6.0 (0.27)	5.0 (0.23)	-	-	-	-	1.5 (0.07)	-	-	28.5 (1.29)	1.29
46	*Stemphylium botryosum* Waller.	-	-	1.0 (0.05)	6.25 (0.28)	-	-	-	-	-	-	-	-	7.25 (0.33)	0.33
47	*Trichoderma viride* Pers. Neues	-	-	-	1.5 (0.07)	-	-	-	-	2.0 (0.09)	-	-	-	3.5 (0.16)	
48	*Trichoderma lignorum* (Tochi & Shimada) Pidolp	-	-	-	1.0 (0.05)	-	-	-	-	-	-	-	-	1.0 (0.05)	0.21
49	*Trichothecium roseum* Link	-	-	-	2.0 (0.09)	3.5 (0.16)	-	-	-	-	-	-	-	5.5 (0.25)	0.25
50	*Verticillium albo-atrum* John & Clarkson	-	2.0 (0.09)	2.0 (0.09)	3.0 (0.14)	1.5 (0.07)	1.00 (0.05)	-	-	-	-	-	-	9.5 (0.43)	0.43
	Total frequency	**146.0** (6.60)	**190.0** (8.59)	**278.5** (12.59)	**342.75** (15.50)	**240.25** (10.86)	**152..75** (6.91)	**130.25** (5.88)	**155.25** (7.02)	**165.0** (7.46)	**155.25** (7.02)	**129.0** (5.83)	**127.0** (5.74)	**2212**	99.57
	1. Values in parenthesis indicates per cent fungal incidence over total frequency of incidence.														

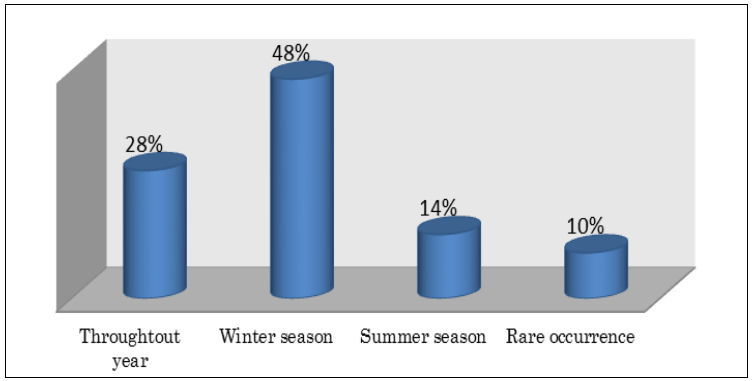


Fig. 1: Periodical fungal count of seed surface contaminants of *Solanum melongena* L. Seeds

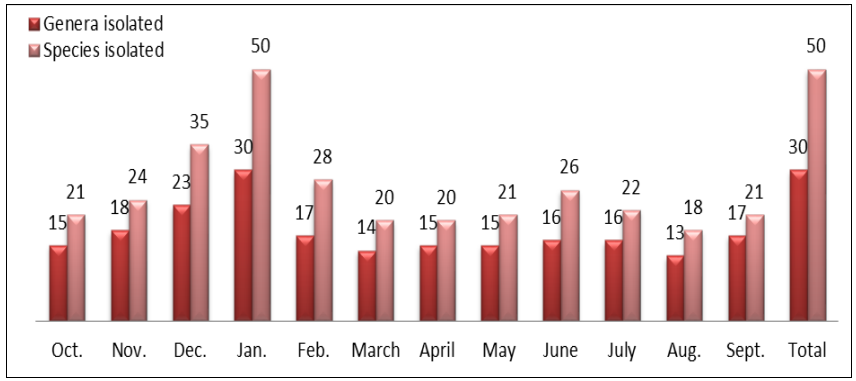


Fig.2: Periodical distribution of isolates in storage on seeds of *Solanum melongena* L.

