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Performance Based Evaluation and Selection of Different Promising Lines of Rapeseed (*Brassica Napus* L.) for the Shattering Tolerance

Muhammad Azeem Tariq[1], Muhammad Tariq[1], Tamoor Hussain[1*], Mazhar Iqbal[1], Ghulam Rabbani[1], Nasrullah Khan aadal[1], Javed Iqbal[1], Attiq-ur- Rehman[1], and Khalil-ur-Rehman[1]
[1]*Barani Agricultural Research Institute, Chakwal, Pakistan*
* *E-mail of the corresponding author: aridianthegreat@gmail.com*

Abstract

To evaluate the ten promising lines of *Brassica napus* against the shattering tolerance, the experiments were carried out in split plot design in the research area of Barani Agricultural Research Institute; Chakwal, Pakistan during two rabi growing season 2011-12 & 2012-13 under rainfed conditions. The main plot was harvested in five different harvesting dates including: $HarD_1$ = Harvesting at physiological maturity of crop, $HarD_2$= 7 days after the first harvesting of each promising line, $HarD_3$= 15 days after the first harvesting of each promising line, $HarD_4$= 21 days after the first harvesting of each promising line, $HarD_5$= 30 days after the first harvesting of each promising line. The difference of grain yield (kg/ha) of each promising line in different harvesting dates with compare to its grain yield (kg/ha) in first harvesting date ($HarD_1$-$HarD_i$) were measured as indices of shattering. The combine analysis of variance of two year revealed that all the promising lines were significant different for harvesting date, harvesting date x promising lines interaction effect and also year and its interaction effects to each study factors. In the present experiment, the promising line 12CBN008 & 10CBN004 had grain yield 1089 kg/ha & 897 kg/ha respectively. The significant difference of genotypes x harvesting dates confirmed different level of shattering of all promising lines in different harvesting dates. The magnitude of grain yield shattering loss was increased in 4th and 5th harvesting dates. On the basis of shattering tolerance among all the promising lines the 11CBN010 was more tolerant to shattering and 11CBN005 were relatively more susceptible to shattering.
Keywords: Rapeseed, Harvesting date, Shattering tolerance

Introduction

Rapeseed is an important oilseed crop in the Pakistan and in most of the worlds. For enhancement of grain yield potential of rapeseed, the important breeding strategies are the good knowledge and utilization of morphological, physiological and genetic basis of grain yield associated attributes in different climatic conditions. (Bruce *et al.*, 2002; Banga *et al.*, 2011). Resistance to shatter is an important attribute for rapeseed grain yield enhancement because the crop ripens and is harvested under warm environment and normally windy summer conditions (Rameeh, 2013). In rapeseed grain yield loss is usually divided into two periods, shattering before and during harvesting (Liu *et al.*, 1994; chandler *et al.*, 2005). Weather conditions prior to and during harvesting are the main factors in the field that influence the level of shattering (Tan *et al.*, 2006). Typically grain yield losses are varied from 10 to 25 percent (Price *et al.*, 1996). Seed losses of as much as 50% of estimated grain yield have been observed when unfavorable weather conditions delayed harvesting (Macleod, 1981; Child and Evans, 1989). Links between pods and other canopy components during windy summer conditions have also been implicit to contribute to shattering in the field. Furthermore, insect-pest and disease damage can result in accelerated ripening and pod shattering (Rameeh, 2013). Prakash *et al*., (1998) and Peng-Fei *et al.*, (2011) in their studies reported that in Brassica species marked losses of grain yield is due to shatter during maturity and harvesting. Moreover the shed seeds may remain viable during a number of years and germinate to produce plants, which represent weeds in the following crops. Shattering involves detachment of the pod valves, which include the seed, from the replum. It could take place in ripe standing crops under windy conditions due to contact from other plants and in windrows from the impact of harvest machinery. (Meakin and Roberts, 1990). Overseas research suggests that genetic variation for pod shattering resistance exists among *Brassica napus* lines (Wen *et al.*, 2008). Recently, (Peng-Fei *et al.*, 2011) studied 68 lines of *Brassic napus* for pods shattering resistance using a ‘ripping’ method and demonstrated that ripping force varies from 0.59N to 2.75N in different *Brassica napus* genotypes. He also further revealed that the inheritance of shatter resistance was determined by two genes, with heritability of 50%. This study revealed that significant genetic gain can be made through conventional breeding methods in rapeseed. However, further development is required to avoid the need to windrow. Morgan *et al*., (1998) observed that resistance in *Brassica napus* was recessive and mostly governed

by additive genes. In their study, correlation of pods shattering resistance with important agronomic attributes was low, signifying that it would be viable to introgress the shatter resistance characters into breeding lines. Furthermore, they also demonstrated the absence of genetic linkage of pod strength with other pod characters such as erect/ horizontal or short/long pod. This suggested that by combining these characters, it should also be achievable to improve pods shattering resistance. Wang *et al*., (2007) observed that lines derived from complex crosses made for development of yellow seeded canola showed better shatter resistance than standard *Brassica napus* varieties.
Selection of Brassica napus promising lines against shattering tolerance is intricate because pods shattering attribute is also control by factors other than the genetic factors such as temperature, drought, time of sowing, timing of pod senescence, pod maturity, method and timing of harvesting. The aim of the present study were to evaluate the degree of genetic variability for shattering tolerance in *Brassica napus* promising lines and also relationship of pods shattering in different harvesting dates.

