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Dormancy studies in *in-situ* germination in Mung bean (*Vigna radiata* L.)

Sandeep Kadam, Jagdish Jahagirdar, Hirakant Kalpande, Shivanand Kalyankar, Akshay Deshmukh, Niranjan Thakur, Sudhir Patil and Prashant Totewad

Abstract
The present investigation entitled "Dormancy studies in *in-situ* Germination in Mungbean (*Vigna radiata* L.)" was undertaken to study the Dormancy in Mungbean, at Department of Agricultural Botany, VNMKV, Parbhani during *Kharif* 2020 and *Kharif* 2021. The experiment arranged in Randomized Block Design (RBD) with two replications all 34 treatments has four rows of 4.5 meter long with 45 cm distance in between rows. The experimental material included in the present study was 34 entries including 9 checks. Morphological characters *viz.*, days to 50% flowering, days to maturity, days to shattering, plant height(cm), number of primary branches, seed yield per plant (g) whereas, seed quality parameters on germination (%) and time to opening pod (hrs) were recorded. The observations on field level were taken on five randomly plants for all the quantitative characters except days to 50% flowering, days to maturity and days to shattering which were taken on whole plot basis and laboratory work completed in the Laboratory of Seed Technology, Department of Agricultural Botany, VNMKV, Parbhani. The statistical analysis of data was carried out as per the standard method. The seed quality parameter i.e. germination percentage, among all the tested genotypes and checks observed range of germination percentage from 73.5% to 94.3% after harvest. Among the genotypes in pooled mean, Phule M 818-8 recorded highest germination percentage followed by AKM-1605 and Phule M 817-13 while TBM-6 recorded lowest germination percentage. On the basis of pooled mean, trait for time to opening the pods, genotypes AKM-1603, AKM-1602 and TBM-4 taken very short time to open the pods. These genotypes required nearly half day to open the pods, means these were found favorable in *in-situ* germination which indicates that these are less dormant genotypes. This study revealed that the dormancy of the Mung bean is indicated by the method of measuring the time of opening the pods by *in-situ* germination.

Keywords: Dormancy, in-situ germination, Mung bean, pre-harvest sprouting

1. Introduction
Most people refer to pulses as "poor man's meat." It serves as the primary source of dietary protein for a large segment of the world's vegetarian population. Average protein content in pulses ranges from 20 to 30%, which is around 2.5 to 3.0 times the amount typically found in cereals. The world's food supply is made up of 71 million tonnes and 79 million hectares of pulses (Anonymous, 2021) [2]. India ranks third with an area of about 4.5 million ha with total production of 2.5 million tonnes (Anonymous 2021) [2]. The mung bean is a well-known crop in Asian countries, and India is the world's largest producer and consumer of pulses, accounting for 22% of global output and 33% of global production overall. It is the third crucial pulse crop after Red Gram and Chickpea. Particularly in Asia, mungbean is a significant grain legume. It is a warm-season crop that may be grown in the dry and semi-arid tropics and during hot, humid seasons (Kulkarni and Pandey, 1988; Pannu and Singh, 1988). Mung bean (*Vigna radiata* L. Wilczek) is one of the most important pulse crop in India. In 2021-22, area and production of Mung bean in India is 30.37 M ha and 26.96 M tonnes with productivity of 888 kg/ha, whereas in Maharashtra it is 3.37 Lakh ha and 1.39 M tonnes with productivity of 531 kg/ha (Anonymous, 2022) [3]. This is less than half of the national productivity (625 kg/ha) there by indicating the scope to improve its productivity potential. Protein from mung beans is added to food, something that cereals cannot possibly offer. Dal, curries, soups, desserts, and snacks are the major foods made with it. The tropics and subtropics often use mung bean as part of their rice or wheat-based farming. The sprouted seed have nutritional value compared with asparagus or mushroom. (USDA and NIH data 2022) [4].

During sprouting, there is an increase in thiamine, niacin and ascorbic acid concentration. The food values of Mung bean lie in its high and easily digestible protein. Saleem *et al*. (1998) reported seed contains total protein (22.88-24.65%), total amino acids (20.98-25.61%), crude fibre (4.30-4.80%) and lipids (1.53-2.63%) components.