Table 2 : Fungal division wise distribution of fungal population in storage associated with seeds of *Solanum melongena* L

Sr. No.	Division	Parameter	Seed borne fungal isolates and their frequency(%) of incidence												Total
			Oct.	Nov.	Dec.	Jan.	Feb.	Mar	Apr.	May	June	July	Aug.	Sept	
A	Oomycota	Genera	1	1	1	2	2	1	1	1	1	1	1	1	2
		Species	1	1	1	2	2	1	1	1	1	1	1	1	2
		Percent incidence	3.0 (0.13)[1]	7.0 (0.32)	15.0 (0.68)	19.0 (0.86)	12.5 (0.57)	5.0 (0.23)	1.5 (0.07)	1.75 (0.08)	2.0 (0.09)	1.0 (0.05)	0.5 (0.02)	2.5 (0.11)	70.75 (3.20)
B	Zygomycota	Genera	3	3	5	5	3	3	3	2	2	2	2	4	5
		Species	4	4	6	6	4	4	3	2	2	2	2	4	6
		Percent incidence	33.75 (1.53)	34.0 (1.54)	51.0 (2.31)	57.0 (2.58)	52.5 (2.37)	4.5 (0.20)	29.0 (1.31)	21.75 (0.98)	25.5 (1.15)	21.0 (0.95)	23.0 (1.04)	30.0 (1.36)	419.0 (18.94)
C	Ascomycota	Genera	4	5	7	8	2	3	3	3	3	3	3	4	8
		Species	7	8	12	19	7	7	7	8	10	8	7	6	19
		Percent incidence	52.0 (2.35)	74.5 (3.37)	90.75 (4.10)	114.75 (5.19)	71.75 (3.24)	57.25 (2.59)	62.5 (2.83)	72.25 (3.27)	81.75 (3.70)	77.5 (3.50)	60.0 (2.71)	56.0 (2.53)	876.0 (39.6)
D	Basidiomycota	Genera	-	-	-	1	-	-	1	1	1	1	1	1	1
		Species	-	-	-	1	-	-	1	1	1	1	1	1	1
		Percent incidence		-	-	1.0 (0.05)	-	-	5.0 (0.23)	7.0 (0.32)	7.0 (0.32)	9.0 (0.41)	5.5 (0.25)	4.75 (0.21)	39.25 (1.77)
E	Deuteromycota	Genera	7	9	10	14	10	7	7	8	9	9	6	7	14
		Species	9	11	16	22	15	8	8	9	11	10	7	9	22
		Percent incidence	57.25 (2.59)	74.5 (3.37)	116.75 (5.28)	151.0 (6.83)	104.0 (4.70)	49.5 (2.24)	32.25 (1.46)	52.5 (2.37)	48.75 (2.20)	46.75 (2.11)	38.0 (1.72)	35.75 (1.62)	807.0 (36.48)
	Total genera		15	18	23	30	17	14	15	15	16	16	13	17	30
	Total species		21	24	35	50	28	20	20	21	25	22	18	21	50

