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Salt Tolerance In *Brassica* Species At Early Seedling Stage

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Abstract: Preliminary studies were conducted to evaluate salt tolerance in some amphidiploids species of *Brassica* at early seedling stage under controlled conditions (Gravel culture). In this regard ten locally adopted genotypes of *Brassica* (five genotypes of *Brassica napus* and five of *Brassica juncea)* were collected from NIA, Tandojam, NIFA Peshawar and ARI Tandojam. Three treatments were imposed (i.e. control, 6, and 9 dS/m NaCl). The results showed that among *Brassica juncea* species, Agati sarheen and Toria selection and in *Brassica napus* species, Wester & Dunckled showed better response to NaCl stress at early seedling stage.The genotype NIFA raya and Durr-e-NIFA of *Brassica juncea* and *Brassica napus* species were found more sensitive to NaCl stress, respectively. The physiological studies with respect to osmotic adjustment showed that almost all the genotypes had enhanced proline accumulation however in tolerant genotypes the relative increase (%) was higher. It was also observed that the tolerant genotypes had Higher K/Na ratio as compared to sensitive ones.

Keywords: salt tolerance *Brassica* seedling.

1. INTRODUCTION

Among the oil seed crops, *Brassica* holds third position. Its oilseed production has increased over the last 40 years and has become one of the most important world sources of vegetable oil after soybean and cotton seed. European Union is the major producer of Brassica oil seed, due to most favorable environmental conditions. In Pakistan, it is widely adopted through out the country and wide range of soil conditions. It has been cultivated under both irrigated and non-irrigated areas of Pakistan. In Sindh province it is mostly cultivated as Zaid kharif (September) crop on residual moisture of rice on both northern and southern rice tracks (Bhatti and Soomro, 1996). The presence of high soil salinity patches on these tracks considerably affects Brassica yield. Brassica is classified as tolerant to salinity (Mass and Hoffman, 1977). It has been assumed that amphidipliod species of Brassica have more salt tolerance as compared to diploid species. *Brassica juncea* and *Brassica napus* are amphidiploid species of Brassica. *Brassica juncea* (n=18) derived from interspecific crosses between *B. nigra* (n=9) and *B. rapa* (n=10) and *Brassica napus* (n =19) derived from interspecific crosses between *B. oleracea* (n = 9) and *B. rapa* (n = 10). The tolerance of plant to Sodium chloride is commonly, but not uniquely, related to the concentration of Sodium in the shoot (Flowers, 2004). According to Ashraf and Leary (1995), salt tolerance is related to exclusion of Na ion in leaves from the all ages. The efflux of Sodium at the plasma membrane of root epidermis and cortical cells, and resorption of Na from xylem sap and its accumulation by xylem parenchyma cells are the processes involved in Na exclusion (Gorham *et al.*, 1986).

Variability among the genotypes mainly occurs due to the pattern of solute accumulation in leaf. According to Munns (2002), sensitive cultivars accumulate ions more quickly than tolerant cultivars and this ion accumulation leads to leaf death and progressively death of the plant The present investigations were conducted to evaluate the salt tolerance in some newly develop amphidiploid species of *Brassica* at seedling stage, control conditions (gravel culture studies).

2. MATERIALS AND METHODS

The study was conducted during rabi season 2007-2008 (i.e. Nov. 2007–2008), at net house, NIA, Tandojam, The beds were filled with coarse gravel and a fine layer of silt spread over it to support seeds during germination. Ten locally adopted genotypes of *Brassica* (five genotypes of *Brassica napus* and five of *Brassica juncea)* were collected from NIA, Tandojam, NIFA Peshawar and ARI Tandojam. The experiment was laid out in randomized manner using randomized complete block design (RCBD), replicated twice. Three salinity treatments were imposed i.e. control (1.56), 6.0 and 9.0 dS/m. Each treatment was imposed in separate bed. The beds were irrigated with nutrient solution using commercial NaCl salts. The experiment was