The term "vivipary" describes the germination of seeds while the pods are still attached to plan and not harvested yet (Elmqvist T. and Cox P. A. 1996) [5]. Pre-harvest sprouting would entail the germination of mature, well-developed seeds before they are harvested. It reveals a continuous development of growth from embryogenesis to germination without a maturation period characterised by occurrences like desiccation, storing of reserves, quiescence, or dormancy. The pre-harvest germination of Mung beans causes major losses to farmers since the crop sprouts seeds in pods while it is still in the field. Excessive moisture conditions, such as prolonged and frequent intermittent showers, heavy dew, high humidity, and even low temperatures, lead to this predicament. For Mung bean production in the kharif season, where rain is always experienced and results in significant output losses due to seed sprouting of pods in the field. The lack of fresh seed dormancy (FSD) in mung bean seeds makes them prone to pre-harvest sprouting (PHS), which lowers the quality of the grain or seed that is produced even if the seeds are protected inside the pod. Farmers are unable to sell their goods for a fair price because of the loss of seed quality. This problem can be solved by making seeds dormant. Therefore, it has become crucial to create Mung bean cultivars with short (10–15 day) fresh seed dormancy (FSD) periods in order to reduce the losses brought on by pre-harvest sprouting (PHS). Pre-harvest sprouting often can result in losses of up to 60–70%. (Durga & Kumar, 1997) [9]. Pre-harvest sprouting is the principal issue associated with an early breakdown of dormancy in crop species. Due to a late start to the monsoon followed by a protracted dry spell, seeding was not completed within the anticipated time frame, which significantly lowered the yield over the past few years. The experiment is conducted while taking the aforementioned criteria into account.

2. Materials and Methods

2.1 Experimental layout

This experiment has conducted in two seasons *Kharif* 2020 and *Kharif* 2021 in black soil of the experimental field at Department of Agricultural Botany, Vasantrao Naik Marathwada Agriculture University, Parbhani, MS, India. The experiment arranged in Randomised Block Design (RBD) with two replications and every treatment has four rows of 4.5 meter long with 45 cm distance in between rows. All agronomic packages of practices were carried out as per recommendation for raising the quality crop.

2.2 Experimental material

The experimental material included in the present study comprised of 34 genotypes including checks were collected from various pulse research stations of Maharashtra. Genotypes and checks involved in the present investigation are presented in Table 1.

Table 1: Experimental Material (Genotypes and checks) used in the study

Sr. No.	Genotypes & checks	Sr. No.	Genotypes & checks
1.	Phule M 707-5	18.	AKM-12-23
2.	AKM-12-14	19.	Phule M 818-8
3.	Phule M 602-9	20.	Phule M 809-10
4.	AKM-12-24	21.	Phule M 402-2-1
5.	BM-2019-1	22..	Phule M 504-20-27
6.	Phule M 702-1	23.	AKM-1606
7.	AKM-1609	24..	AKM-1605
8.	AKM-1603	25.	AKM-1608
9.	AKM-1602	26.	BM-4 (C)
10.	Phule M 816-10	27.	BPMR-145 (C)
11.	Phule M 817-13	28.	BM-2002-1 (C)
12.	TBM-4	29..	BM-2003-2 (C)
13.	TBM-6	30.	PKVM-4 (C)
14.	AKM-12-28	31.	PKVM-8802 (C)
15.	TBM-10	32.	PKV-Green Gold (C)
16.	TBM-127	33.	Vaibhav (C)
17.	Phule M 809-12	34.	Utkarsh (C)

2.3 Observations to be recorded:

Morphological traits like Days to 50% flowering, Days to maturity and Days to Shattering were recorded on the plot basis. Whereas, five pods of each entry were kept in petriplates which was dipped in water for 8 days and recorded the Germination percentage and Time for opening the pods (hrs). The five characters were recorded in the field and laboratory and the mean values were subjected for statistical analysis.

2.4 Statistical analysis

The statistical analysis of data was carried out as per the standard method suggested by Panse and Sukhatme (1989). The analysis of variance for each character was carried out and indicated in Table 2. Characters studied in this experiment showed the significance variation among the genotypes.

