

## Differential water uptake response in Indian mustard genotypes with varying seed coat colour

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**ABSTRACT** The present investigation was undertaken with the objectives to study the water uptake in conventional and quality Indian mustard [*Brassica juncea* Czern & Coss] genotypes of different seed coat colour under freely and restricted water conditions. The material consisted of eight genotypes of Indian mustard in which four genotypes each were of conventional and quality types. The seed of these genotypes varied for seed coat color *i.e.* four black seeded and four yellow seeded. All these genotypes were initially assessed for the seed quality parameters *viz.*; percent moisture content, test weight and germination per cent and subsequently, for their imbibition behavior under free and limited available water conditions. The studies were carried out in both fresh and controlled deteriorated seeds. It was found that imbibitional rate were significantly associated with the seed colour as well as quality of the genotypes. The fresh and controlled deteriorated seeds with yellow seed coat had the highest water uptake, while black seed had the lowest water uptake ratio under both conditions of water availability. In addition, decrease in imbibition of deteriorated yellow seeded genotypes could be attributed to lowered ability of its testa to withhold moisture. Imbibitional damage during aging could be one of the factors which contribute to seed quality differences among Indian mustard genotypes with varying seed coat colour.

**Keywords:** Indian mustard, water uptake, seed coat colour, controlled deterioration, conventional and quality genotypes

Seed germination remains a key to agriculture because of its role in plant stand establishment. It is a complex physiological process, involving many individual reactions and phases, each of which is affected by temperature, gases and water [1]. The process of enzyme activation, breakdown, translocation and use of reserve storage material is stimulated by imbibition of water in any non-dormant seed. The extent to which water imbibition occurs, is dependent on three factors: (1) composition of the seed, (2) water availability and (3) seed coat permeability. The early stages of dry seed imbibition represent a crucial period for seed germination, where composition of the seed has a vital role. The low water potentials are a consequence of the relationship of water with components of the seed.

The principal component of seed

responsible for the imbibition of water is protein. Proteins are zwitterions which exhibit both negative and positive charges that attract the highly charged polar water molecules. In contrast, the starches such as amylose may have little affinity for water while lipids don't have any charges on the molecular structure, hence have no affinity for water. Thus, high protein containing seeds will imbibe more water than starch or oil containing seeds. The cuticle of the impermeable soybean cultivar contained a disproportionately high amount of hydroxylated fatty acids relative to that of the permeable ones [2]. They also found that the outermost cuticle of the soybean seed coat has an unusual chemical composition, lacking typical mid-chain hydroxylated fatty acids but being relatively rich in other types of hydroxylated fatty acids.

During the process of germination, imbibition is the triphasic event of water

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uptake into a seed, which depends typically upon water potential attributed to their osmotic and matric characteristics. The solutes in the imbibing solution alter the dynamics of the volume increase, indicating several types of influences; these include osmotic effects, salt effects, valence effects, pH effects and lyotropic effects. It is suggested that deformation resulting from imbibitional swelling may contribute to the stresses experienced by seed tissues during hydration [3]. Solutes in the imbibing solution will depend upon the amount of available water. Free available water was used to avoid any discrepancy in results due to limited water for imbibition, whereas, under natural conditions the water is bound with many forces such as matrix, osmotic etc. [4].

Entry of water into seeds is greatly influenced by the nature of the seed coat (or pericarp). Water permeability is usually greatest at the micropylar area where the seed coat is ordinarily quite thin. The hilum of many seeds also permits easy water entry. Mucilages extruded from seed coats such as *Salvia* seed increase imbibition as do the cellulose and pectins located in the cell walls. The presence of an intact seed coat is important to slow down and delay the uptake of water into the seed [5]. Formation or activation of messenger RNA during germination in many seeds requires only contact with water at the appropriate temperature. The higher temperatures cause slightly greater rates of water increase due to the lower viscosity of water as temperatures increases. However, rapid uptake can cause imbibition damages to the embryos of germinating seeds, particularly those that imbibe water quickly, whereas, slow imbibition rate causes germination delay [6]. The forces that determine the rate of water imbibition by seeds are complex and, therefore, it is not uniform throughout the seed or amongst seeds. Variability exists for hydration capacity in Indian mustard cultivar as reported by Yadav *et al.* [7], where 20

cultivars were segregated into six different groups for hydration index. The seed coat also directs water movement both tangentially and radially into the embryonic axis. Seed coat colour is governed by different pigments and secondary metabolites [8]. Seed coat colour in honey locust had a significant effect on seed moisture content, seed coat weight, endosperm weight, water uptake, and germination [9]. Many other studies have also reported it as one of the correlated traits with restrictions of water movement in seed.