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terminated three weeks after salinity treatment. Growth observations were recorded in terms of shoot & root length, Shoot & root fresh weight. Shoot and root dry weight was recorded after drying plant samples in hot air oven for 72 hours (or when no change in dry weight). To study the solutes (organic and inorganic) accumulation in plant, leaf samples were collected at the time of termination of experiment. Proline was determined according to Bates *et al.*, 1973. Sodium (Na) and Potassium (K) were determined by flame Photometer according to the standard methods as reported by Jackson (1962). All the data was subjected to analysis of variance (ANOVA) to discriminate the superiority of treatment means and least significant difference (LSD) test was applied to compare the means. For this purpose a Microsoft computer package "MSTATC" was used.

3. RESULTS

Shoot length (cm)

The data for the shoot length is presented in table-1. There was a significant decrease in shoot length with the increase in salinity level. The decrease at 6 dS/m (low salinity level) was comparatively less as compared to 9 dS/m (i.e. higher level). The average values for shoot length under non saline (control) treatment were ranged as (16.7 to 21.5 cm) and (16.41 to 19.57cm), at low salinity treatment (6.0 dS/m) (13.17 to 17.83 cm) and (11.67 to 14.93cm) and at highest salinity levels (9 dS/m) (7.20– 12.37cm) and (9.73–11.00 cm) in *Brassica juncea and Brassica napus* respectively.

Variability in shoot length was also observed among the individual genotypes in both species of Brassica. Among the *Brassica juncea,* the least affected genotypes was Agati sarheen (12.37cm), whereas, maximum reduction in shoot length at 9dS/m salinity was recorded in P-78(7.20cm) and NIFA-raya (8.80cm). The other genotypes which also showed less reduction were Toria selection (11.77cm) and Sultan Raya (10.33cm).

On the other hand in case of *Brassica napus* species almost all the genotypes performed well. The least affected genotype with respect to shoot length was Dunckled showing 11.00cm at 9.0 dS/m salinity. The other genotypes which were at par were Shiralee and Wester showing 10.17 and 10.10 cm at highest salinity treatment. (i.e. 9.0 dS/m). Minimum values for shoot length were recorded in genotype Durre-e-NIFA. (9.73cm).

Root length (cm)

Significant decrease in root length was observed in both the species, with increasing salinity level. Root length of all the genotypes of both *Brassica* species, under control environment was ranged as (5.64 - 7.13 cm) and (6.2 – 6.67cm), in *B. juncea* and *B. napus*, respectively. Like in case of shoot length, reduction in root length was high at 9 dS/m as compared to 6 dS/cm salinity level.

The data with respect to individual genotypes also showed variation among the genotypes. The genotype Toria selection of *Brassica juncea* genotypes had maximum root length at high salinity levels, followed by Sultan raya and Agati sarheen. However, the least reduction percentage at 9.0 dS/m was recorded as 9.62% in Agati sarheen and 13.31% in Sultan raya. Whereas, in case of *Brassica napus* species, the genotypes Dunckled had maximum root length (5.67cm) followed by Durr-e-NIFA (5.60cm), at 9 dS/m salinity levels. The data regarding the relative decrease over control showed 9.68% and 14.09% in Durr-e-NIFA and Dunckled.

The most affected genotypes among the two species were P-78 of *Brassica juncea* and Abaseen-95 of *Brassica napus*, showing 31.3 and 28.5 % reduction in root length at highest salinity treatment.

Shoot fresh weight (gm)

The effect of salinity treatments on shoot fresh weight was also significant among the species as well as among the genotypes. The overall reduction in shoot fresh weight (SFW) was more prominent at high salinity treatment as compared to low salinity regimes. The reduction in shoot fresh weight was almost above 50% in all the genotypes tested except in Wester, where relative reduction was bit less than 50%. The mean values for shoot fresh weight were ranged as 25.29, 17.92 and 6.76 g in *Brassica juncea* species and 25.29, 14.26 and 7.64g in *Brassica napus* species under control, 6.0 and 9.0 dS/m, respectively.