Table 2: Analysis of variance for experimental design

Source of variation	d. f.	Sum squares	Mean sum of squares	Expected M.S.
Replications	(r–1)	SS_1	M_1	$\sigma^2 e + g\sigma^2 r$
Genotypes	(g–1)	SS_2	M_2	$\sigma^2 e + r\sigma^2 g$
Error	(r–1)(g–1)	SS_3	M_3	$\sigma^2 e$
Total	(rg–l)	--	--	--

Where,
r = Number of replications
g = Number of genotypes
σ^2 e = Error variance
σ^2 r = Variance due to replications
σ^2 g = Variance due to genotypes

3. Results and Discussion

In mungbean, where rains typically shower around harvesting period, seed dormancy is a key characteristic. Non-dormant cultivars typically germinate in-situ on the standing crop. The importance of seed dormancy rests in the seed's capacity to endure adverse circumstances and survive until the onset of favourable conditions. When seeds are in the dormant stage, they do not germinate even in the presence of ideal moisture, temperature, and oxygen levels (Wareing, 1963).

Fresh seed dormancy (FSD) can be induced to circumvent losing of seed quality disadvantage. The present investigation was undertaken with assess the Dormancy in Mungbean. The observations of yield contributing characters *viz.* days to 50% flowering, days to Maturity, days to shattering were taken at field whereas, seed quality parameters *viz.*, germination percentage, time to open the pods (hrs) activity were analysed in laboratory of Seed Technology, Department of Agricultural Botany VNMKV, Parbhani in *Kharif* 2020 and *Kharif* 2021 seasons and results were presented in Table 3.

Table 3: Analysis of variance for randomized block design for different characters in an individual season and over a pooled mean in mungbean

Sr. No.	Characters	Location	Source of variation			
			Replications	Genotypes		Error
			d. f. (1)	d. f. (33)		d. f. (33)
1.	Days to 50% flowering	*Kh*-2020	3.31	4.92	**	1.01
		Kh-2021	0.72	6.64	**	1.02
		Pool	2.01	5.78	**	1.01
2.	Days to maturity	*Kh*-2020	0.49	9.96	**	5.8
		Kh-2021	0.53	10.27	**	6.35
		Pool	0.51	10.11	**	6.08
3.	Days to shattering	*Kh*-2020	3.31	20.58	**	0.85
		Kh-2021	3.37	44.14	**	0.94
		Pool	3.33	32.36	**	0.89
4.	Germination%	*Kh*-2020	13.24	53.55	**	4.33
		Kh-2021	0.06	47.63	**	3.79
		Pool	6.65	50.59	**	4.06
5.	Pod opening time (hrs)	*Kh*-2020	0.06	1253.4	**	0.04
		Kh-2021	0.04	1107	**	0.03
		Pool	0.05	1180.2	**	0.04

* Significant at 5 per cent and ** 1 per cent level

Range, mean and grand mean values for the experiment of different traits of genotypes studied for different morphological and seed quality characters of mungbean were given in Table 4 and Table 5.

Table 4: Range, Mean and Grand Mean of genotypes for different characters in *Kharif* 2020, *Kharif* 2021 and Pooled data in mungbean

Sr. No.	Characters	GM	*Kharif*- 2020		*Kharif*- 2021		Pool	
			Mean	Range	Mean	Range	Mean	Range
1	Days to 50% flowering	37.6	37.4	35.5-41.0	37.8	34.5-41.5	37.6	35.0-41.3
2	Days to maturity	69.5	69.4	65.5-74.0	69.6	65.0-75.5	69.5	65.3-74.8
3	Days to shattering	78.9	78.9	68.5-84.5	78.8	67.5-85.5	78.9	68.0-85.0
4	Germination%	86.7	86.2	72.0-94.0	87.2	73.5-94.3	86.7	72.8-93.8
5	Pod opening time (hrs)	32.6	33.6	0.50-83.0	31.6	0.50-78.0	32.6	0.8-80.8

Where – M: Mean and GM: Grand Mean

3.1. Germination percentage

Genotypes studied in this experiment showed the nine different characters in both seasons and pooled mean. Results indicated the significance difference among the genotypes (Table 5). Germination percentage among all the genotypes and checks varied from 72.8% to 93.8% with mean of 86.7% in pooled, while ranges from 72.0% to 94.0% with 86.2% grand mean and 73.5% to 94.3% with 87.2% in *Kharif* 2020

and 2021 respectively.

