

Morphological Characterization of Notified Varieties of Cabbage for Conducting DUS Tests

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Six notified varieties of cabbage, viz., Golden Acre, Pusa Mukta, Pusa Drum Head, Pusa Ageti, Pride of India and Kinner Red were characterized morphologically using 21 qualitative and 12 quantitative characters. Except 5 qualitative characters, all exhibited polymorphism between varieties, thus explaining their immense potential for varietal characterization. However, varietal distinctness reference to cumulative characters has an edge over single character. The slight variation, might be due to environment, was apparent in the expression of characters for three consecutive seasons confirming uniformity and stability of the varieties.

Key Words: Cabbage, *Brassica oleracea* L. var. *capitata*, Characterization, Notified varieties

Introduction

Being signatory member of World Trade Organization (WTO), India made provisions for protecting plant varieties. Thus, Indian Government passed an Act "Protection of Plant Varieties and Farmers' Rights (PPV & FR)" in 2001, which provides the registration of a variety of a crop if it conforms to the criteria of distinctness, uniformity and stability (DUS). The main objective of this is to protect unlawful commercial exploitation of varieties, the rights of farmers and plant breeders, and to strengthen the research activities in this field. Although, different varieties/hybrids of the crop are available but providing genetically pure seed of these varieties is a great challenge. For attaining high genetic purity and avoiding exploitation of varieties, it is imperative to define each variety with suitable descriptors. Moreover, characterization is also desired for their protection under PPV & FR Act.

Cabbage (*Brassica oleracea* L. var. *capitata*) is an important member of family, *Brassicaceae*, which ranks first in production and second in area among cole crops in India (FAO, 2005). Cabbage has been classified into three distinct groups based upon their leaf characters, viz., white cabbage (with almost smooth leaves), red cabbage (with red-purple leaves) and savoy cabbage (blistered and puckered leaves). White cabbage is commonly grown in India but savoy and red cabbages which are less important are mainly grown in Europe. In general, cabbages are distinguished by the formation of a thickened main bud called 'head'. The shape of heads varies from flat-topped to conical in outline. There are many morphological characters, which help in making distinction between different varieties of cabbage. Thus, the present study was

conducted with the aim to distinguish cabbage varieties using morphological characters for the assessment of distinctness.

Materials and Methods

Genetically pure seeds of six notified varieties of white cabbage, viz., Pusa Ageti, Pusa Drum Head, Pusa Mukta, Golden Acre, Pride of India and one red cabbage variety, namely, Kinner Red were characterized for qualitative and quantitative characters at IARI, Regional Station, Katrain. Pusa Ageti represented sub-tropical origin and rest of the five varieties belongs to the temperate group. The varieties and their sources of availability are given in Table 1.

Available notified varieties of cabbage were grown during *Rabi* 2004-05, 2005-06 and 2006-07 cropping season with two replications and assessed for 33 different morphological characters on randomly selected five plants as per UPOV guidelines (2004), proposed Indian DUS test guidelines (2004) and Gangopadhyay (2001). Details of parameters and criterion for their assessment are presented in Table 2.

Results and Discussion

The data pertaining to qualitative/ quantitative traits are presented in Table 3. All the varieties included in the present study were of temperate type except Pusa Ageti which represented sub-tropical origin. In the present study, the varieties have shown differences for morphological attributes, hence grouped into different categories, and have been discussed separately to facilitate, distinction among varieties.

Qualitative Characters

The character which distinguished Pusa Drum Head from

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Table 1. Cabbage varieties available for characterization

S.No.	Varieties	Source
1.	Pusa Drum Head, Pusa Mukta, Golden Acre, Pusa Ageti	IARI
2.	Pride of India and Kinner Red	UHF, Solan