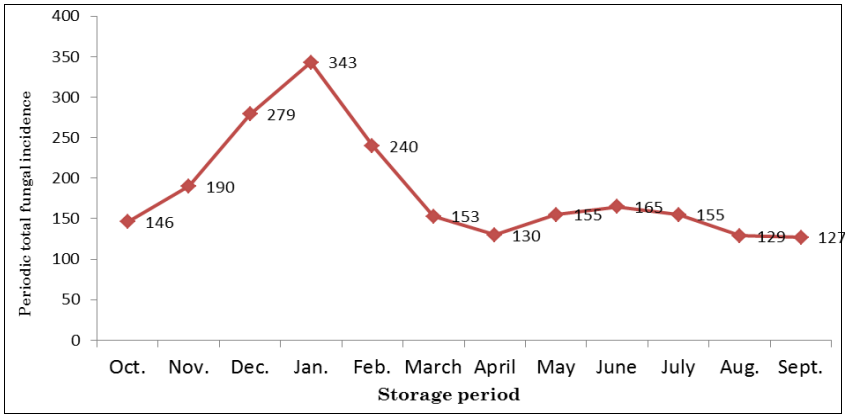
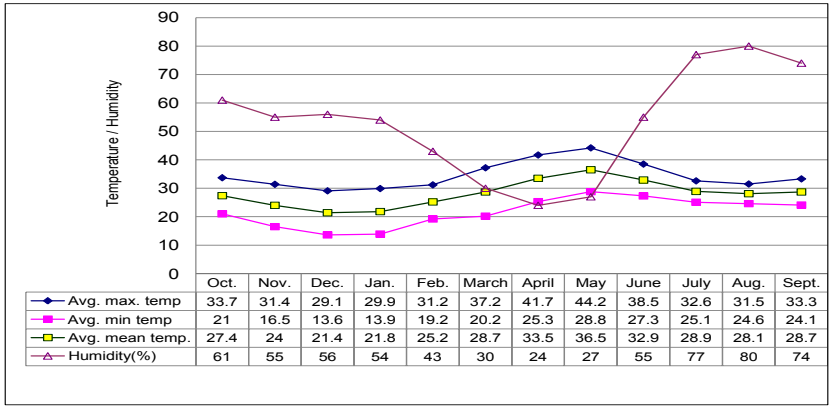


Fig.3: Periodical fungal total incidence of seed borne pathogens on seeds of *Solanum melongena* L.



	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
Avg. max. temp	33.7	31.4	29.1	29.9	31.2	37.2	41.7	44.2	38.5	32.6	31.5	33.3
Avg. min temp	21	16.5	13.6	13.9	19.2	20.2	25.3	28.8	27.3	25.1	24.6	24.1
Avg. mean temp.	27.4	24	21.4	21.8	25.2	28.7	33.5	36.5	32.9	28.9	28.1	28.7
Humidity(%)	61	55	56	54	43	30	24	27	55	77	80	74

Fig.4. Record of average temperature in degree celsius and per cent humidity of seed sample storage environment

A population of all fungal seed borne isolates encountered to seeds for a year of storage in a set of environment has been categorized under various divisions and count of isolates as well as their per cent incidence for individual division is presented in table 2. *Oomycota* contributed maximum 2 genera and 2 species to a month of *January* and *February* with higher, 19.0 and 12.5per cent total incidence respectively while other each month period had single isolate. Incidence frequency varied between, 3.0 – 19.0 per cent during the winter while it was detected 0.5-2.5 per cent in summer (Table 2). *Zygomycota* contributed maximum 6 species and 5 genera to the months of *December* and *January* while 2 -4 species and genera confined to seeds in other each month. Greater fungal incidence, 57.0 and 52.5 per cent has been recorded in the months of *January* and *February* respectively. During winter, excluding *March*, fungal incidence varied between 33.0 – 57.0 per cent while it was recorded 21-30 per cent in summer (Table 2). *Ascomycota* had higher count of 19 species and 8 genera, with cumulative 114.75 per cent incidence in a month of *January* followed by *Decembe*r, contributing 90.8 per cent incidence. An isolate count of 6-10 species and 3-5 genera were confined to other each month period. Winter dominates with heavy infestation ranged between 52.0 – 114.8 per cent while it was recorded 56.0 - 81.8 per cent during summer (Table 2). Similar trend was observed for *Deuteromycota*, contributing higher count of 22 species and 14 genera to a month of *January* with cumulative 151.0 per cent incidence followed by *December* with 115.8 per cent. Winter season had significant level of infestation over summer. *Basidiomycota* contributed single isolate throughout in the summer season with 4.8 - 9.0 per cent incidence but its prevalence was frequent in the winter season (Table 2).