Among the individual genotypes of *Brassica juncea*, the genotypes Agati sarheen and Toria selection performed better shoot fresh wt. at 9dS/m salinity treatment (i.e. 9.66 and 9.54g), respectively. Whereas, the minimum shoot fresh weight values were recorded in genotype P-78 (i.e. 4.65g). Variability among the individual genotypes of *Brassica napus* was also evident. Maximum values for shoot fresh weight at high salinity treatment were observed in genotype Wester followed by Abaseen-95, showing SFW values 10.89 and 8.41g, respectively. While minimum values were recorded in genotypes Durr-e-NIFA (i.e. 5.27g).

Root fresh weight (gm)

Root fresh weight (RFW) was also reduced due to salinity in *Brassica* genotypes. The reduction in root fresh weight was more at 9.0 dS/m salinity plots as compared to 6.0 dS/m salinity plots. The situation in case of RFW was bit better as compared SFW. The mean values for root fresh weight was ranged as 0.58, 0.37 and 0.21 g in *Brassica juncea* genotypes and 0.45, 0.34 and 0.23 g in *Brassica napus* genotypes under control, 6.0 and 9.0 dS/m, respectively.

Among the individual genotypes of *Brassica juncea* species, the genotype Sultan raya performed better, showing maximum RFW values (i.e.0.245g) at 9 dS/m salinity treatment, whereas, the minimum RFW values were recorded in genotype NIFA raya (i.e. 0.167g). Reduction in RFW, among the individual genotypes of *Brassica napus* was also observed, however the relative reduction was comparatively low as compared to the genotypes of *Brassica juncea* species. Except Dunckled all the genotypes showed less than 50% reduction in RFW. Maximum values for root fresh weight at high salinity treatment were observed in genotype Durr-e-NIFA (0.27g) followed by Abaseen-95(0.26 g). respectively. Minimum values for RFW were recorded in genotypes shiralee (i.e. 0.16 g).

Shoot dry weight (gm)

Presence of salts in the growing medium also found to reduce significantly shoot dry weight (SDW), in *Brassica* genotypes.The average SDW were recorded as 1.69, 1.38 and 0.47g for *Brassica juncea* genotypes and 1.57, 1.25 and 0.54g for *Brassica napus* genotypes at control, 6.0 and 9.0 dS/m salinity treatments. Maximum SDW at 9.0 dS/m, among the genotypes of *Brassica juncea*, was recorded in Toria selection (0.63g) and Agati sarheen(0.62g), whereas, as minimum value of SDW was recorded in NIFA-raya (i.e. 0.30 g).

Shoot dry weight in *Brassica napus* genotypes is also showing similar trend as in SFW, except Wester almost all the genotypes had more than 50% reduction at high salinity treatment (i.e. 9.0 dS/m). The SDW recorded at 9.0 dS/m salinity in Wester was 0.88g, followed by Abaseen-95 (0.60 g). The least value for SDW was recorded in Durr-e-NIFA (i.e. 0.23 g).

Root dry weight (gm)

Root dry weight (RDW), also reduce significantly, in Brassica genotypes due to the presence of salinity of the medium. Reduction in RDW was more or less similar in both species of *Brassica,* however the differences were non significant in *Brassica napus* genotypes and significant in *Brassica juncea,* when compared statistically. The average RDW were recorded as 0.095, 0.064 and 0.026g for *Brassica juncea* genotypes and 0.08, 0.06 and 0.03 g for *Brassica napus* genotypes at control, 6.0 and 9.0 dS/m salinity treatments. Among the genotypes of *Brassica juncea,* maximum SDW at 9.0 dS/m, was recorded in Agati sarheen (0.035g) Toria selection (0.032g), whereas, as minimum values of RDW were recorded in NIFA-raya (i.e. 0.019g). Maximum shoot dry weight in *Brassica napus* genotypes was recorded at 9.0 dS/m salinity in Wester (0.039g), followed by Abaseen-95 (0.032g). On the other hand, minimum values for RDW were recorded in Durr-e-NIFA (i.e. 0.026g).