Table 2. Detail of parameters and criterion for their assessment

S.No.	Parameters	Type of observation/ optimum stage
1.	Time of initiation of head formation	VS/1
2.	Time of harvest maturity	VS/2
3.	Plant height (cm) (soil surface to tip of the head)	MS/2
4.	Plant: max. diameter (frame size, cm)	MS/2
5.	Outer leaf shape	VS/2
6.	Outer leaf profile of upper side of blade	VS/2
7.	Plant attitude of outer leaves	VS/2
8.	Leaf margin	VS/2
9.	Outer leaf blistering	VS/2
10.	Outer leaf crimping	VS/2
11.	Outer leaf colour (with wax)	VS/2
12.	Outer leaf waxiness	VS/2
13.	Outer leaf incision of margin	VS/2
14.	Outer leaf reflection of margin	VS/2
15.	Outer leaf undulation of margins	VS/2
16.	Head anthocyanin colouration of cover leaf	VS/2
17.	Head colour of cover leaf (external colour)	VS/2
18.	Head cover	VS/2
19.	Head blistering of cover leaf	VS/2
20.	Head compactness	VS/2
21.	Number of non-wrapping leaves	MS/2
22.	Length of outer stem (stalk length) (cm)	MS/2
23.	Outer leaf size (cm)	
	a) Leaf length	
	b) Leaf breadth	MS/2
24.	Head length (cm)	MS/2
25.	Head diameter (cm)	MS/2
26.	Length of interior core stem axis (core length) (cm)	MS/2
27.	Head shape of longitudinal section	VS/2
28.	Head internal colour	VS/2
29.	Head shape of base in longitudinal section	VS/2
30.	Head internal structure	VS/2
31.	Etching type	VS/-
32.	Time of bursting after head maturity	VS/3
33.	Head shape (head index, length/width ratio)	MS/2

VS= Visual assessment of plants or parts of plant, MS= Measurement of plants or parts of plant, 1= Initiation of head formation (50%), 2= Appearance of compact heads (50%), 3= Bolting

rest of the varieties was shape of outer leaf, where as Pusa Drum Head expressed transverse broad elliptic shape in contrast to broad obovate shape in remaining varieties under study. Similarly, Pusa Ageti differed from other varieties by its erect plant attitude, while others had semi-erect attitude. Non-serrated margins were observed only in Pusa Ageti, whereas rest of the varieties had serrated leaf margins. The outer leaves of Golden Acre and Pusa Drum Head were strongly crimped in comparison to Pusa Ageti, Pride of India, Pusa Mukta and Kinner Red. The

colour of outer leaves in Pusa Ageti and Pusa Drum Head was light green in contrast to Pusa Mukta, Pride of India and Golden Acre, whereas characteristically purple coloured leaves were present in Kinner Red. The waxiness of outer leaves was absent/ very weak in Pusa Mukta and strong in Kinner Red. The character was weak in Golden Acre and Pusa Drum Head, followed by medium in Pusa Ageti and Pride of India. The margins of Pusa Mukta were strongly undulated clearly distinguishing it with medium undulation in Pusa Ageti, Pride of India, Kinner Red and Pusa Drum Head; Golden Acre, however, had weak undulation.

The typically circular heads were apparent in Golden Acre, Pusa Mukta and Pride of India. The respective shape, however, was broad ovate, transverse narrow elliptic and broad elliptic in Pusa Ageti, Pusa Drum Head and Kinner Red. The head was fully covered in Pusa Ageti, Golden Acre, Pusa Mukta, Pride of India and Kinner Red and partially covered in Pusa Drum Head. Only Kinner Red exhibited strong anthocyanin colouration of the outer leaf. Apparently, colour of the head of Pride of India, Pusa Mukta, Golden Acre and Pusa Drum Head was light green, followed by green in Pusa Ageti and purple in Kinner Red. The qualitative purple colour of interior of the head is the characteristic of Kinner Red, which was typically yellowish in rest of the varieties. The base of head in longitudinal section was raised in Kinner Red and level in rest of the varieties. The compact heads were observed in Golden Acre, Pride of India and Kinner Red, however, these were medium compact in Pusa Drum Head, Pusa Mukta and Pusa Ageti. Evidently, the internal head structure was fine in Golden Acre, Pusa Mukta and Kinner Red. The medium and coarse textures were apparent in Pusa Drum Head and Pride of India; and Pusa Ageti, respectively.