Fungal spore concentration on seed surface varies with seasonal climate. Prevalence of higher count of isolates, contributing greater incidence during winter elicited response to climate of this season. Greater count of isolates comprising of 50 species and 30 genera was detected to a month of *January* followed by *December*, contributing 35 species and 23 genera while *February* had 28 species and 17 genera. Storage period of *October* and *November* had moderate counts. A population of an isolates was observed decline during summer (Table 2). Similar trend has been reported for fungal infestation. Heavy infestation was confined in middle period of winter season, estimated maximum, 342.75 per cent to a month of *January* followed by *December* (278. 5%) and *February* (240.25%) while moderate, total 190 per cent in *November*. It was observed decline, in summer to the months of *June* (165.0%); *May* & *July* (155.0%); *March* (152.75%) and detected low in *April* (130.25%), *August* (129.0%) and *September* (127.0%). It was again enhanced to 146 per cent in an initiation period (*October*) of the winter season (Table 2). Seed viability for initial storage period of five months did exhibit little or negligible change, representing 80-83per cent seed germination. Thereafter, it began to decline from *March* and finally reduced to 24 per cent in *September* (Table 2).

The seed borne fungal flora include a very large, diverse and heterogeneous group of microfungal contaminants that occupy position of great economic importance in agriculture, exhibiting an enormous diversity in life-history strategies. Post-harvest seeds of *Solanum melongena* L are highly infested by fungal contaminants (Bhajbhuje, 2013). The standard blotter technique is applied in routine seed health test to periodic/monthly detection of seed surface contaminants for longer storage period of a year as this technique is inevitable for getting a complete picture of seed surface mycoflora (Ramesh et al, 2013). Diverse fungal population of total 50 species classified under 30 genera has been recorded from seeds of *Solanum melongena* as surface contaminants for diverse geographic area of Vidarbha. *Deuteromycota* dominated with 44 per cent, exhibiting highest fungal count followed by *Ascomycota* (38%). *Zygomycota* contributed 12 per cent while *Oomycota* & *Basidiomycota* had least count of isolates (Table.1). This result is in agreement with the finding of Ramesh et al., (2013) who reported comparatively greater count of fungal isolates for *Deuteromycota*, followed by *Ascomycota, Zygomycota* and zero count for *Basidiomycota* from stored seeds of *Coriandrum sativum* L. Recently, Bhajbhuje (2013) reported higher count of fungal population categorized under *Deuteromycota* from stored seeds of *Solanum melongena* L. by blotter paper test. The dominant microfungal genera of this group include *Alternaria, Curvularia, Helminthosporium, Fusarium, Drechslera, Trichoderma, and Paecilomyces* (Table 1). Majority species confined to genus, *Aspergillus* contributing greatest percent incidence over total. This finding is in consistent with Niaz et al (2011) who reported greater level of infestation by *Aspergilli* to stored maize seeds. Ramesh et al., (2013) reported huge population of *Aspergillus candidus, A. flavus, A. fumigatus, A. nidulans, A. niger, A. parasiticus, A. sydowi, A. terreus* in addition to predominant occurrence of *Alternaria solani, Curvularia lunata, Fusarium oxysporum, Helminthosporium tetramera* and *Trichoderma viride* from coriander seeds. The isolates of genera, *Aspergillus, Alternaria, Penicillium, Cladosporium, Fusarium* and *Stachybotrys atra* were reported in higher frequency from seeds of *Oryza sativa* (Archana and Prakash, 2013). Of the total frequency of incidence recorded periodically in storage for a year, *Ascomycota* contributed greatest, 39.6 per cent, followed by *Deuteromycota* (36.5%) and *Zygomycota* (18.9%). *Oomycota* had 3.3 per cent while

Basidiomycota contributed little incidence (Table 1). These results are in conformity with the earlier findings (Kuri et al., 2011; Bhajbhuje, 2013).