Among the genotypes in pooled mean, Phule M 818-8 (92.9%) recorded highest germination percentage followed by AKM-1605 (92.3%), Phule M 817-13 & Phule M 402-2-1 (88.3%) while genotype, TBM-6 (72.8%) recorded lowest germination percentage followed by AKM-1228 (77.1%), AKM-1603 (78.0%).

Checks, PKVM 4 & BM2003-2 (93.8%) expressed highest germination percentage, followed by Utkarsh (92.6%), BPMR145 (92.5%) and BM2002-1 (92.4%) while only one genotype i.e. TBM-6 showed the significant low results as compare with minimum seed certification standard (MSCS) standard regarding the germination percentage.

Time to opening of pods

Experimental results show the high variation for time to opening of pods. Thus we categorized the genotypes in three groups *viz*., highly susceptible genotypes, highly susceptible genotypes and resistant genotypes to Time to opening of pods.

Table 5: Mean and Pooled Mean of genotypes for different characters in *Kharif* 2020 and *Kharif* 2021 in mungbean

Sr. No.	Genotypes	D50%			DM			DS			GP			POT (hrs.)		
		Kh-2020	*Kh*-2021	Pool	*Kh*-2020	*Kh*-2021	Pool	*Kh*-2020	*Kh*-2021	Pool	*Kh*-2020	*Kh*-2021	Pool	*Kh*-2020	*Kh*-2021	Pool
1.	Phule M 707-5	38.5	39.5	39	73	73	73	82.5	83.5	83	88.5	87.5	88	29.5	32	30.8
2.	AKM-12-14	37	37.5	37.3	65.5	66.5	66	68.5	67.5	68	82.5	82.5	82.5	5	5.5	5.3
3.	Phule M 602-9	38.5	38.5	38.5	66.5	67.5	67	69.5	68.5	69	80.5	84	82.3	1	1.5	1.3
4.	AKM-12-24	36.5	35.5	36	71	69.5	70.3	84.5	83.5	84	85.8	87.5	86.6	25	22.5	23.8
5.	BM-2019-1	35.5	36.5	36	71.5	70.5	71	84.5	83.5	84	85.5	86	85.8	20	16.5	18.3
6.	Phule M 702-1	37	38.5	37.8	67.5	66.5	67	76.5	77.5	77	86.8	87.5	87.1	38.5	35	36.8
7.	AKM-1609	35.5	34.5	35	65.5	66	65.8	75.5	75	75.3	85	86.5	85.8	44.5	48	46.3
8.	AKM-1603	37.5	37.5	37.5	67	68.5	67.8	78	77	77.5	77.5	78.5	78	1	0.5	0.8
9.	AKM-1602	36.5	35.5	36	65.5	66.5	66	75.5	74.5	75	85.5	87.3	86.4	0.5	1	0.8
10.	Phule M 816-10	38.5	39.5	39	70	70.5	70.3	83	83.5	83.3	86.8	87	86.9	28.5	32	30.3
11.	Phule M 817-13	40.5	41.5	41	73	72.5	72.8	84	84.5	84.3	88	88.5	88.3	37.5	35	36.3
12.	TBM-4	40	40.5	40.3	71.5	71.5	71.5	81.5	81	81.3	78	80.5	79.3	0.5	1	0.8
13.	TBM-6	41	41.5	41.3	70.5	71.5	71	79	79.5	79.3	72	73.5	72.8	1	1.5	1.3
14.	AKM-12-28	37.5	36.5	37	71	70.5	70.8	79.5	80.5	80	76.8	77.5	77.1	4.5	6	5.3
15.	TBM-10	40.5	41.5	41	70.5	69.5	70	78.5	79.5	79	80	80.5	80.3	5	3.5	4.3
16.	TBM-127	37.5	38.5	38	68.5	69	68.8	76.5	75.5	76	86.5	87.8	87.1	45	41.5	43.3
17.	Phule M 809-12	38.5	37.5	38	71	70.5	70.8	83.5	84	83.8	85.5	87	86.3	39.5	41	40.3