Solute accumulation

Solute accumulation plays a vital role in osmotic adjustment of plant. To study the accumulation of solutes in *Brassica* genotypes, both organic (Proline) and inorganic (Na and K), were determined in plant leave samples. The detailed results are as under:

Proline

There was an increase in proline accumulation in plant with the increasing salinity treatments, showing two to three folds as compared to control. The increase was significantly higher under both salinity levels (i.e. 6 and 9 dS/m). Average values of proline accumulation among genotyes of two *Brassica* species were more are less similar, ranging as (9.91, 29.64 and 29.47ug/g F wt) in *Brassica juncea* and (11.15, 29.42 and 29.18 ug/g F wt) in *Brassica napus* at control, 6.0 and 9.0 dS/m salinity, respectively. Proline accumulation within the individual genotypes of *Brassica juncea* genotypes species were at par (i.e. 29.60 – 30.59 ug/g F.wt), when compared statistically, except in case of Toria selection, where, minimum proline accumulation was observed (29.60 ug/g F.wt). Similarly in case of *Brassica napus* genotypes the values for proline accumulation were also at par within Durr-e-NIFA, Shiralee and Wester genotypes (30.3 to 32.53 ug/g F.wt). Minimum proline accumulation was observed in Dunckled (24.08 ug/ g F.wt.) at 9.0 dS/m salinity treatment.

Sodium

Presence of salinity in the growing medium of the plant also resulted in gradual increase of Sodium uptake in plant. Comparatively higher accumulation of Sodium was observed in *Brassica juncea* genotypes than *Brassica napus* genotypes. The average values of Sodium, among two species of *Brassica* were ranged as (0.96, 1.02 and 1.40 %) in *Brassica juncea* and (0.87, 1.02 and 1.04 %) in *Brassica napus* at control, 6.0 and 9.0 dS/m salinity. Among *Brassica juncea* genotypes minimum Sodium accumulation was observed in P-78 (1.21 %), followed by Toria selection (1.22 %) and Agati sarheen (1.33 %), While, among *Brassica napus* genotypes minimum Sodium contents were recorded in Wester (1.04%), followed by Abaseen-95 (1.09 %) and Durr-e-NIFA (1.14 %). On the other hand maximum Sodium contents at 9.0 dS/m salinity level were recorded as 1.54% and 1.32% in Toria selection (*Brassica juncea*) and Shiralee (*Brassica napus),* respectively.

Potassium

Maintenance of smooth Potassium uptake is necessary to tolerate under saline environment. The Potassium contents in the present investigations showed an overall decrease in Potassium uptake with increasing salinity level. There was comparatively less decrease of Potassium in *Brassica napus* genotypes than *Brassica juncea* genotypes. The average Potassium contents were ranged as (1.05, 0.65 and 0.54 %) in *Brassica juncea* and (0.86, 0.56 and 0.53 %) in *Brassica napus* at control, 6.0 and 9.0 dS/m salinity. At high salinity patches, Potassium contents in Agati sarheen and Wester were found maximum i.e. 0.65 and 0.69%, respectively. The other genotypes which also maintained smooth flow of Potassium were Toria selection, Abaseen -95 and Durr-e-NIFA. Maximum decrease in Potassium among *Brassica* genotypes were observed in P-78 (0.49%) and Dunckled (0.46%).

K/Na ratio

Sufficient Potassium uptake and restriction of high Sodium accumulation is necessary to tolerate under salinity stress. Therefore K/Na ratio was also estimated in *Brassica* genotypes under salinity stress. K/Na ratio decreased under salinity in all the Brassica genotypes.It was also observed the better performing genotypes especially Agati sarheen of *Brassica juncea* and wester of *Brassica napus,* had higher values of K/Na ration, i.e. 0.49 and 0.67, respectively. On the other hand minimum K/Na ratio values were observed in poor performing genotypes NIFA-raya and Dunckled, with K/Na values 0.31 and 0.38, respectively

