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Quality analysis of CMS-based pigeonpea hybrids

S.L. SAWARGAONKAR[a1*], I.A. MADRAP[a2], S. ISMAIL[a3] and K.B. SAXENA[b4]

[a] *Deptt. of Genetics & Pl. Breeding, Marathwada Agricultural University, Parbhani - 431 401 (Maharashtra)*

[b] *International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru - 502 324 (A.P.)*

ABSTRACT. The experimental materials comprised of 102 pigeonpea hybrids (F_1) along with check (BSMR 736) were derived by crossing three CMS-lines (ICPA 2043, ICPA 2047 and ICPA 2092 with 34 testers. The *dal* of 250 gm sun-dried F_1 seeds of hybrids and check was prepared. This *dal* was used to study cooking time (min), water absorption (gg^{-1}), *dal* recovery (%) and protein content (%). The analysis of variance for four quality traits studied was highly significant, indicating the presence of variation in the materials studied. The cooking time of *dal* had negative correlation with dal recovery while positive with protein content; whereas water absorption had negative correlation with protein content. The hybrid made between all the three male-sterile lines with four male parents ICP 3525, ICP 3963, ICP 3374 and ICPL 20106 took less time to cook than the check. The water absorption of *dal* by cooking (gg^{-1}) for ICPA 2043-derived hybrids was slightly less than ICPA 2047- and ICPA 2092-derived hybrids. The mean *dal* recovery (%) for ICPA 2047- and ICPA 2092-derived hybrids was 66.2 %. The hybrid ICPA 2047 x ICP 3374 and ICPA 2092 x ICP 3374 (77.9 %) recorded significantly greater *dal* recovery (%) over the check BSMR 736 (69.37 %). The results of protein content among three CMS-based hybrids revealed that there was 20% protein present among three CMS-derived hybrids of pigeonpea. The hybrids ICPA 2043 x BSMR 198, ICPA 2043 x BSMR 175 and ICPA 2043 x ICP 3407 possess significantly more protein (%) than the check (BSMR 736).

Keywords : *Cajanus cajan, hybrid, quality analysis, pigeonpea.*

INTRODUCTION

Pigeonpea [*Cajanus cajan* L. Millsp.] is an important pulse crop of India and almost entire production (2.8 m t) is consumed in form of *dal* i.e. (decorticated split peas) (FAO STAT, 2008). The productivity of this crop is low and unstable mainly due to various biotic, abiotic, and management reasons. To break yield barrier a hybrid technology has successfully been developed (Saxena 2008a). This breeding technology is capable of substantially increasing the productivity of pigeonpea, and hope of pulse revolution in the country (Saxena and Nadarajan, 2010). The cytoplasmic-nuclear male-sterility based hybrids in extra short, short and medium maturity groups have recorded grain yield superiority of 61% over the best check cultivar in different locations across India (Saxena, 2008 a). Besides improvement in productivity, adaptability and yield the improvement of nutritional quality of pulses has often been emphasized (Singh, 1994; Singh *et al.*, 1997). The consumer acceptance characteristics and the effects of improved processing technology and storage on the overall nutritional quality is the most important considerations in introducing any new pulse cultivars for commercialization (Saxena *et al.*, 2005). The introgression of wild genome during inter-specific crosses, some traits may affect the quality of grains resulting in decline in consumers preference. It has been estimated that the total production of legumes provide almost as much protein (20-30 %) to the world as wheat and over 50 % more than rice or corn (Rockland and Radke, 1981 and Gopalan *et al.*, 1985). The present investigation was carried out with the objective to study of the quality parameters of CMS-based hybrids of pigeonpea *dal*.