18.	AKM-12-23	35.5	36	35.8	70.5	70	70.3	84	84.5	84.3	86.5	87.8	87.1	35	30.5	32.8
19.	Phule M 818-8	35.5	39.5	37.5	65.5	65	65.3	69.5	68.5	69	92.3	93.5	92.9	70.5	68	69.3
20.	Phule M 809-10	37.5	38.5	38	71	70.5	70.8	79.5	78.5	79	86	87	86.5	54.5	49	51.8
21.	Phule M 402-2-1	38.5	38.5	38.5	68.5	67.5	68	81	81.5	81.3	87.5	89	88.3	40	35.5	37.8
22.	Phule M 504-20-27	36.5	37.5	37	69.5	70.5	70	83	83.5	83.3	86.3	87.8	87	30.5	25	27.8
23.	AKM-1606	35.5	36.5	36	67.5	68	67.8	76	75.5	75.8	85.5	87.3	86.4	45.5	40.5	43
24.	AKM-1605	36.5	37.5	37	70	70.5	70.3	76.5	75.5	76	91.5	93	92.3	5	4.5	4.8
25.	AKM-1608	37.5	37	37.3	69	69.5	69.3	77	76.5	76.8	85.5	86.8	86.1	55	49.5	52.3
26.	BM-4 (C)	36.5	37.5	37	71	71.5	71.3	80.5	81.5	81	86	87.5	86.8	35	30.5	32.8
27.	BPMR-145 (C)	38.5	37.5	38	70.5	71	70.8	80	79.5	79.8	92.3	92.8	92.5	74.5	70	72.3
28.	BM-2002-1(C)	37.5	36.5	37	69	69.5	69.3	75.5	76	75.8	91.5	93.3	92.4	10	7.5	8.8
29.	BM-2003-2(C)	36.5	37.5	37	67.5	66.5	67	77.5	77	77.3	94	93.5	93.8	67.5	60	63.8
30.	PKVM-4 (C)	39.5	39.5	39.5	70.5	71.5	71	80	80.5	80.3	93.3	94.3	93.8	30	25.5	27.8
31.	PKVM-8802 (C)	36.5	37.5	37	68.5	68	68.3	76.5	75.5	76	92.3	91.5	91.9	83.5	78	80.8
32.	PKV-Green Gold (C)	35.5	34.5	35	70	70.5	70.3	81.5	80.5	81	86.5	87	86.8	35.5	38	36.8
33.	Vaibhav (C)	38.5	37.5	38	74	75.5	74.8	84.5	85.5	85	92	91.5	91.8	75	72	73.5
34.	Utkarsh (C)	36	36	36	69.5	71.5	70.5	80.5	82.5	81.5	92.5	92.8	92.6	70	65.5	67.8
	Mean	37.5	37.8	37.7	69.4	69.6	69.6	78.9	78.8	78.9	86.2	87.2	86.7	33.6	31.6	32.6
	SE±	1	1.01	1	0.9	2.51	1.7	0.92	1.83	1.4	2.08	1.95	2.35	0.12	0.03	0.31
	CD	2.88	2.91	2.9	2.58	7.24	4.9	2.66	5.28	4	5.98	5.6	7.05	278.91	120.83	0.93

D50%-Days to 50% Flowering, DM: Days to Maturity, DS: Days to Shattering, GP: Germination% and POT: Pods opening Time (hrs)

3.1.1. Highly susceptible genotypes

Range for Time to opening of pods observed from 0.5 to 83.0 hrs. with mean value 33.6 hrs. in *Kharif* 2020, 0.5 to 78.0 hrs. with mean 31.6 hrs. in *Kharif* 2021 and 0.8 to 80.8 hrs with mean 32.6 hrs. in pooled mean. The grand mean value for time of opening the pod was 32.6 hrs. On the basis of pooled mean, AKM-1603, AKM-1602 and TBM-4 (0.8 hrs.) followed by Phule M 602-9 and TBM-6 (1.3 hrs.) and TBM-10 (4.3 hrs.) showing very short time to open the pods. These genotypes required nearly half day to open the pods, means these lines were found favorable in *in-situ* germination, i.e. less dormant genotypes for *in-situ* germination (Figure 1).