Quantitative Characters

The plants of Pride of India, Pusa Ageti and Kinner Red registered a height of more than 20 cm whereas it ranged between 15-20 cm in Golden Acre, Pusa Mukta and Pusa Drum Head. The minimum plant spread (<50 cm) was apparent in Golden Acre, Pride of India and Kinner Red, however, it was maximum (>60 cm) in Pusa Drum Head and remaining two had a medium spread. Except Pusa Ageti and Pusa Drum Head, the leaf length in rest of the varieties varied from 20-30 cm. In terms of leaf breadth, Pusa Mukta and Pusa Drum Head exhibited large leaves (>25 cm). Stalks were long (>1cm) in Kinner Red, while rest of the varieties had medium (0.5-1.0 cm) long stalks.

Table 3. Morphological characterization of cabbage varieties

S.No.	Characteristics	States	Note	Example varieties
A. Qualitative Characters				
1.	Outer leaf shape	Broad elliptic		-
		Broad ovate		-
		Circular		-
		Transverse broad elliptic	4	PDH
		Broad obovate	5	GA, PM, PoI, PA, KR
2.	Outer leaf profile of upper side of blade	Concave		-
		Flat		-
		Convex	3	PDH, GA, PM, PoI, PA, KR
3.	Plant attitude of outer leaves	Erect	3	PA
		Semi-erect	5	PDH, GA, PM, PoI, KR
		Horizontal		-
4.	Leaf margin	Serrate	1	PDH, GA, PM, PoI, KR
		Non-serrate	2	PA
5.	Outer leaf blistering	Absent/very weak	1	PDH, GA, PM, PoI, PA, KR
		Weak		-
		Medium		-
		Strong		-
6.	Outer leaf crimping	Weak	3	PA, PoI, PM, KR
		Medium		-
		Strong	7	GA, PDH
7.	Outer leaf colour (with wax)	Light green	1	PA, PDH
		Green	2	PoI, GA, PM
		Grey green		-
		Bluish green		-
		Purple	5	KR
8.	Outer leaf waxiness	Absent/ very weak	1	PM
		Weak	3	GA, PDH
		Medium	5	PA, PoI
		Strong	7	KR
9.	Outer leaf incision of margin	Absent		-
		Present	9	PDH, GA, PM, PoI, PA, KR
10.	Outer leaf reflection of margin	Absent	1	PDH, GA, PM, PoI, PA, KR
		Present	-	-
11.	Outer leaf undulation of margins	Absent/very weak		-
		Weak	3	GA
		Medium	5	PA, PoI, PDH, KR
		Strong	7	PM
		Very strong		-
12.	Head anthocyanin colouration of cover leaf	Absent/very weak	1	PDH, GA, PM, PoI, PA
		Weak		-
		Medium		-
		Strong	7	KR
13.	Head colour of cover leaf (external colour)	Light green	1	PoI, PM, GA, PDH
		Green	2	PA
		Grey green		-
		Blue green		-
		Purple	5	KR
14.	Head compactness	Very loose		-
		Loose		-
		Medium	5	PA, PDH, PM
		Compact	7	PoI, GA, KR
15.	Head shape of longitudinal section	Transverse narrow elliptic	1	PDH
		Transverse elliptic		-
		Circular	3	GA, PM
		Broad elliptic	4	PoI, KR
		Broad obovate		-
		Broad ovate	6	PA
		Angular ovate		-
16.	Head internal colour	Whitish		-
		Yellowish	2	PDH, GA, PM, PoI, PA
		Green		-
		Purple	4	KR

Contd.

Table 1. contd.