The fungal isolates belong to genera*, Aspergilli* and *Penicilli* of *Ascomycota* as well as *Alternaria, Curvularia, Fusarium, Helminthosporium* of *Deuteromycota* contributed as major components on *Solanum melongena* L seed, represented a group of taxa of cosmopolitan fungal organisms that can exploit virtually any organic substrate provided favourable storage environment of oxygen, temperature & relative humidity and accumulates toxic secondary metabolites (Saskatchewan, 2013). *Deuteromycota* had comparative higher count of isolates may possibly due to heavy infestation to seed coat by spores, acervuli and other propagules of *Hyphomycetes* during post-harvest period of crop. *Ascomycota* exhibited greatest level of incidence may attributed to rapid propagation and sporulation of isolates on nutrient rich seed surface with availability of favourable storage climate of slight low temperature, high humidity and seed moisture content (Jyoti and Malik, 2013). Moreover, members of this group are known facultative parasites on crop plants as well as involved as saprophyte in deterioration of seeds and debris of plant & animal origin (Ismael, 2010). Under storage, in moist climate, seeds form an ideal organic substrate to storage fungal flora (Stephan, 2013). Members of *Deuteromycota* are mitosporic, sporulate rapidly and complete their life cycle asexually producing numerous resistant, long persisting thick walled conidia which may remain viable for longer period in adverse climatic environment (Ramesh et al., 2013). The conidia *Alternaria, Cladosporium, Curvularia, Helminthosporium* and *Trichothecium* were remained prevailing in greatest abundance under storage even at low humidity, generally during warmer climate (Niaz et al, 2011). It was interesting to record that members of *Basidiomycotina* rarely persist on eggplant seeds may be possibly attributed to mode of nutrition as majority of fungal organisms of this group are obligate parasites of other crop plants.

Seasonal and regional occurrence of plant diseases to a greater extent is determined by temperature, humidity and other climatological factors of the geographical area understudy. Prevalence of fungal flora on seeds surface depends on their ability to survive and proliferate under the extremes of dry condition of seed storage (Ramesh et al, 2013). Certain fungal flora survived and majority of them prevalent during winter and others during summer. An existence of fungal flora in certain season can be attributed to host, pathogen as well as seasonal fluctuation in environmental climate. The hosts are available in a particular season and therefore a season is usually favourable for propagations of fungal pathogens. It is proved that temperature and humidity existing before or after a particular season may be unfavourable for survival of dormant propagules of pathogen (Nazim et al, 2013). An experiment has been designed for an establishment of seasonal variation pattern as well as the possible correlations with the climatological factors. To establish same, storage climate of laboratory and Nagpur city's (M.S.) maximum and minimum temperature in degree Celsius and humidity in percentage have been taken into consideration for a storage period. There was no marked variation in the climate of laboratory and Nagpur city (Fig. 4). At an interval of a month, isolation of seed surface contaminants was made by usual blotter method from randomly selected 400 seeds stored in gunny bags under laboratory climate. Fungal count, level of infestation as percent incidence and seed viability has been presented (Table 1).

Results from the present study revealed that fungal population of seed surface contaminants varied significantly in response to seed quality as substrate, fluctuating climatological conditions and storage period. Of the total population recorded during storage period for a year, the winter season is dominated by 48 per cent; nearly half of total population of isolates while 28 per cent isolates survived luxuriously throughout the storage period. Summer season is represented by 14 per cent while population of 10 per cent isolates was prevailed rarely without exhibiting any specificity to a time of recurrence (Fig.1). Moreover, greatest fungal count was confined in the months of *January* followed by *December* and *February* while moderate count in *October* and *November*. Declining of fungal count began from the end of the winter and remained throughout the summer (Fig. 2). These results are confirmed with earlier finding (Bhajbhuje, 1989; Nazim et al, 2013). Similar trend has been reported concerning fungal infestation to seed coat that was confined significant in the mid-period of the winter season. Heavy infestation in term of percent incidence was estimated to a storage period in *January* followed by *December* and *February* months while it was reported moderate in *November*. Infestation level had declined with the initiation of summer, reached to minimum level between the months of *March* to *September* and again enhanced gradually at the onset of winter season (Fig. 3). Heavy fungal infestation to seeds of diverse crops in winter season at slightly low temperature and high humidity over summer was reported by Bhajbhuje (1989); Javed et al (2008) and Ramesh et al (2013).