Most seeds have critical moisture content for germination to occur. Once the critical seed moisture content is attained in the seed, sufficient water is present to initiate germination and the seed is committed to that event and cannot reverse back. It is the first key event that moves the seed from a dry, quiescent, dormant organism to the resumption of embryo growth. Thus, any consideration of seed germination physiology and its resultant impact on plant stand establishment should focus initially on water uptake. There is hardly any report of imbibitional behaviour in varieties of Indian mustard with respect to testa colour. Therefore, water uptake studies carried out under both, freely and restricted water conditions, both for fresh and controlled deteriorated seeds have been presented in this paper.

## MATERIALS AND METHODS

The material consisted of eight genotypes of Indian mustard, in which four genotypes each were of conventional and quality types. The seed of these genotypes varied for seed coat color *i.e.* four black seeded and four yellow seeded genotypes as shown in the table.

All different types of Indian mustard genotypes were assessed, initial for the seed quality parameters *viz.* percent moisture content, test weight, and germination percent. The germination percent was estimated in fresh as well as in controlled deteriorated (CD) seeds. All these genotypes were then dried

Type of Seeds	Conventional type	Quality type
Black seeded genotypes	Pusa Vijay	Pusa Mustard 21 (PM 21)
	Pusa Mustard 28 (PM 28)	Pusa Mustard 30 (PM 30)
Yellow seeded genotypes	Navgold	Pusa Karishma
	NPJ 189	LES 48 (Low erucic strain 48)

to around 8 percent seed moisture before carrying out imbibitional studies under free and limited water conditions. The methodologies used have been given below.

#### Moisture content

Initial moisture content of seeds was calculated as per ISTA recommended method [10]. Five grams seeds from each of the genotypes were drawn as working samples in quadruplicate. Weight of empty container was recorded as  $M_1$ . The seeds were then placed in weighed containers and weight of container plus sample before drying was recorded as  $M_2$ . The containers with seeds were then kept for drying at  $103^{\circ}\text{C}\pm 10$  in hot air oven. After 17 h of drying, the weight of seeds with container was recorded as  $M_3$ . Moisture content was calculated by the formula:

$$\text{Moisture content} = (M_2 - M_3) * 100 / (M_2 - M_1)$$

Where,  $M_1$ -weight of empty container.

$M_2$ - weight of container and sample (before drying).

$M_3$ - weight of container and sample (after drying).

#### Seed drying

The seeds were kept for drying in hot air oven maintained at  $32^{\circ}\text{C}\pm 10$  till 8 percent of moisture was attained. After the stipulated period, the seeds were packed in cloth bags and kept in desiccators containing silica gel for further experimentation.

#### Test weight

A random sample from dry, pure and clean seed fraction was used for estimating 1000 seed weight. Eight replicates of 100 seeds were weighted. The value of test weight was

obtained by multiplying mean with 10 and expressed in grams.

#### Controlled deterioration (CD) test

The dry seeds were placed at  $20^{\circ}\text{C}$  on moist germination paper and allowed to imbibe water and kept on reweighing repeatedly till seed moisture content reached to a level of 20 percent. Once, the seed moisture rose to desired level, seeds were packed in aluminum foil packet and kept overnight at  $70^{\circ}\text{C}$  in order to uniformly distribute moisture in each packet. The packets were then placed in water bath at  $45^{\circ}\text{C}$  for 24 h, cooled under running water and kept for drying in shade to bring it to original moisture [11]. After drying to initial moisture, the seeds were placed for testing germination percentage.

#### Germination percentage

Seeds from pure and clean seed fraction were used for estimation of percent germination [10]. Eight replications of 50 seeds each were placed equidistantly on top of two layers of moist filter paper in petri plates at  $20^{\circ}\text{C}$ . First count was taken on fifth day. The seeds were categorized into normal seedling, abnormal seedling, hard and dead seeds on seventh day. The percentage of normal seedling was used to determine standard germination percentage.