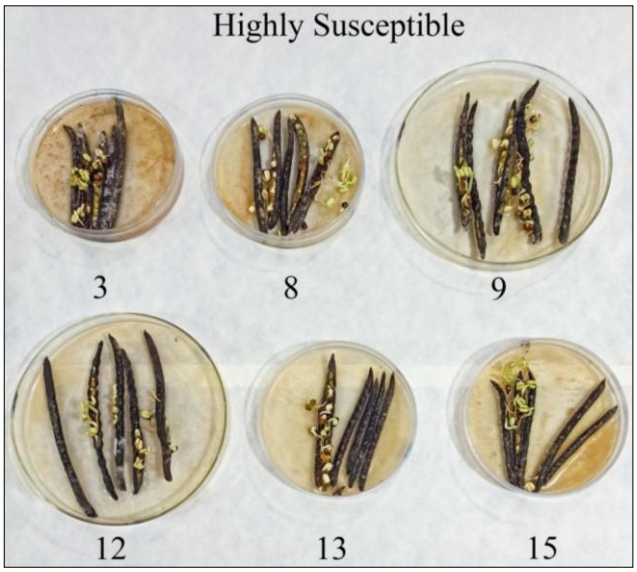

Fig 1: Germination of highly susceptible genotypes for *in-situ* germination in lab condition

3.1.2. Moderately susceptible genotypes:

Genotypes with moderately susceptible showed the range from 5.3 hrs. to 46.3 hrs.for time of opening the pods *viz.*, Phule M 707-5 (30.8 hrs.), AKM-12-14 (5.3 hrs.), AKM-12-24 (23.8 hrs.), BM-2019-1 (18.3 hrs.), Phule M 702-1 (36.8 hrs.), AKM-1609 (46.3 hrs.), Phule M 816-10 (30.3 hrs.), Phule M 817-13 (36.3 hrs.), AKM-12-28 (5.3 hrs.), Phule M 809-12 (40.3 hrs.), AKM-12-23 (32.8 hrs.), Phule M 402-2-1 (37.8 hrs.), Phule M 504-20-27 (27.8 hrs.), AKM-1605 (4.8 hrs.), BM-4 Ch. (32.8 hrs.), BM-2002-1 Ch. (8.8 hrs.), PKVM-4 Ch. (27.8 hrs.) and PKV Green Gold Ch. (36.8 hrs.) showed medium time period to open the pod. These genotypes showed nearly 1-2 days time taken for opening of pods (Figure 2).

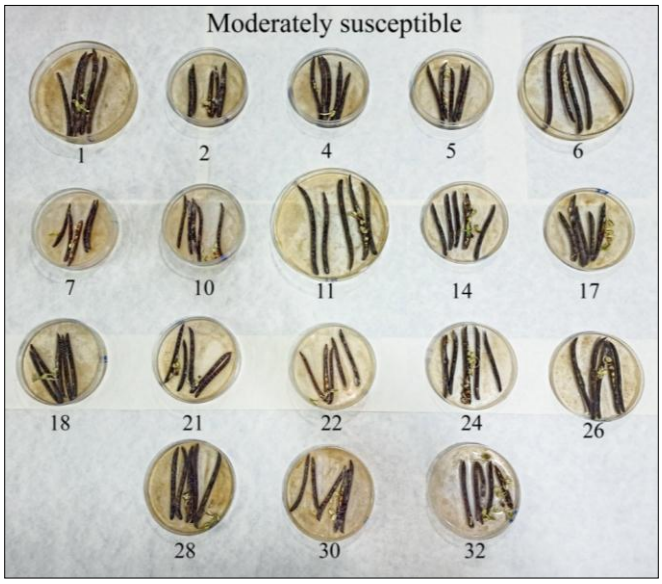

Fig 2: Germination of moderately susceptible genotypes for *in-situ* germination in lab condition

3.1.3. Resistant genotypes:

On the observation of (pre harvest sprouting) time for opening the pods genotypes *viz;* TBM-127 (43.3 hrs.), Phule M 818-8 (69.3 hrs.), Phule M 809-10 (51.8 hrs.), AKM-1606 (43.0 hrs.), AKM-1608 (52.3 hrs.), BPMR-145 Ch. (72.3 hrs.), BM-2003-2 Ch. (63.8 hrs.), PKVM-8802 Ch. (80.8 hrs.), Vaibhav Ch. (73.5 hrs.) and Utkarsh Ch. (67.8 hrs.) were found resistant to opening the pods (Figure 3). These genotypes almost took four days for opening the pods and showed highest resistant among the genotypes studied. Thus, we can conclude these genotypes are highly dormant for germination in pre harvest condition.