Fungal population of total 14 species categorize under 11 genera were significantly prevailing throughout a storage of a year with greater per cent incidence to a period of *January* except *Absidia corymbifera, Aspergillus fumigatus, Nigrospora sp. Phytophthora infestans*. Among these exceptional

isolates, *Absidia corymbifera* and *Aspergillus fumigatus* were encountered with low per cent incidence in winter season but their degree of infestation was confined significant over others between the months of *March* to *July*. Depletion in level of infestation correlated with gradual increased temperature of storage environment (Fig.3 & 4). Fungal isolates had low frequency during summer season although remained prevalent throughout a year on seeds surface are obviously more versatile in a food requirement and capacity of tolerance for varying environment. Moreover, infestation level of these isolates varied in relation to a variation in temperature and humidity of an environmental climate may be attributed to their variable existence on seed coats. Bhajbhuje (1989) studied seasonal variation of seed mycoflora of some vegetable crops and drawn similar conclusion. These fungal isolates are mostly mesophilic, rapidly proliferate and sporulate at 25-28^{0}C. Moreover, *Absidia corymbifera* and *Aspergillus fumigatus* are thermo-tolerants, able to propagate in moderate humidity at 30-35^{0}C (Stephan, 2013). *Alternaria porri, Aspergillus flavus, A. niger, Penicillium oxalicum* and *Rhizopus stolonifer* were most predominant on seed surface to a period between *December* to *February* at a storage temperature between 22-28^{0}C (Fig.4). These results are confirmed to earlier findings from infested seeds involving cotton (Javed et al., 2008), solanaceous vegetables (Ismael, 2010); maize (Niaz et al, 2011); cabbage (Gupta et al., 2012); coriander (Ramesh et al., 2013). Joshi and Kareppa (2010) reported optimum temperature 25-27^{0}C for rapid mycelial growth and sporulation of *Aspergillus flavus, A. niger, Alternaria alternata, Curvularia lunata, Rhizopus nigricans Fusarium oxysporum* and 30-35^{0}C for *Aspergillus fumigatus* Stephan (2013) suggested higher and lower standard temperature of seed health testing (20-28^{0}C) for mesophiles and 30-35^{0}C for thermo-tolerants.

The seed surface contaminants confined only in winter season included a population of total of 10 species belong to 10 genera, *Aspergillus parasiticus, Botrytis cinera., Cladosporium fulvum, Curvularia intermedia, Fusarium oxysporum, Helminthosporium tetramera, Mortierella sp., Rhizopus nigricans, Stachybotrys atra* and *Verticillium albo-atrum* with heavy infestation to a period of *January* followed *December* and *February* at 22-28^{0}C temperature of storage. They did not exist in summer season. This is in agreement with the finding of Javed et al., (2008), Swer et al., (2011) and Gupta et al., (2012), who reported optimum temperature 25^{0}C for rapid propagation of mesophilic mycoflora, above this limit, fungal count had declining trend. Stephan (2013) reported very slow or negligible rate of proliferation and sporulation for majority of mesophiles or they becomes dormant above 30-35^{0}C. This is confirmed to finding of Nazim et al (2013) that winterly occurring fungal population reflects greater sensitivity to a storage temperature.