4. <u>DISCUSSION</u>

Germination and early seedling growth are the main criterion for the evaluation of salt tolerance in crop plants. There was an overall decrease in different growth parameters with the increasing salinity levels of the medium. In the present study *Brassica* genotypes responded varyingly to Sodium chloride stress. Among the *Brassica juncea* genotypes, the performance of Agati sarheen and Toria selection were better, whereas in case of *Brassica napus* the genotype Wester was best. It has been assumed that the adaptability of plant under saline conditions is mainly depends upon better adjustment of osmotic potential. Presence of higher concentration of salt in the growing medium lowers the osmotic potential, resulting in less availability of water and essential nutrients. According to Ashraf (2004), among many physiological indicators, osmotic adjustment and ion transport have recently gained ground because there are numerous reports in literature which show that plant with high capacity of osmotic adjustment by excluding ions from the cell or tissue and accumulating low molecular weight organic osmotica, show enhanced tolerance to salt stress. This was found true in the present studies; almost all the good performing genotypes showed an enhanced accumulation of proline in leaves samples, whereas, the poor performing genotype Dunckled of *Brassica napus* species comparatively showed low accumulation of proline. However, the results did not agree with the above statement in case of *Brassica juncea* species where, the genotypes NIFA-raya and P-78 in spite of its poor performance, showed enhanced accumulation of proline in leaves samples under NaCl stress.

Under saline environments, the main target for plant is restricted entry of Sodium in the plant or blockage of it in to the root. The genotypes, Agati sarheen and Wester are also showing low uptake of Sodium ions in leaves. According to Gorham *et al*., (1997), Sodium gains entry into root cell cytosole through cation channels or transporters (selective and nonselective) or into the root xylem stream via an apoplastic pathway depending upon the plant species. The genotypes NIFA-raya and Dunckled could not restrict the entry of Sodium in the upper plants part. Regulation of K uptake and/ or prevention of Na entry, efflux of Na from the cell and utilization of Na for osmotic adjustment are the strategies commonly used by plants to maintain desirable K/ Na ratios in the cytosole. In the present study the tolerant genotypes are also expressing the same trend. The K/Na ratio in the tolerant genotypes (i.e. Agati sarheen and Wester), was comparatively higher than the sensitive ones.

Although some other genotypes (i.e. Dunckled and P-78 also had high K content but due to higher accumulation of Na could not maintain desirable K/Na ratio inside the cell. According to (Zhu, 2002), Na competes with K uptakes through Na-K co-transporters, and may also block the K specific transporters of root cell under salinity. Hence it is concluded that the adaptability of tolerant *Brassica* genotypes might be due to low accumulation of Na, resulting in high K/Na ratio for turgor maintenance. The results are in agreement with the findings of Ashraf and McNeilly (2004), who reported that the maintenance of high tissue K+/Na+ and Ca^2+/Na+ ratios has been suggested as an important selection criterion for salt-tolerance in *Brassica* species.

Table 1. Effect of salinity (NaCl) on shoot and root length (cm) of different genotypes of *Brassica juncea* and *Brassica napus* species

Genotypes	Shoot length (cm)			Root length (cm)		
	Control	6 dS/m NaCl	9 dS/m NaCl	Control	6 dS/m NaCl	9 dS/m NaCl
Brassica juncea						
NIFA - raya	18.50 bc	13.67 f	8.800 j	6.567 abc	5.633 cdefg	4.70 gh
Sultan raya	18.63 bc	14.33 ef	10.33 i	6.267 bcd	4.933 gh	5.43 defg
Toria selection	21.47 a	17.83 cd	11.77 h	7.233 a	6.033 cdef	5.57 defg
Agati sarheen	16.67 d	15.17 e	12.37 gh	5.643 cdefg	5.133 efg	5.100 fg
P-78	19.47 b	13.17 fg	7.200 k	7.133 ab	6.067 cde	4.900 gh
Mean	18.95 A	14.83 B	10.09 C	6.569 A	5.560 B	5.140 BC
LSD (0.05)	1.274			0.9466		
Brassica napus						
Durr - e - NIFA	15.95 cd	11.67 ef	9.73 ghij	6.20 abcd	5.70 cdef	5.60 cdefg
Abaseen - 95	18.77 ab	14.93 d	9.87 fghi	6.67 a	5.80 bcde	4.77 ghi
Shiralee	16.41 cd	12.27 e	10.17 fghi	6.37 abc	4.13 i	5.10 efgh
Wester	19.57 a	14.63 d	10.10 fghi	6.57 ab	5.70 cdef	4.95 fghi
Dunkled	17.24 bc	12.17 e	11.00 efg	6.60 ab	5.50 defg	5.67 cdef
Mean	17.59 A	13.13 B	10.17 C	6.479 A	5.367 B	5.217 B
LSD (0.05)	1.846			0.8396		