[1] Visiting Scientist, [2] Head, [3] Assoc. Prof., [4] Pr. Scientist *Correspondence

MATERIALS AND METHODS

Experimental material and other details : The experimental materials comprised of 102 pigeonpea hybrids (F_1) along with two check (BSMR 736 and ICPH 2671) were derived by crossing three CMS-lines (ICPA 2043, ICPA 2047 and ICPA 2092 with 34 testers during rainy season 2008 at Marathwada Agricultural University, Parbhani. The F_1 seeds harvested from female parent were advanced to F_1 and 250 gm sun-dried F_1 seeds of hybrids and check were cleaned and manually ground in the stone chakki to prepare *dal* (Singh and Jambunathan, 1981a; Jayasekera, 1996). The half split seed samples were then sun dried by spreading on gunny bag for two days. Finally the material was dehusked with a stone chakki. Various byproducts i.e. dehusked *dal*, broken *dal* (1 mm diameter) and husk was separated, and weighed separately on electronic balance. This *dal* was used to study cooking time (min), water absorption (gg^{-1}), *dal* recovery (%) and protein content (%). The observations on the following four parameters of *dal* quality were recorded in duplicate for each hybrid and check.

Cooking time : The half split seed (10 g) of each hybrid and check was taken in a 100 ml test tube and cooked with 50 ml distilled water on hot plate. Cooking time was determined by boiling the 10 gm of *dal* in distilled water in test tube on heater and total time required for cooking of *dal* were recorded in minutes by using stopwatch. In between of cooking, the split *dal* was checked three times by removing a few *dal* at different time intervals during cooking and pressing between forefingers till softening of *dal* to avoid overcooking of *dal*.

Protein (%) : Protein content of sample was determined by Micro Kjeldhal procedure (AOAC 1990). After determination of Nitrogen contents total protein was calculated by converting nitrogen values into protein values by multiplying these with 6.25.

Dal recovery (%) : *Dal* recovery was calculated by using total weight of dehusked *dal* (split *dal*, and broken *dal*) to the total weight of seed used for dehusking and expressed in percentage.

Water absorption (gg^{-1}) : About 10 g of pigeonpea *dal* was boiled in distilled water to cook till softening of split *dal*. The increase in weight of *dal* during boiling in water was considered to be an increase in moisture content. The cooked *dal* was reweighed after draining the extra water and the percent water absorption was calculated in gram per gram.

Statistical analysis : The data were analyzed statistically by using Genstat 12 edition. The Pearson's correlation coefficients among the characteristics were estimated.

RESULTS AND DISCUSSION

The analysis of variance for four quality traits studied was highly significant (**Table 1**), indicating the presence of variation in the materials studied. Seed quality determines the acceptability of a commodity among the consumers. Pigeonpea seeds dry, green, or processed in the form of *dal* and other products are consumed after cooking. Therefore, besides various nutritional aspects the cooking time assumes significant importance Saxena *et al.* (2002). Consumers always prefer a *dal* that cooks fast and produces more volume upon cooking with high consistency and flavor. Time required for cooking of seeds is important consideration in term of energy use. Kurien *et al.* (1972) stated that cooking time of various grain legumes varied from 30-60 minutes. Cooking time recorded between 22 to 44 minutes for *dal* and between 45 to 67 minutes for whole seed by Sharma *et al.* (1973) indicated the extent of genotypic variation present for this trait. However, Gupta *et al.* (2000) recorded cooking time for pigeonpea genotypes from 37 to 53 minutes. Similar results were observed in present study where hybrids derived from three different CMS-lines, recorded different time to cook. The cooking time among ICPA 2043 derived hybrids ranged from 18 min (ICPA 2043 x BSMR 736) to 61 min (ICPA 2043 x ICP 3514, ICPA 2043 x VIPULA) with a mean of 33.5 min. Similarly, the cooking time among ICPA 2047 hybrids ranged from 13.5 min (ICPA 2047 x PHULE T-00-1-25-1) to 60.5 (ICPA 2047 x ICP 11376) min with mean of 33.9 min. The hybrids ICPA 2092 x PHULE T-00-1-25-1 and ICPA 2092 x ICP 11376 were observed to possess 13.5 min and 60.5 min cooking time, respectively, among ICPA 2092-derived hybrids with a mean of 33.9 min. Out of 102 hybrids evaluated, 36 recorded significantly less cooking time than the check BSMR 736 (38.3 min). Hybrids ICPA 2047 x PHULE T-00-1-25-1, ICPA 2092 x PHULE T-00-1-25-1, ICPA 2043 x BSMR 736 and ICPA 2047 x ICP 3514 recorded significantly less cooking time as compared to the check. The mean cooking time of *dal* of the three CMS-derived hybrids revealed that ICPA 2043 hybrids were earlier to cook followed by ICPA 2047 and ICPA 2092. However, the cooking time varied between 33.1–42.6 min for chickpea, 18.3–22.3 min for pigeon pea and 13.3–15.2 min for green gram (Singh *et al.*, 2010). Tripathi and Singh (1979) also found significant differences in varieties for cooking time in pigeonpea. Such effect of genotypes on cooking time from 37 to 45 minutes was previously reported by Srivastava and Srivastava (2006) in pigeonpea. The hybrid made between all the three male-sterile lines with four male parents ICP 3525, ICP 3963, ICP 3374 and ICPL 20106 took less time to cook than the check. These crosses offer an excellent opportunity for developing new hybrids with less cooking time. Jambunathan and Singh (1981) studied various physico-chemical characters of pigeonpea, and reported that quick cooking trait of dal was associated with large seed size, high solid dispersal, more water absorption, and high nitrogen solubility. Narasimha and Desikachar (1978) and Pal (1939) reported a positive association of cooking time of pigeonpea seeds with their calcium and magnesium contents.