Fungal isolates dominated only in the summer season included a population of 7 species belong to 5 genera, *Aspergillus candidus, A. ochracious, A. terreus, Chaetomium glabosum, Myrothecium roridum, Paecilomyces varioti* and *Sporotrichum pulverulentum*, had significant level of per cent incidence to a period of *June* and *July* at a storage average maximum temperature 32-38^{0}C, but it was declined at 41-44^{0}C in *April* and *May* (Fig. 4). These results are conformed to earlier findings (Javed et al., 2008; Joshi and Kareppa, 2010; Niaz et al., 2011; Gupta et al., 2012; Nazim et al., 2013). Ramesh et al (2013) reported heavy infestation by *Ascomycota* group including some species of *Aspergillus* and *Chaetomium* at 35-40^{0}C. *Myrothecium roridum, Paecilomyces varioti* also sporulate in warm summer (Bhajbhuje, 1989). This is in agreement with the finding of Joshi and Kareppa (2010) who reported that thermo-tolerant fungal isolates unable to sporulate at low range of temperature indicating higher sensitivity to a storage temperature. However, *Aspergillus nidulans, A. sulphureus, Cunninghamella elegans, Syncephalastrum racemosus* and *Trichoderma viride* were confined as seed surface contaminants, but did not exhibit any consistence of their recurrence in relation to changing and fluctuating environment (Fig.1). It is possibly due to non-availability of substrate with proportional nutrients for propagation and sporulation of these isolates.

In nature, temperature not only determines a process of propagation, proliferation and sporulation of fungal pathogens but it is a decisive climatic factor in their dissemination and geographical distribution (Javed et al, 2008). The temperature range for sporulation of fungal organisms is comparatively much narrower than that for mycelial growth. Under natural conditions the fungal organisms have to face considerable temperature fluctuation (Nazim et al, 2013). The record of storage climate for temperature and humidly has been presented (Fig. 4). Significant heavy infestation, 15.5 per cent of a total frequency was confined to a period of *January* at average mean temperature 21.8^{0}C., followed by *December* (12.6%) and February (10.9%) at 21.4^{0}C and 25.2^{0}C respectively while it was recorded 32.9^{0}C for *June*; 33.5^{0}C for *April* and 36.2^{0}C for *May* (Fig. 3 & 4). Infestation level declined in hot summer where maximum temperature recorded in range between 33-44^{0}C and reaches minimum to a period of *April*, *August* and *September* (Fig. 3). Gupta et al., (2012) reported reduction in fungal population associated with cabbage seeds and their low level of incidence in warmer climate and low humidity but rate of sporulation becomes higher at optimum temperature and high humidity. On the contrary, maximum storage temperature above 40^{0}C

was recorded to a period of *May, June* and *July* but level of incidence enhanced over other period of summer season (Fig. 3), may attributed to rapid proliferation of thermo-tolerants. It is in agreement with finding of Joshi and Kareppa (2010) who reported higher count and greater frequency of some thermo-tolerants on oil seeds. Nazim et al., (2013) studied seasonal decomposition of naturally growing mangrove population by soil fungal flora in association with major bacterial group and reported higher rate of decomposition to a period of *June*, maximum accumulation in *August* while minimum litter accretion in *January*. These results are contrary to a present study, may possibly attributed to quite variation in weather condition in Pakistan over Vidarbha (India) and secondly involvement of bacteria in association with fungi for decomposition. Average mean temperature curve of a storage period coincides with level of infestation, revealed that enormous isolates required optimum value ranged between 25-28^{0}C for sporulation while thermo-tolerants propagates at 30-35^{0}C (Fig. 3 & 4). Relatively narrow range of temperature permitting sporulation suggested that this phase involves some physiochemical processes, may not seemed essential for mycelial growth but more exacting their temperature requirement than those which suffice for vegetative phase (Stephan, 2013).

The rare occurrence of seed mycoflora reflects their more demanding nature of nutrients and environmental condition. It is also quite likely that such organisms are missed mostly during examination and thus they become more important than others. Inconspicuous seed-borne inoculum may be produce diseases in the fields ranging from scarcely detectable symptoms to quite destructive epiphytotic (Stephan, 2013). Pathogenic microfungal organisms did not cause any severity to the crop plants. The occurrence and dominance of fungal antagonist such as *Trichoderma viride,* some species *of Aspergilli* and *Penicilli* might have aid in antagonizing the pathogenic species and reduce disease severity which these fungi can inflict on seed surface (Ramesh et al (2013).