Materials and Methods

To study the genotypes of Brassica napus against the shattering tolerance, experiments were carried out in the research area of Barani Agricultural Research Institute; Chakwal located in Pakistan under rainfed conditions. The research material comprised of 10 lines of rapeseed including one approved variety viz 10CBN001, 10CBN002, 11CBN005, 11CBN005, 11CBN006, 11CBN010, 11CBN013, 12CBN004, 12CBN008 and "Shiralee" were grown in a split plot design with four replications. The main plot was harvested in five different harvesting dates including $HarD_1$ = Harvesting at physiological maturity of crop, $HarD_2$= 7 days after the first harvesting of each promising line, $HarD_3$= 15 days after the first harvesting of each promising lines, $HarD_4$= 21 days after the first harvesting of each promising lines, $HarD_5$= 30 days after the first harvesting of each promising lines. All the treatments ($HarD_{1,}$ $HarD_{2,}$ $HarD_{3,}$ $HarD_4$ and $HarD_5$) were harvested and threshed by hand. Each sub plot comprised of similar promising lines along with local approved variety "Shiralee" and consisted of 5 rows of 1.8 m long with plant to plant and row to row distance was kept at 10cm and 45 cm respectively. All the cultural practices are adopted alike for all the plots as per requirement of the crop. The difference of grain yield (Kg/ha) of each promising line in various harvesting dates with compare to its grain yield (Kg/ha) in 1st harvesting date ($HarD_1$-$HarD_i$) were considered as indices of shattering tolerance and calculate by using the formula give as Rameeh, (2013).
Shattering tolerance index= ($HarD_1$-$HarD_i$)

Shattering tolerance in percentage with compare to 1st harvesting date can be calculated as;

Shattering Resistance (%) = [($HarD_1$-$HarD_i$)/$HarD_1$] x100

Where "$HarD_1$" is the grain yield (kg/ha) of each promising line in the 1st harvesting date and "$HarD_i$" is the grain yield (kg/ha) of each promising line in following harvesting dates. The combine analysis of variance on the basis of split plot design was calculated by using the Statistix software version 8.1.

Results and Discussions

From the inference of present study, combine analysis of variance on the basis of split plot design for grain yield represented that each promising line was different significantly from each others. Also different harvesting dates had significant effects on grain yield (Kg/ha). On the other hand, the different harvesting dates x promising lines interaction had significant effects on grain yield which indicated that variation in grain yield of promising lines were varied in different harvesting dates (Table-1). The Table-2 showed average grain yield (Kg/ha) for two year results of each promising line in different harvesting dates. The promising line 12CBN008 showed highest average yield (kg/ha) in all the harvesting dates and lowest average yield (kg/ha) was found in 10CBN004. However, this average value decreases in all the promising lines in subsequent harvesting dates. The index of shattering tolerance was shown in Table -3. The difference of grain yield of all the advanced line in 1st and 2nd harvesting date varies from 46 kg/ha in 12CBN008 to 70 kg/ha in 10CBN001 & 11CBN005. This result indicates that the 11CBN005 is more susceptible to shattering as compare to 12CBN008. Others genotypes likes 10CBN002, 10CBN004, 11CBN006, 11CBN010, 11CBN013, 12CBN004 and Shiralee are also susceptible to shattering. Weng *at al*., (2008) and Rameeh, (2013) also studied that genetic variation are present for pods shattering resistance in Brassica napus lines. When evaluate the difference of grain yield of 1st and 3rd harvesting dates, promising lines showed ranged from 95 kg/ha to 165 kg/ha in 11CBN010 and 10CBN001 respectively. Highest average yield kg/ha was determined for the 10CBN001 followed by 11CBN005. This analysis revealed that the promising lines 10CBN001 and 11CBN005 are more susceptible to shattering index. The difference of mean value of 1^{st} and 4^{th} harvesting dates ($HarD_1$-$HarD_4$) diverse from 145 kg/ha to 234 kg/ha in 11CBN010 and 11CBN005 respectively. This result investigated that 11CBN005 is more susceptible to shattering than all the others promising lines. The difference of average value of 1^{st} and 5^{th} harvesting dates ($HarD_1$-$HarD_5$) were more varies then all the others differences, so on the basis of this outcome, the ($HarD_1$-$HarD_5$) index is main source for the assortment of promising lines against the shattering tolerance. The difference of grain yield of ($HarD_1$-$HarD_5$) index were significant varies from 209 kg/ha to 305 kg/ha in 11CBN010 & 11CBN005 respectively. On the basis of present conclusion from (HD_1-HD_5) index, the 11CBN005 is more susceptible to shattering then all the other promising lines. In addition, the percentage of grain yield shattering with compare to 1^{st} harvesting date revealed that grain shattering in 2^{nd} harvesting date ranged from 4.18 to 7.37 percent in 12CBN008 & 11CBN005 promising lines respectively. on the other hand, grain shattering in 3^{rd}, 4^{th} and 5^{th} harvesting dates, the genotype 11CBN010 showed lowest percentage of grain shattering while genotype 11CBN005 showed highest percentage of grain shattering in these three harvesting dates (Table-4). The present consequences are in corroborated with the findings of *Price et al*., (1996) who studied grain yield losses ranged from 10 to 25 percent in Brassica napus lines. Macleod, (1981) and Child and Evans, (1989) also verified that grain yield losses are up to 50 percent when adverse weather situation delayed harvesting.