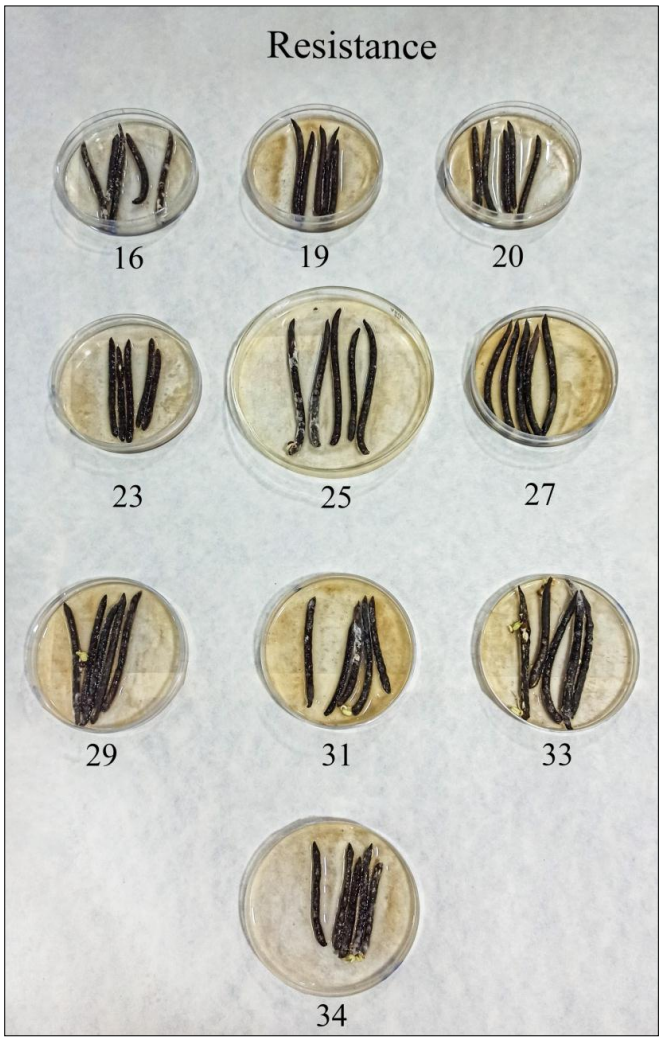

Fig 3: Germination of resistant genotypes for *in-situ* germination in lab condition

4. Conclusion

On the observation of germination percentage, in *Kharif* 2020 and *Kharif* 2021, out of 34 studied genotypes following five genotypes *viz.* Phule M 818-8, AKM-1605, Phule M 402-2-1, Phule M 817-13 and Phule M 707-5 were found superior in germination percentage while 19 genotypes were also found an above the Minimum Seed Certification Standard (MSCS) and only one genotype TBM-6 was found in both the seasons below the MSCS level. All the standard checks in this study were also estimated the best germination percentage in both the seasons over the MSCS level of Mungbean.

The genotype Phule M 818-8 was taken highest time to opening of pods, followed by AKM 1608, Phule M 809-10, AKM-1609 and TBM127 i.e. nearly 2-3 days for opening of pods means it may dormant for *in-situ* germination. The remaining genotypes required nearly half day to open the pods, means these lines were found favorable in *in-situ*

germination, i.e. less dormant genotypes for *in-situ* germination. Regarding the standard checks, PKVM-8802, Vaibhav, BPMR-145, Utkarsh and BM 2003-2 were found more time taking variety for the opening of pods means more dormant for *in-situ* germination and checks BM2002-1, PKVM-4, BM-4 and PKV Green Gold were opened the pods within an half to 1.5 days period which indicates less dormancy for *in-situ* germination.

And thus it is recommended that those genotypes found resistant and moderate to opening the pods (More fresh seed dormancy) may be use as a parent in breeding for inducing the dormancy for pre-harvest sprouting through crossing programme.

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