#### Imbibition under free water available conditions

Imbibition studies were conducted under free water available conditions following the method suggested by Chachalis and Smith [12]. Three replications of 1000 seeds each were placed in a 200 ml beaker containing 100 ml of distilled water at  $25^{\circ}\text{C}$ . Seeds were removed from beakers after 1, 2, 3, 4, 5, 6, 7, 8

and 24 h of imbibition and weighed after wiping with blotter paper. Water uptake was calculated and expressed as a percentage weight gain over initial weight of dry seeds.

#### *Imbibition under limited water conditions*

Imbibition studies were conducted under limited water available conditions following the method suggested by Siddiqui *et al.* [6]. Twenty replications of 50 seeds each were weighed and placed in tight-fitting plastic petri plates containing four layers of blotter paper with 8 ml of water added to it. The petri plates were then kept at 25°C for imbibition. Seeds were removed from petri plates after 1, 2, 3, 4, 5, 6, 7, 8 and 24 h and weighed after wiping with blotter paper. Water uptake was calculated and expressed as a percentage weight gain on dry weight basis.

#### *Statistical analysis*

The data collected from the experiments on all parameters studied were subjected to statistical analysis using SPSS statistical package (version 10) and LSD were obtained. The contrast analysis (using I matrix in SPSS), instead of multi-factorial CRD analysis, was performed for comparisons between black and yellow seeded and conventional and quality genotypes. The contrast analysis was also run for comparison within the group *i.e.* conventional and quality genotypes within black seeded, conventional and quality genotypes within yellow seeded, black and yellow seeded genotypes within conventional type and black and yellow seeded genotypes within quality type. The variance ratio for significance at 5% level of probability was calculated in all cases. The percent data of the germination was transformed to arc sine values using the formula suggested by Yadav *et al.*, [7] and same were used for the calculation of C.D. of such variables.

## RESULTS AND DISCUSSION

### *Initial seed quality status*

The data on initial seed quality parameters *viz.* percent moisture content, test weight, electrical conductance, germination per cent and vigour indices of all the varieties has been given in table 1. The moisture content in black seeded genotypes was found significantly higher than that present in yellow seeded genotypes. The yellow seeded quality genotype, LES 48 had the highest moisture content (8.47%) whereas black seeded conventional genotype, Pusa Vijay had the lowest (8.0%) moisture content. Based upon the contrast analysis, it was found that the moisture content significantly varied between the conventional and quality genotypes and within black and yellow seeded genotypes. Test weight of conventional varieties was 6.12g, which was significantly higher than that of quality genotypes (4.02g). The test weight significantly varied from 4.49g (NPJ 189) to 8.30g (Pusa Vijay) in case of conventional genotypes, whereas it was significantly lower in quality genotypes. The high test weight of Pusa Vijay could be due to pure, healthy and clean seeds. LES-48 (2.76g) than PM-30 (6.45g) among the quality type of genotypes. The black seed coat colored quality variety PM 30 had the test weight at par with black and yellow seed coat colored conventional varieties; PM 28 (5.39g) and Navgold (6.31g), respectively.

Significant interactions were observed between quality status and variety for germination percentage estimated in both fresh as well as in controlled deteriorated seeds (Table 1). The effect of controlled deterioration on percent germination was more pronounced amongst the quality type of varieties, which differed significantly among themselves too. Moreover, significant differences in germination percentage within both, black and yellow seeded varieties of quality types were detected. In controlled deteriorated seeds, germination percentage of yellow seeded genotypes recorded 62.0% which was significantly lower than germination percentage of black seeded

**Table 1. Seed quality status of different types of Indian mustard genotypes**

Genotypes	Moisture Content (%)	Test Weight (g)	Germination (%)	
			Fresh seeds	CD seeds
Pusa Vijay (BS: C <sup>^</sup> -)	8.00	8.30	96.0(78.5)#	82.0(64.93)
PM 28 (BS: C)	8.13	5.39	95.0(77.12)	89.0(70.67)
PM 21(BS: Q <sup>^^</sup> -)	8.03	3.46	90.0(71.60)	78(62.06)
PM 30 (BS:Q)	8.30	6.45	92.0(73.61)	91.5(73.09)
Navgold (YS <sup>**</sup> : C)	8.30	6.31	94.0(75.86)	92.5(74.14)
NPJ 189 (YS:C)	8.33	4.49	90.0(71.30)	75.5(60.36)
P. Karishma (YS: Q)	8.43	3.42	96.0(78.50)	60.5(51.09)
LES 48 (YS: Q)	8.47	2.76	91.0(72.58)	15.0(22.80)
Mean	8.25	5.07	93.0(74.70)	73.0(58.72)
CD (p=0.05)	0.18	0.77	4.01	6.16