The mean water absorption of *dal* by cooking among ICPA 2043 derived hybrids was 1.8 gg^{-1} while it was ranged between 0.9 gg^{-1} (ICPA 2043 x AKT 9913) to 2.7 gg^{-1} (ICPA 2043 x ICP 11376). Similarly, the water absorption among ICPA 2047-derived hybrids ranged from 1.3 gg^{-1} (ICPA 2047 x BSMR 175) to 2.5 gg^{-1} (ICPA 2047 x BWR 154) with mean of 1.9 gg^{-1}, whereas among ICPA 2092-derived hybrids the water absorption in pigeonpea *dal* ranged from 1.3 (ICPA 2092 x BSMR 175) to 2.5 gg^{-1} (ICPA 2092 x BWR 154) with mean of 1.9 gg^{-1}. The water absorption of *dal* by cooking (gg^{-1}) for ICPA 2043-derived hybrids, therefore, is slightly less than ICPA 2047- and ICPA 2092- derived hybrids. It was observed that parents ICP 11376, ICP 3514, PHULE T-00-5-7-4-1 and BSMR2 when crossed with all three male-sterile lines produced hybrids with significantly more water absorption ability of *dal* than check.

The *dal* recovery (%) among ICPA 2043-derived hybrids ranged from 47.3% (ICPA 2043 x BSMR 203) to 74.1 % (ICPA 2043 x ICP 3525) with mean of 66.4%. Likewise *dal* recovery (%) among ICPA 2047-derived hybrids ranged from 53.2 (ICPA 2047 x BSMR 571) to 75.6 % (ICPA 2047 x BSMR 203) and among ICPA 2092-based hybrids ranged from 50.2 (ICPA 2092 x BSMR 571) to 77.9% (ICPA 2092 x ICP 3374). The mean *dal* recovery (%) for ICPA 2047- and ICPA 2092-derived hybrids was 66.2. Out of 102 hybrids evaluated, only ICPA 2047 x ICP 3374 and ICPA 2092 x ICP 3374 (77.9 %) recorded significantly greater *dal*

Table 1. Analysis of variance for cooking quality characters in pigeonpea

S.V.	df	Cooking time (Min)	Protein (%)	Water absorption (gg^{-1})	Dal recovery (%)
Genotype	138	193.29**	4.56**	0.29**	70.15**
Replication	1	0.71	1.19	0.2**	68.92**
Error	138	3.12	0.54	0.2	5.57