S.No.	Characteristics	States	Note	Example varieties	
17.	Head shape of base in longitudinal section	Raised	1	PA	
		Level	2	PDH, GA, PM, PoI, KR	
		Arched		-	
18.	Head cover	Uncovered		-	
		Partially covered	2	PDH	
		Covered	3	PA, GA, PM, PoI, KR	
19.	Head blistering of cover leaf	Absent / very weak	1	PDH, GA, PM, PoI, PA, KR	
		Weak		-	
		Medium		-	
		Strong		-	
		Very strong		-	
20.	Head internal structure	Fine	3	PM, GA, KR	
		Medium	5	PDH, PoI	
		Coarse	7	PA	
21.	Etching type	Tropical		-	
		Sub-tropical	2	PA	
		Temperate	3	PDH, GA, PM, PoI, KR	
B. Quantitative characters					
1.	Time of initiation of head formation	Early (<50 days)	1	GA, PoI, PM	
		Medium (51-60 days)	3	PA, PDH	
		Late (>60 days)	5	KR	
2.	Time of harvest maturity	Early (<70days)	1	GA, PM, PoI, PA	
		Medium (71-85 days)	3	PDH	
		Late (>85 days)	5	KR	
3.	Plant height (cm)	Short (< 15)		-	
		Medium (15-20)	5	PDH, GA, PM	
		Tall (> 20)	7	PoI, PA, KR	
4.	Plant max. diameter (cm)	Small (< 50)	3	GA, PoI, KR	
		Medium (50-60)	5	PA, PM	
		Large (> 60)	7	PDH	
5.	Number of non-wrapping leaves	Few (<10)		-	
		Medium (10-15)	3	PDH, GA, PM	
		Many (>15)	5	PoI, PA, KR	
6.	Outer leaf size (cm)	a) Leaf length	Small (<20)		-
			Medium (20-30)	5	PoI, GA, PM, KR
		Long (>30)	7	PA, PDH	
		b) Leaf breadth	Small (<20)		-
			Medium (20-25)	5	PoI, GA, PA, KR
7.	Length of outer stem (cm)	Large (>25)	7	PM, PDH	
		Short (< 0.50)		-	
		Medium (0.50-1.0)	5	PDH, GA, PM, PoI, PA	
8.	Head length (cm)	Long (>1.0)	7	KR	
		Short (<10)		-	
		Medium (10-15)	5	PDH, GA, PM, PoI, KR	
9.	Head diameter (cm)	Long (>15)	7	PA	
		Small (<10)	3	KR	
		Medium (10-15)	5	PA, PoI, GA	
10.	Length of interior core stem axis (cm)	Large (>15)	7	PDH, PM	
		Short (<5)		-	
		Medium (5-8)	5	PoI, GA, PDH, PM, KR	
11.	Time of bursting after head maturity	Long (>8)	7	PA	
		Early (<10 days)	3	PM, PA, GA	
		Medium (10-20 days)	5	PoI, PDH	
12.	Head shape (length/width ratio)	Late (>20 days)	7	KR	
		Flat (<0.85)	1	PDH,	
		Round (0.85-1.10)	3	GA, PM	
		Oval (1.11-1.25)	5	PoI, KR	
		Conical (>1.25)	7	PA	

PDH=Pusa Drum Head, GA = Golden Acre, PM= Pusa Mukta, PoI= Pride of India, PA= Pusa Ageti and KR= Kinner Red