\*BS-Black seeded genotype; YS<sup>\*\*</sup>- Yellow seeded genotype;

C<sup>^</sup>- Conventional Type; Q<sup>^^</sup>- Quality Type;

#Figures in parenthesis are transformed values

genotypes (95.0%). Yellow seeded quality genotype, LES 48 recorded significantly lower germination (15.00%) whereas, black seeded quality genotype PM 30 (93.00%) recorded significantly higher germination. The genotypes Pusa Vijay (80.00%), PM 28 (88.00%), PM 30 (92.00%) and Navgold (91.00%) were at par with each other.

Thus, it was found that yellow seeded genotypes showed drastic reduction in germination percentage following controlled deterioration, whereas, black seeded genotypes were less affected by such damage and indicates the ability of black seeds to overcome the stress. This differential response to germination by black seeded genotypes from yellow seeded genotypes could be linked to the superiority of black colored genotypes in mediating imbibitional damages by slower rate of water uptake [8-9]. We propose that under natural set of conditions at particular relative humidity, yellow seeded genotypes may acquire higher level of moisture than black seeded genotypes. Such fluctuations in moisture may cause higher rate of deterioration in yellow seeded genotypes.

#### *Imbibition behaviour by fresh seeds under free available water conditions*

Imbibitional studies were carried out both under free available water and with restricted water availability. Water uptake under freely water available condition by fresh seeds of various genotypes significantly differed from 1 to 24 h (Table 2). The highest water uptake (54.53%) of all the genotypes was recorded at 1h and it increased steadily from 8.07 to 12.77 percent till 5h of imbibition. Increment in percent increase in water uptake after 5h was very slow. During the first hour of imbibition, the significant lower percent water uptake was observed in black seeded conventional genotype, Pusa Vijay (26.07%) which was at par with PM 28 (38.05%). The black seeded conventional type genotype recorded lowest water uptake throughout the imbibition period. The yellow seeded conventional genotype, NPJ 189 recorded the highest water uptake (72.58%), which was at par with quality genotypes LES 48 and Pusa Karishma. During second hour of imbibition, the yellow seeded quality genotype, Pusa Karishma (89.40%) recorded significantly higher imbibition

**Table 2. Differential response in percent water uptake by fresh seeds in different types of Indian mustard genotypes under freely available water condition**

Genotypes	Duration of imbibition (h)								
	1	2	3	4	5	6	7	8	24
Pusa Vijay (BS: C <sup>-</sup> )	26.07	37.22	42.97	50.35	56.24	57.11	59.67	62.08	67.12
PM 28 (BS: C)	38.05	48.95	56.98	60.31	63.59	65.58	67.07	70.35	73.10
Navgold (YS: C)	47.51	62.72	70.39	72.26	79.54	82.83	84.80	89.16	94.58
NPJ 189 (YS: C)	72.58	82.89	90.68	97.37	97.13	99.35	100.39	103.20	105.93
PM 21(BS: Q <sup>+</sup> )	55.84	63.22	84.84	93.04	103.14	106.31	107.69	110.33	116.70
PM 30 (BS: Q)	56.65	71.18	82.42	85.32	86.92	88.86	90.89	93.97	98.93
P. Karishma (YS: Q)	68.63	89.40	98.32	103.20	111.03	113.77	115.73	121.69	128.25
LES 48 (YS: Q)	70.87	82.84	93.54	112.16	141.12	144.10	145.73	150.34	156.32
Mean	54.53	67.30	77.52	84.25	92.34	94.74	96.50	100.14	105.12
CD (p=0.05)	11.48	12.24	14.18	23.44	15.41	14.44	15.22	16.34	17.63

\*BS-Black seeded genotype; \*\*YS- Yellow seeded genotype, C<sup>-</sup>- Conventional Type, Q<sup>+</sup>-Quality type genotype

followed by yellow seeded genotypes; NPJ 189 (conventional type) and LES 48 (quality type).