**means followed by same letters do not differ significantly at p=0.05 according to duncon multiple multiple range test (DMRT)*

Table 2. Effect of salinity (NaCl) on shoot,root fresh weight (gm) of different genotypes of *Brassica juncea* and *Brassica napus* species

Genotypes	shoot fresh weight (gm)			Root fresh weight (gm)		
	Control	6 dS/m NaCl	9 dS/m NaCl	Control	6 dS/m NaCl	9 dS/m NaCl
	Brassica juncea					
NIFA - raya	26.03 c	11.87 f	4.85 hi	0.567 b	0.233 de	0.17 def
Sultan raya	16.50 e	15.93 e	5.12 h	0.367 c	0.367 c	0.25 d
Toria selection	34.30 a	28.30 b	9.54 g	0.533 b	0.533 b	0.20 def
Agati sarheen	22.13 d	17.40 e	9.67 g	0.767 a	0.400 c	0.21 def
P-78	28.43 b	16.10 e	4.65 hi	0.700 a	0.350 c	0.20 def
Mean	25.48 A	17.92 B	6.76 C	0.587 a	0.377 B	0.21 C
LSD (0.05)	1.467			0.105		
	Brassica napus					
Durr - e - NIFA	24.83 bc	10.57 fg	5.274 gh	0.497 a	0.300 de	0.27 def
Abaseen - 95	36.23 a	21.37 cd	8.407 fgh	0.500 a	0.437 abc	0.26 def
Shiralee	14.50 ef	10.85 fg	6.737 gh	0.317 cde	0.287 de	0.16 fg
Wester	21.40 cd	18.60 de	10.89 fg	0.467 ab	0.333 cde	0.23 efg
Dunkled	29.50 b	9.93 fgh	6.90 gh	0.500 a	0.367 bcd	0.22 efg
Mean	25.29 A	14.26 B	7.641 C	0.456 A	0.345 B	0.23 C
LSD (0.05)	6.233			0.128		

**means followed by same letters do not differ significantly at p=0.05 according to duncon multiple multiple range test (DMRT)*

Table 3. Effect of salinity (NaCl) on shoot, root dry weight (gm) of different genotypes of *Brassica juncea* and *Brassica napus* species.

Genotypes	Shoot dry weight (gm)			Root dry weight (gm)		
	Control	6 dS/m NaCl	9 dS/m NaCl	Control	6 dS/m NaCl	9 S/mNaCl
Brassica juncea						
NIFA - raya	1.47 cd	0.95 e	0.30 g	0.09 abc	0.04 bcde	0.019 de
Sultan raya	1.57 bcd	1.38 d	0.41 fg	0.12 a	0.06 bcde	0.022 de
Toria selection	1.75 ab	1.75 ab	0.63 f	0.09 ab	0.09 ab	0.032 cde
Agati sarheen	1.81 ab	1.71 abc	0.62 f	0.09 abc	0.07 bcd	0.035 de
P-78	1.87 a	1.11 e	0.41 fg	0.09 ab	0.06 bcde	0.024 de
Mean	1.69 A	1.38 B	0.47 C	0.10 A	0.06 AB	0.027 BC
LSD (0.05)	0.2561			0.0523		
Brassica napus						
Durr - e - NIFA	1.46 abc	0.98 cde	0.23 g	0.061	0.05	0.026
Abaseen - 95	1.85 a	1.74 a	0.60 defg	0.092	0.08	0.032
Shiralee	0.83 def	0.78 defg	0.50 efg	0.052	0.05	0.028
Wester	1.72 a	1.64 ab	0.88 def	0.084	0.08	0.039
Dunkled	1.98 a	1.10 bcd	0.51 efg	0.098	0.04	0.030
Mean	1.57 A	1.25 A	0.54 B	0.08	0.06	0.03
LSD (0.05)	0.5507			NS		