The viable seeds are capable of germination under favourable climate and responsible for spread of vegetation of new generation in a set of climatic conditions (Stephan, 2013). The count for viable seeds from mixed seed samples under storage was significantly higher in initial period then declined gradually and reduced to greater extend at the end. Loss of seed viability in storage was reported by several workers (Niaz et al., 2011; Ramesh et al., 2013). Deterioration of nutritional content of seeds by fungal contaminants in supportive storage climate may leads to loss of viability (Jyoti and Malik, 2013). Reduction in quality of seeds may be due to discoloration caused by seed mycoflora and an ultimate catastrophe in a continuous process of deterioration, leading to death.

Heavy infestation to seeds under storage by a large population of diverse fungal isolates, mostly in the winter season, reflects faster rate of fungal activity, growth and sporulation provided organic nutrient rich substrate and favourable storage climate. It seems possibly that storage climate with optimum temperature in combination with high humidity for period of the winter season resulted in greater fungal population over warmer summer. Significant correlations between fungal populations and storage climate proved that temperature and humidity are the two major climatological factors which play pivotal role in establishing rate of fungal propagation and sporulation. Seed nutrient content in storage may serve as organic rich substrate can be viewed as an excellent way in harbouring higher fungal populations (Javed et al., 2008; Bhajbhuje, 2013). It is proposed that optimum temperature of storage in the winter season, high nutritive & moisture content of seed moisture creates favourable microclimates for a profuse growth and sporulation of isolates leads to higher population of fungal species in winter season (Stephan, 2013). *Deuteromycota* comprises mostly cellulose decomposing saprophytes, proliferates at faster rate on readily available organic rich substrate. This could be one explanation for dominance of *Deuteromycota* species in an organically rich substrate. Inconsistent periodic variation in fungal population under storage and diversity could be due to different stages of fungal growth, the type, availability and a degree of deterioration of an organic substrate (Niaz, et al, 2011; Gupta et al, 2012; Nazim et al, 2013). During different stages of propagation, the nutrient uptake by saprophytes increases and this resulted in insufficient or depletion of nutrient availability for the fungal flora. As such, fungal population reduces when the crop growth is at its peak. In present study, lower fungal count in the summer season is attributed to lack of supportive storage environment, fluctuation in temperature and humidity during the post- harvest could be another factor for an uneven distribution of fungal propagules.

CONCLUSION

The seeds are known to carry several fungal contaminants that transmit from seed to seedling and spread the diseases as well as deteriorate seeds provided favourable microclimate in storage. Seasonal and regional prevalence of fungal population is determined by climatological factors of the geographical area. Existence of enormous, diverse mycoflora throughout a year of storage on seed surface of *Solanum*

melongena L from diverse geographic location of Vidarbha revealed possible correlation of temperature and humidity for the establishment of seasonal diversity of seed borne fungal population. A climate of *December* to *January* of winter season favours to heavy infestation by mesophilic mycoflora to seeds over very warm summer where infestation level began decline. It is correlated to the climatological pattern of Vidarbha where summer is extremely hot, reaching average temperature above 44^0C and winter is pleasant with 22-25^0C. Inconsistent monthly variation of fungal population coincides with fluctuating temperature & humidity of storage environment and degree of deterioration of stored seeds as substrate. The average mean temperature curve of a storage period coincides with level of infestation. Only surface sterilized healthy seeds respond better to all inputs thus seeds can be stored under ambient temperature and relative humidity at very low cost, without deterioration in quality for periods over one or more season is of immense importance for farmers. The farmers are advised to use improved scientific methods of storage to discourage seed infestation.

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