The yellow seeded quality genotypes; Pusa Karishma and LES 48 imbibed maximum water and were at par till 4 h. Thereafter, significantly higher amount of water uptake was recorded by LES 48 genotype compared to other genotypes. Percent water uptake after 24 h showed that the black seeded conventional genotype PM 28 recorded 73.20% of water uptake on fresh weight basis which was at par with Pusa Vijay, whereas, among yellow seeded conventional genotype, NPJ 189 recorded higher water uptake (105.93%) which was at par with Navgold, another yellow seeded conventional type genotype. Among the quality types, the black seeded PM 21 recorded significantly higher water uptake than PM 30. Significantly lower values were recorded in quality genotype, Pusa Karishma (128.25%) in comparison to yellow seeded quality genotype LES 48 (156.32%).

The significant differences were revealed in contrast analysis of black and

yellow seeded genotype and conventional and quality type genotypes. It was also observed that fresh seeds of yellow seeded quality genotype imbibed significantly more water than black seeded quality and conventional type genotypes.

Thus, it was observed that the mean water uptake at first h for yellow seeded genotypes with freely available water showed that they imbibed much faster (64.9%) than black seeded genotypes (44.15%) and trend of increasing water uptake continued till 24 h. At first hr of imbibition, the conventional type of mustard genotypes imbibed slower than quality type of mustard genotypes and remained much behind even at 24 h of imbibition than in quality type of seeds.

*Imbibition behaviour by CD seeds under freely available water conditions*

Water uptake in CD seeds under freely available water condition of different genotypes significantly varied from 1h to 24 h (Table 3). The highest water uptake (51.71%) of all the genotypes was recorded at 1h and it increased steadily from 7.16 to 14.88

percent till 4 h of imbibition. Similar to fresh seeds, increment in percent increase in water uptake after 4 h was very slow.

After first h of imbibition, black seeded conventional type genotype PM 28 recorded significantly lower per cent water uptake (35.68%) than yellow seeded quality genotype Pusa Karishma (68.11%), whereas, water uptake by all other varieties was at par among themselves. The black seeded conventional genotype, PM 28 recorded lowest water uptake throughout the imbibition period. However, the yellow seeded quality genotype, Pusa Karishma recorded highest water uptake till 6 h of imbibition and genotype LES 48 recorded maximum water uptake thereafter. Moreover, both these genotypes remained at par with respect to percent water uptake throughout the imbibition period.

Percent water uptake after 24 h showed black seeded conventional genotypes *viz.*, Pusa Vijay and PM 28 recorded lower imbibition compared to yellow seeded conventional genotypes where maximum water uptake (104.87%) was by NPJ 189. Among the quality material, the lowest

water uptake was observed in black seeded genotype PM 21, followed by PM 30 (104.40%), whereas yellow seeded quality type genotype, Pusa Karishma observed 103.94% water uptake.

In contrast analysis of CD seed, it was found that yellow seeded genotypes imbibed more water than that of black seeded genotypes. However, non-significant difference between conventional and quality type of genotypes was observed after 1, 2, 3, 8 and 24 h of imbibition. Following controlled deterioration, the rate of imbibition increased in black seeded genotypes but not in yellow seeded genotypes (observed only in freely available water). However, the imbibition rate in black seeded genotypes was still much lower than that of yellow seeded genotypes. Decrease in imbibition of deteriorated yellow seeded genotypes could be attributed to reduced ability of its testa to with hold moisture.

This could also be correlated with increased values of electrical conductivity in controlled deterioration after 24 h, which increased in yellow seeded genotypes (data not shown), suggesting more cell leakage [13].