**means followed by same letters do not differ significantly at p=0.05 according to duncon multiple multiple range test (DMRT)*

Table-4. Effect of salinity (NaCl) on solute accumulation of different genotypes of *Brassica juncea* and *Brassica napus*.

Genotypes	Proline (ug/g. F.wt)			Sodium (%)			Potassium			K/Na ratio		
	Cont.	6.0 dS/m	9.0 dS/m	Cont	6.0 dS/m	9.0 dS/m	Cont.	6.0 dS/m	9.0 dS/m	Cont.	6.0 dS/m	9.0 dS/m
Brassica juncea												
NIFA-raya	9.02 d	29.81 abc	30.44 abc	0.89 gh	1.02 efgh	1.70 a	1.03 ab	0.61 cd	0.52 d	1.16 ab	0.60 efg	0.31 hi
Sultan raya	11.55 d	31.17 ab	30.59 abc	0.82 gh	0.95 fgh	1.22 cdef	1.11 a	0.64 cd	0.53 d	1.38 a	0.69 def	0.40 ghi
Toria selection	8.29 d	28.14 bc	26.74 c	1.23 def	1.43 abc	1.54 ab	0.81 bc	0.65 cd	0.51 d	0.67 def	0.45 fgh	0.35 hi
Agati sarheen	9.595 d	29.95 abc	29.95 abc	0.90 gh	0.75 h	1.327 bcd	1.06 a	0.66 cd	0.65 cd	1.19 ab	0.89 cd	0.49 efgh
P-78	11.12 d	29.14 bc	29.60 abc	0.96 fgh	0.95 fgh	1.215 cdef	1.01 ab	0.71 cd	0.49 de	1.04 bc	0.74 de	0.42 gh
Mean	9.915 B	29.64 A	29.47 A	0.96 B	1.019 B	1.400 A	1.01 A	0.65 B	0.54 B	1.09 A	0.68 B	0.39 C
LSD (0.05)		3.853			0.310			0.2254			0.25	
Brassica napus												
Durr -e -NIFA	11.45 e	32.14 ab	32.53 ab	0.95 klm	1.15 cdefgh	1.14 cdefghi	0.67 bcde	0.55 cdefg	0.49 defghi	0.70 cd	0.49 fg	0.43 fgh
Abaseen-95	11.17 e	29.27 abc	29.15 abc	0.95 klm	1.01 ijkl	1.09 defghijk	1.26 a	0.57 cdef	0.55 cdefgh	1.05 a	0.56 def	0.50 efg
Shiralee	12.80 e	28.29 bcd	30.03 ab	0.99 jklm	1.04 fghijkl	1.32 ab	0.74 bc	0.52 cdefghi	0.47 defghi	0.75 bc	0.50 efg	0.36 ghi
Wester	8.75 e	25.11 cd	30.13 ab	0.87 m	1.02 hijkl	1.04 ghijkl	0.80 b	0.54 cdefgh	0.69 bcd	0.92 ab	0.53 defg	0.67 cde
Dunkled	11.15 e	32.31 ab	24.08 d	1.06 efghijkl	1.18 cdef	1.22 bcd	0.84 b	0.63 bcde	0.46 efghi	0.80 bc	0.53 defg	0.38 ghi
Mean	11.07 C	29.42 B	29.18 B	0.97 C	1.08 B	1.16 AB	0.86 A	0.56 B	0.53 B	0.84 A	0.52 B	0.47 B
LSD (0.05	4.604			0.1368			0.2194			0.1715		

**means followed by same letters do not differ significantly at p=0.05 according to duncon multiple multiple range test (DMRT)*

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