*, ** = significant at 5 and 1 % level

Table 2. Some cooking quality parameter of ICPA 2043 based hybrids

Hybrids	Cooking time (Min)	Water absor-ption (gg^{-1})	Dal reco-very (%)	Protein (%)
ICPA 2043 x BSMR 198	26.5	2.0	57.1	23.0
ICPA 2043 x BSMR 846	43.5	1.5	66.6	22.0
ICPA 2043 x BSMR 164	37.0	1.4	68.1	21.5
ICPA 2043 x BDN 2001-6	40.0	2.0	68.3	22.0
ICPA 2043 x ICP 3525	22.0	1.4	74.1	20.4
ICPA 2043 x BSMR 175	27.5	1.7	60.3	22.0
ICPA 2043 x BSMR 2	39.5	2.3	66.1	23.0
ICPA 2043 x ICPL 12749	28.5	1.2	72.4	21.0
ICPA 2043 x BSMR 203	40.5	2.1	47.3	21.5
ICPA 2043 x BWR 154	22.5	1.2	69.3	21.5
ICPA 2043 x BSMR 571	29.0	1.8	64.8	22.0
ICPA 2043 x ICP 13991	29.0	2.0	66.3	21.5
ICPA 2043 x ICP 10934	24.0	1.9	70.1	21.0
ICPA 2043 x HPL 24-63	32.0	2.1	64.2	19.3
ICPA 2043 x AKT 9915	44.0	2 2	64.5	20.9
ICPA 2043 x ICP 3407	34.0	2.1	67.5	23.0
ICPA 2043 x ICP 10650	29.0	1.7	66.1	19.0
ICPA 2043 x ICP 3475	34.0	1.8	71.0	17.2
ICPA 2043 x BSMR 736	18.0	1.8	66.4	18.4
ICPA 2043 x TV 1	36.0	1.7	70.7	17.8
ICPA 2043 x AKT 8811	30.0	1.8	69.6	18.4
ICPA 2043 x PHULE T-00-1-25-1	24.0	2.0	66.1	18.4
ICPA 2043 x PHULE T-04-1-31	30.0	1.8	62.9	18.6
ICPA 2043 x AKT 9913	29.0	0.9	63.9	18.7
ICPA 2043 x AKT 222521	36.0	2.3	69.9	18.9
ICPA 2043 x AKT 00-12-6-4	29.0	1.6	71.5	18.6
ICPA 2043 x ICP3963	23.0	1.9	66.7	18.3
ICPA 2043 x PHULE T-00-5-7-4-1	26.0	2.5	73.2	19.5
ICPA 2043 x VIPULA	61.0	1.8	67.1	19.4
ICPA 2043 x PHULE T-00-4-11-6-2	47.5	1.9	62.2	19 4
ICPA 2043 x ICP 11376	56.0	2.7	56.2	19.8
ICPA 2043 x ICP 3514	61.0	2.6	68.4	20.2
ICPA 2043 x ICP 3374	24.0	1.2	67.4	21.9
ICPA 2043 x ICPL 20106	26.0	1.8	72.2	20.0
BSMR 736 (Check 1)	38.25	19.86	2.14	69.37
Mean	33.5	1.8	66.4	20.2
Range	18 to 61	0.9 to 2.7	47.3 to 74.1	17.2 to 23
SEm ±	5.06	0.98	4.75	0.63
CV (%)	3.80	8.10	3.10	0.40
C.D. at 5 %	14.15	2.75	13.29	1.77
C.D. at 1 %	18.69	3.63	17.55	2.34