**Table 3. Differential response in percent water uptake by controlled deteriorated seeds in different types of Indian mustard genotypes under freely available water conditions**

Genotypes	Duration of imbibition (h)								
	1	2	3	4	5	6	7	8	24
Pusa Vijay (BS: C <sup>^</sup> -)	52.87	63.60	73.35	82.09	87.14	91.39	89.99	93.08	93.49
PM28 (BS: C)	35.68	42.66	48.10	53.39	57.80	57.13	61.01	68.35	70.77
Navgold (YS <sup>**</sup> : C)	53.54	72.76	78.58	83.13	87.33	86.53	89.15	95.88	95.16
NPJ 189 (YS: C)	52.91	75.98	83.85	87.36	94.86	95.99	98.90	103.29	104.87
PM 21(BS: Q <sup>^^</sup> -)	54.74	70.45	78.22	90.60	90.17	95.23	98.18	98.12	103.21
PM 30 (BS: Q)	45.46	62.33	73.76	80.78	87.68	89.89	93.00	97.99	104.40
P. Karishma (YS: Q)	68.11	79.54	85.34	93.32	104.00	100.87	101.74	104.12	103.94
LES 48 (YS: Q)	50.40	65.42	76.78	84.62	85.45	99.64	101.91	115.39	115.56
Mean	51.71	66.59	74.75	81.91	86.80	89.58	91.73	97.03	98.92
CD (p=0.05)	14.33	15.06	15.68	10.96	13.00	17.69	18.96	27.55	27.86

\*BS-Black seeded genotype; \*\*YS- Yellow seeded genotype,  
C<sup>^</sup>- Conventional Type, Q<sup>^^</sup>-Quality type genotype

Thus, it might be due to more susceptibility of seed coat of yellow seeded genotypes to deterioration and which loses its ability to regulate water flow and withhold moisture under free water availability condition. Similar results have been reported in soybean [14].

#### *Imbibition behaviour by fresh seeds under limited water conditions*

The water uptake under limited available water condition by fresh seeds of various genotypes upto 24 h is presented in Table 4. Water uptake under limited water condition by fresh seeds of black and yellow seeded genotypes differed significantly from 2 to 24 h of soaking, whereas, fresh seeds of conventional and quality seeded genotypes showed non-significant differences for water uptake under limited water conditions. In fresh seeds, at first hour of soaking, significant higher water uptake was observed in yellow seeded quality mustard genotype LES 48 (27.67%) and significant lower water uptake was observed in black seeded quality mustard genotype PM 30 (11.52%). After 24 h of soaking, yellow seeded quality mustard genotype, LES 48 showed highest water

uptake (71.23%), whereas, black seeded conventional mustard genotype PM 28 recorded lowest weight gain of 36.17 percent at 24 h of soaking. Under limited water conditions, the movement of water into the seed is due to diffusion and capillary action, with water moving from a region of higher to lower water potential. The slow water movement also reduces the imbibitional damages to seed. In addition, the seed coat thickness and pigments plays an important role in determining the ability of the seed to take up water. Since black seeded genotypes had thick testa and phenols compared to yellow seeded genotypes and hence, more water uptake was seen in yellow seeded ones.

#### *Imbibition behaviour by CD seeds under limited water condition*

Water uptake under limited available water condition by controlled deteriorated seeds of various genotypes differed significantly from 1 to 24 h (Table 5). Following controlled deterioration, uptake of water in black and yellow seeded genotypes showed significant differences for water uptake at 2, 3, 4 and 5 h of imbibition. After 24 h of soaking, black seeded conventional mustard genotype, PM

**Table 4. Differential response in percent water uptake by fresh seeds in different types of Indian mustard genotypes under limited available water conditions**

Genotypes	Duration of imbibition (h)								
	1	2	3	4	5	6	7	8	24
Pusa Vijay (BS: C <sup>^</sup> -)	13.41	23.50	30.43	39.82	43.78	48.28	52.57	54.83	61.02
PM 28 (BS: C)	18.60	21.61	23.58	27.00	29.44	29.55	31.71	33.79	36.17
Navgold (YS <sup>^</sup> : C)	19.74	23.23	27.19	31.67	33.39	35.20	37.95	40.10	41.36
NPJ-189 (YS: C)	12.96	20.40	23.47	27.44	29.72	33.42	36.09	37.77	60.68
PM 21(BS: Q <sup>^^</sup> -)	16.27	27.75	34.31	41.31	47.22	50.65	53.67	56.90	43.70
PM 30 (BS: Q)	11.52	13.82	14.99	23.32	27.02	29.71	31.54	32.31	37.74
P. Karishma (YS: Q)	18.97	29.16	37.12	43.33	46.24	52.83	55.31	57.14	55.69
LES 48 (YS: Q)	27.67	38.48	44.15	49.57	55.98	60.66	63.46	68.62	71.23
Mean	17.39	24.74	29.40	35.43	39.10	42.54	45.29	47.68	50.95
CD (p=0.05)	11.27	10.47	10.60	11.24	11.83	10.82	9.02	9.58	11.08