Table 4. Distinction among the varieties expressed as descriptor note

S.No.	Descriptors/Varieties	Note					No. of varieties distinguished	
		GA	PM	PoI	PDH	PA		KR
1.	Time of initiation of head formation	1	1	1	3	3	5	3
2.	Time of harvest maturity	1	1	1	3	1	5	3
3.	Plant height (soil surface to tip of the head)	5	5	7	5	7	7	2
4.	Plant: max diameter (frame size)	3	5	3	7	5	3	3
5.	Outer leaf shape	5	5	5	4	5	5	2
6.	Outer leaf profile of upper side of blade*	3	3	3	3	3	3	0
7.	Plant attitude of outer leaves	5	5	5	5	3	5	2
8.	Leaf margin	1	1	1	1	2	1	2
9.	Outer leaf blistering*	1	1	1	1	1	1	0
10.	Outer leaf crimping	7	3	3	7	3	3	2
11.	Outer leaf colour (with wax)	2	2	2	1	1	2	2
12.	Outer leaf waxiness	3	1	5	3	5	7	3
13.	Outer leaf incision of margin*	9	9	9	9	9	9	0
14.	Outer leaf reflection of margin*	1	1	1	1	1	1	0
15.	Outer leaf undulation of margins	3	7	5	5	5	5	3
16.	Head anthocyanin colouration of cover leaf	1	1	1	1	1	7	2
17.	Head colour of cover leaf (external colour)	1	1	1	1	2	5	3
18.	Head cover	3	3	3	2	3	3	2
19.	Head blistering of cover leaf*	1	1	1	1	1	1	0
20.	Head compactness	7	5	7	5	5	7	2
21.	Number of non-wrapping leaves	3	3	5	3	5	5	2
22.	Length of outer stem (stalk length)	5	5	5	5	5	7	2
23.	Outer leaf size							
	a) Leaf length	5	5	5	7	7	5	2
	b) Leaf breadth	5	7	5	7	5	5	2
24.	Head length	5	5	5	5	7	5	2
25.	Head diameter	5	7	5	7	5	3	3
26.	Length of interior core stem axis (core length)	5	5	5	5	5	7	2
27.	Head shape of longitudinal section	3	3	4	1	6	4	4
28.	Head internal colour	2	2	2	2	2	4	2
29.	Head shape of base in longitudinal section	2	2	2	2	1	2	2
30.	Head internal structure	3	3	5	5	7	3	3
31.	Etching type	3	3	3	3	2	3	2
32.	Time of bursting after head maturity	3	3	5	5	3	7	3
33.	Head shape (length/ width ratio)	3	3	5	1	7	5	4

*Descriptor exhibiting no polymorphism among the varieties

PDH=Pusa Drum Head, GA = Golden Acre, PM= Pusa Mukta, PoI= Pride of India, PA= Pusa Ageti, and KR= Kinner Red

Pride of India, Pusa Ageti and Kinner Red had more than 15 non-wrapping leaves; however, these were within the range of 10-15 in Golden Acre, Pusa Drum Head and Pusa Mukta. The varieties, Pride of India, Golden Acre and Pusa Mukta took less than 50 days for head formation; whereas Pusa Drum Head and Pusa Ageti started head formation between 51-60 days; and Kinner Red took more than 60 days. The marketable maturity was achieved in less than 70 days in Golden Acre, Pusa Mukta, Pride of India and Pusa Ageti. Pusa Drum Head fell under medium maturity group (71-85 days), while Kinner Red under late maturity group (>85 days). Golden Acre, Pusa Mukta and Pusa Ageti must be harvested within 10 days of head maturity to avoid bursting. Pride of India and Pusa Drum Head may withstand for 10-20 days followed by more than 20 days in Kinner Red. Core length was longer in

Pusa Ageti and medium in Pride of India, Golden Acre, Pusa Drum Head, Pusa Mukta and Kinner Red. Based on their head index, Golden Acre and Pusa Mukta were categorized as round, Pride of India and Kinner Red as oval, Pusa Ageti as conical and Pusa Drum Head as flat headed.

Conclusions

Five qualitative characters, viz., outer leaf profile of upper side of blade, outer leaf blistering, outer leaf incision of margin, outer leaf reflection of margin and head blistering of cover leaf (Table 4) did not show polymorphism among the six varieties. Hence, while going for DUS testing, any one of the six varieties may be used as an example variety for the above 5 characters. Further, blistering of leaf is a characteristic of savoy type of cabbages and the

reference collection represented only white cabbages, therefore such descriptors may be excluded when testing is not to be done for savoy cabbage types. Similarly, none of the white cabbage varieties exhibited the characteristics as anthocyanin colouration of cover leaf and head internal colour as purple (as in case of variety Kinner Red) which is a characteristic of red cabbage types. From Table 4 it may also be deduced that a maximum of 4, varieties could be distinguished by each of the 2 descriptors, viz., head shape of the longitudinal section and head shape (head length/width ratio). Nine descriptors could distinguish 3 varieties each and the remaining 17 descriptors were able to distinguish 2 varieties each out of the 6 varieties under investigation.

This maiden attempt to characterize the notified varieties as per DUS test guidelines will serve as a ready reckoner for plant variety protection and their utilization in breeding programmes.

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