Table 3. Some cooking quality parameter of ICPA 2047 based hybrids

Hybrids	Cook-ing time (Min)	Water abso-rption (gg^{-1})	Dal reco-very (%)	Prot-ein (%)
ICPA 2047 x BSMR 198	31.0	2.1	67.2	21.0
ICPA 2047 x BSMR 846	33.0	1.8	63.2	20.0
ICPA 2047 x BSMR 164	51.0	2.0	60.6	20.9
ICPA 2047 x BDN 2001-6	34.0	1.8	67.6	21.5
ICPA 2047 x ICP 3525	24.0	1.8	58.2	18.8
ICPA 2047 x BSMR 175	41.0	1.3	68.2	18.6
ICPA 2047 x BSMR 2	39.0	1.7	66.8	18.4
ICPA 2047 x ICPL 12749	34.0	2.1	69.1	17.7
ICPA 2047 x BSMR 203	32.0	1.7	75.6	18.6
ICPA 2047 x BWR 154	34.0	2.5	62.2	19.3
ICPA 2047 x BSMR 571	39.0	2.0	53.2	19.4
ICPA2047 x ICP 13991	31.0	1.7	55.1	21.0
ICPA 2047 x ICP10934	51.0	2.0	70.5	19.6
ICPA 2047 x HPL 24-63	39.0	2.3	71.5	21.0
ICPA 2047 x AKT 9915	31.0	2.3	54.9	21.0
ICPA 2047 x ICP 3407	28.5	1.9	70.7	22.3
ICPA 2047 x ICP10650	25.5	1.8	67.5	21.0
ICPA 2047 x ICP 3475	23.5	1.9	69.1	22.0
ICPA 2047 x BSMR 736	44.5	1.8	67.1	20.0
ICPA 2047 x TV 1	38.5	1.7	67.3	19.5
ICPA 2047 x AKT 8811	30.5	2.0	60.5	18.5
ICPA 2047 x PHULE T-00-1-25-1	13.5	1.6	64.1	18.6
ICPA 2047 x PHULE T-04-1-31	33.5	1.6	74.1	17.7
ICPA 2047 x AKT 9913	23.5	1.7	71.8	17.8
ICPA 2047 x AKT 222521	23.5	2.0	60.0	21.0
ICPA 2047 x AKT 00-12-6-4	28.5	2.0	66.2	22.0
ICPA 2047 x ICP 3963	25.5	2.1	65.0	20.6
ICPA 2047 x PHULE T-00-5-7-4-1	56.5	2.1	73.0	21.0
ICPA 2047 x VIPULA	41.5	2.2	70.0	21.7
ICPA 2047 x PHULE T-00-4-11-6-2	36.5	2.3	66.0	19.4
ICPA 2047 x ICP 11376	60.5	2.3	62.0	20.8
ICPA 2047 x ICP 3514	21.5	1.6	61.0	20.5
ICPA 2047 x ICPR 3374	26.5	1.7	77.9	20.3
ICPA 2047 x ICPL 20106	25.5	1.5	73.0	21.2
Mean	33.9	1.9	66.2	20.1
Range	13.5 to 60.5	1.3 to 2 5	53.2 to 77.9	17.7 to 22.3

recovery (%) over the check BSMR 736 (69.37 %). These hybrids contain common parent ICP 3374 which may be responsible for greater *dal* recovery (%). These hybrids ICPA 2047 x ICP 3374 and ICPA 2092 x ICP 3374 recorded less cooking time (min), high protein (%) and low water absorption (gg^{-1}) makes ICP 3374 an important genotype for hybrid breeding. The water absorption was reported to increase with increasing level of protein content (Rhee *et al.*, 1981; Kinsella, 1979; Lin and Leeder, 1974). Tripathi and Singh (1979) reported highest *dal* recovery of 84.5% among varieties of pigeonpea whereas Ehiwe and Reichert (1987) reported relatively less variation (79-83%) in *dal* yield of pigeonpea cultivars compared to other legumes. In a recent study Saxena, (2008b) reported milling quality with 69.2% (46.47% and 22.76% 1st and 2nd quantity *dal*, respectively) recovery in a CMS based hybrid (ICPH 2671). The dal recovery varied between 76.2– 71.4 % for chickpea, 69.0–73.7 % for pigeon pea and 72.8–76.7 % for green gram (Singh *et al.*, 2010).