\*BS-Black seeded genotype; \*\*YS- Yellow seeded genotype, C<sup>^</sup>- Conventional Type, Q<sup>^^</sup>-Quality type genotype

28 recorded lowest weight gain of 48.11 percent, whereas yellow seeded quality mustard genotype, LES 48 (71.23%) showed highest water uptake among all the genotypes. The conventional and quality genotypes showed significant differences for imbibition under limited water condition at 1, 5 and 6 h of imbibition. For reactivation of metabolic processes in dry seed, the first essential step is slow and controlled hydration, leading to germination and growth. Intact testa regulates water incorporation into the seed to accomplish the regular reconstitution of the membrane organization of these tissues, thus preventing the destruction of the seed tissues at the beginning of imbibition. Thus, testa protects seeds against leakage. Similar results have been obtained in soybean, pea, bean and peanut [15] Thus, it could be hypothesized that if water is not a limiting factor, yellow seeded genotypes would imbibe water rapidly and lose its strength to withhold moisture subsequently.

## CONCLUSION

The significance of seed coat and its

composition in determining imbibition rate has been reported in crops like peanut, soybean and pea. It was emphasized that pigment content of testa such as melanin content greatly affects the imbibition properties and flooding tolerance of seeds in *B. napus* [8]. In legumes, white seeds imbibe more rapidly than colored seeds and germinate earlier [16]. In honey locust seeds, the percentage imbibition rose more rapidly in yellow coated seeds than in dark brown seeds [8-9]. These authors have also suggested that faster imbibition may lead to imbibitional injury and thus affects seed vigour. Similar results have been obtained in our study also, which was also substantiated by electrical conductivity results, where yellow seeded genotypes showed higher conductance than the black seeded genotypes indicating greater damage in yellow seeded genotypes.

Hence, it can be suggested that yellow seeded genotypes imbibe faster than black seeded genotypes. In addition, quality mustard genotypes showed higher rate of imbibition than that of conventional mustard genotypes. Keeping above facts in view, it

**Table 5. Differential response in percent water uptake by controlled deteriorated seeds in different types of Indian mustard genotypes under limited available water condition**

Genotypes	Duration of imbibition (h)								
	1	2	3	4	5	6	7	8	24
Pusa Vijay (BS: C <sup>^</sup> -)	20.58	27.80	35.34	40.23	45.73	50.15	56.70	60.61	65.69
PM 28 (BS: C)	13.64	22.36	26.34	30.39	35.42	38.02	43.76	45.73	48.11
Navgold (YS <sup>**</sup> : C)	18.65	35.43	40.16	45.09	49.19	52.11	56.07	55.77	58.71
NPJ 189 (YS: C)	16.83	25.03	25.58	33.54	35.31	37.80	41.75	47.08	59.70
PM 21(BS: Q <sup>^^</sup> -)	17.15	20.74	25.95	31.30	37.14	40.01	48.84	53.30	59.14
PM 30 (BS: Q)	26.03	29.36	33.46	38.03	40.97	46.16	52.08	53.45	59.24
P. Karishma (YS: Q)	23.42	35.15	43.86	47.51	50.36	51.49	52.77	55.31	63.53
LES 48 (YS: Q)	36.10	45.06	53.15	54.60	65.69	66.74	68.18	71.54	71.23
Mean	21.55	30.12	35.48	40.09	44.98	47.81	52.52	55.35	60.67
CD (p=0.05)	10.23	14.10	14.82	14.20	12.24	12.49	12.01	12.28	13.82

\*BS-Black seeded genotype; \*\*YS- Yellow seeded genotype,  
C<sup>^</sup>- Conventional Type, Q<sup>^^</sup>-Quality type genotype

could be inferred that the conventional type genotypes are more protected against imbibitional damage than the quality type mustard genotypes and among them yellow seeded genotypes are more prone to imbibitional damage in both quality and conventional types.

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