The mean protein content among the ICPA 2043-derived hybrids was 20.2 %. The minimum protein (17.2%) content was observed in ICPA 2043 x ICP 3475 while three hybrids (ICPA 2043 x BSMR 198, ICPA 2043 x BSMR 2 and ICPA 2043 x ICP 3407 showed maximum protein content (23%). Similarly, among ICPA 2047-based hybrids the minimum protein content (17.7 %) recorded by three hybrids ICPA 2047 x ICPL 12749, ICPA 2047 x PHULE T-04-1-3-1 and ICPA 2047 X AKT 9913 while highest exhibited by ICPA 2047 x ICP 3407, ICPA 2047 x ICP 3475 and ICPA 2047 x AKT 00-12-6-4 (22.3 %) with mean of 20.1 %. The protein content among ICPA 2092-derived hybrids ranged from 17.7 % (ICPA 2092 x ICPL 12749, ICPA 2092 x PHULE T-04-1-3-1) to 22.3 % (ICPA 2092 x ICP 10650) with mean of 20%. The results of protein content among three CMS-based hybrids revealed that there was 20% protein present. The protein content

Table 4. Some cooking quality parameter of ICPA 2092 based hybrids

Hybrids	Cooking time (Min)	Water absorption (gg^{-1})	Dal recovery (%)	Protein (%)
ICPA 2092 x BSMR 198	31.0	2.1	67.2	21.0
ICPA 2092 x BSMR 846	33.0	1.8	63.2	20.0
ICPA 2092 x BSMR 164	51.0	2.0	60.6	20.9
ICPA 2092 x BDN 2001-6	34.0	1.8	67.6	21.5
ICPA 2092 x ICP 3525	24.0	1.8	58.2	18.8
ICPA 2092 x BSMR 175	41.0	1.3	68.2	18.6
ICPA 2092 x BSMR 2	39.0	1.7	66.8	18.4
ICPA 2092 x ICPL 12749	34.0	2.1	69.1	17.7
ICPA 2092 x BSMR 203	32.0	1.7	75.6	18.6
ICPA 2092 x BWR 154	34.0	2.5	62.2	19.3
ICPA 2092 x BSMR 571	39.0	2.0	53.2	19.4
ICPA 2092 x ICP 13991	31.0	1.7	55.1	21.0
ICPA 2092 x ICP 10934	51.0	2.0	70.5	19.6
ICPA 2092 x HPL 24-63	39.0	2.3	71.5	21.0
ICPA 2092 x AKT 9915	31.0	2.3	54.9	21.0
ICPA 2092 x ICP 10650	28.5	1.9	70.7	22.3
ICPA 2092 x ICP 3407	25.5	1.8	67.5	21.0
ICPA 2092 x ICP 3475	23.5	1.9	69.1	22.0
ICPA 2092 x BSMR 736	44.5	1.8	67.1	20.0
ICPA 2092 x TV 1	38.5	1.7	67.3	19.5
ICPA 2092 x AKT 8811	30.5	2.0	60.5	18.5
ICPA 2092 x PHULE T-00-1-25-1	13.5	1.6	64.1	18.6
ICPA 2092 x PHULE T-04-1-31	33.5	1.6	74.1	17.7
ICPA 2092 x AKT 9913	23.5	1.7	71.8	17.8
ICPA 2092 x AKT 222521	23.5	2.0	60.0	21.0
ICPA 2092 x AKT 00-12-6-4	28.5	2.0	66.2	22.0
ICPA 2092 x ICP 3963	25.5	2.1	65.0	20.6
ICPA 2092 x PHULE T-00-5-7-4-1	56.5	2.1	73.0	21.0
ICPA 2092 x VIPULA	41.5	2.2	70.0	21.7
ICPA 2092 x PHULE T-00-4-11-6-2	36.5	2.3	66.0	19.4
ICPA 2092 x ICP 11376	60.5	2.3	62.0	20.8
ICPA 2092 x ICP 3514	21.5	1.6	61.0	20.5
ICPA 2092 x ICP 3374	26 5	1.7	77.9	20.3
ICPA 2092 x ICPL 20106	25.5	1.5	73.0	21.2
Mean	33.9	1.9	65.8	20.1
Range	13.5 to 60.5	1.3 to 2.5	53.2 to 77.9	17.7 to 22.3

was within the range of 19-23% as reported by Duke (1981); while, 21% reported by Eltayeb *et al.* (2010) in pigeonpea. Hybrids ICPA 2043 x BSMR 198, ICPA 2043 x BSMR 175 and ICPA 2043 x ICP 3407 possess significantly more protein (%) than the check. It was observed that the hybrid ICPA 2043 x BSMR 198 and ICPA 2043 x ICP 3407 with high protein (%) were earlier to cook and had more water absorption capacity but low *dal* recovery (%). This indicated that there was positive correlation between protein (%), cooking time (min) and water absorption (gg^{-1}). Tripathi and Singh (1979) found the significant differences in varieties for protein (%), *dal* recovery (%) and cooking time (min). Panigrahi *et al.* (2002) revealed that protein content of *cajanifolius* (30.8%) was much higher than the two pigeonpea cultivars AKT 9013 (22.8%) and AKPH 1156 (21.6%). The F_1 hybrids from both the crosses had much higher protein (%) than the mid-parental values and were very close to the wild species *Cajanus cajanifolius* evidencing for positive heterosis (Rangasamy *et al.* 1991). Srivastava and Srivastava (2006) reported protein (%) in different genotypes of pigeonpea from 18.4 to 22 % and cooking time from 37 to 45 minutes.

Quality analysis across three male-sterile lines : Out of 34 testers, five (ICP 3525, ICP 10934, PHULE T-00-1-25-1, ICP 3374 and ICPL 20106) produced hybrids with ICPA 2043 which had early cooking time. Similarly the crossing of same five testers with ICPA 2047 and ICPA 2092 produced hybrids exhibited less cooking time. This revealed effect of nuclear genes of male parents on cooking time. The hybrids ICPA 2043 x ICP 11376, ICPA 2043 x PHULE T-00-5-7-4-1 and ICPA 2043 x AKT 9913 showed more water absorption during cooking. When these male parents (ICP 11376, PHULE T-00-5-7-4-1 and AKT 9913 crossed with ICPA 2047 and ICPA 2092 showed more water absorption capacity. The *dal* prepared among three groups of CMS-based hybrids revealed that none of the common tester increased the *dal* recovery of the hybrids. For protein (%) six out of 102 hybrids registered more protein (%). The tester BSMR 198 and BDN 2001-6 when crossed with three male-sterile lines produced hybrids which showed high protein content.

Association among quality traits : Trait correlations are common phenomena in biology. Plant breeders need to consider trait correlations to either improve correlated traits simultaneously or to reduce undesirable side effects when improving only one of the correlated traits. Pleiotropy or close linkage are the two major reasons for genetic trait correlations. The study of correlation is important for simultaneous improvement of desired trait by breeding. The correlation coefficients calculated for the different quality traits are presented in Table 4. In present study, there was significantly negative correlation (-0.02) was observed between cooking time and *dal* recovery while the correlation between cooking time and protein was significantly positive (0.09). As more cooking time also show negative impact on seed protein thus this positive correlation in present study will increasing the nutrient value of diet. In contrast to present study, Raghuvanshi *et al.* (1994) observed the negative correlation of cooking time with protein content. Jambunathan and Singh (1981) found significantly negative correlation between cooking time and water absorption characteristics of *dal*. However, in present study, no correlation was exhibited between cooking time and water absorption of *dal*. The percent *dal* recovery was significantly negative correlated with protein content and water absorption where as, water absorption had negative correlation with protein content. Increment in yield in the form *dal* recovery and seed size generally reduces the protein content (Afzal *et al.*, 2003). Therefore breeding should be evolved to maintain the *dal* recovery and protein content of seed. In present study hybrid ICPA 2047 x PHULE T-00-5-7-4-1 took less time to cook, high protein (%) and greater *dal* recovery (%) than the check. While out of six correlation values four were exhibited significant negative correlation.

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