In present study, the genetic variation for pods shattering tolerance was found among all promising lines of rapeseed. However, different methods were used for study the inheritance of shattering resistance but delaying in harvesting date in compare to physiological maturity is also practicable method for the estimation of shattering tolerance of rapeseed promising lines under normal climatic conditions in rainfed areas. As the inference from the present study, the difference of grain yield of 1^{st} and 5^{th} harvesting dates ($HarD_1$-$HarD_5$) were more varied therefore, it is useful tool for the screening of rapeseed promising lines against the shattering tolerance. Among all the advanced lines the 11CBN010, 11CBN006, 12CBN008 and Shiralee were more tolerant to shattering then all the others advanced lines. 11CBN005, 10CBN001, 10CBN002, 10CBN004 and 8CBN001 were relatively more susceptible to shattering. So the line with more tolerant to shattering characteristics can be used by plant breeders in their breeding program for development of shattering tolerance Brassica napus varieties.

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Table-1: Results of combine analysis of variance of two years 2011-12 & 2012-13

Source of Variation	Degree of Freedom	M S	F. test	P. Value
Y	1	1936653**	1114.52	0.0000
HarD	4	547848**	150.50	0.0000
Y x HarD	4	15629**	5.04	0.0006
Error 1	18	1351	-	-
PL	9	10999**	32.92	0.0000
Y x PL	9	15060**	34.49	0.0000
HarD x PL	36	4771*	1.89	0.0067
Y x HarD x PL	36	5533**	2.56	0.0001
Error 2	120	1771	-	-

* and ** Significant at 5% and 1% level respectively
Y: Year, R: Replication, HarD: Harvesting date, PL: Promising line

Table-2: Average grain yield (kg/ha) of Brassica napus promising lines in different harvesting dates during two rabi seasons 2011-12 & 2012-13

Promising Lines	1st Harvesting Date ($HarD_1$)	2nd Harvesting Date ($HarD_2$)	3rd Harvesting Date ($HarD_3$)	4th Harvesting Date ($HarD_4$)	5th Harvesting Date ($HarD_5$)
10CBN001	1044	974	879	817	748
10CBN002	1044	984	920	842	753
10CBN004	897	832	765	706	638
11CBN005	944	874	784	710	639
11CBN006	962	908	855	803	748
11CBN010	985	938	890	840	777
11CBN013	1053	1001	943	879	798
12CBN004	1003	946	897	841	768
12CBN008	1089	1044	981	915	849
Shiralee	988	933	883	825	767

$HarD_1$ = Harvesting at physiological maturity of crop, $HarD_2$= 7 days after the first harvesting of each promising line, $HarD_3$= 15 days after the first harvesting of each promising lines, $HarD_4$= 21 days after the first harvesting of each promising lines, $HarD_5$= 30 days after the first harvesting of each promising lines

Table-3: Least Significant Difference (LSD) for mean grain yield (Kg/ha) shattering of Brassica napus promising lines during two rabi seasons 2011-12 & 2012-13

Promising Lines	(HarD$_1$-HarD$_2$)	(HarD$_1$-HarD$_3$)	(HarD$_1$-HarD$_4$)	(HarD$_1$-HarD$_5$)
10CBN001	70	165	227	297
10CBN002	60	124	202	291
10CBN004	65	132	191	259
11CBN005	70	160	234	305
11CBN006	54	107	159	214
11CBN010	48	95	145	209
11CBN013	52	110	175	256
12CBN004	57	106	162	235
12CBN008	46	109	174	241
Shiralee	55	105	163	221

* and ** Significant at 5% and 1% level respectively
HarD$_1$ = Harvesting at physiological maturity of crop, HarD$_2$= 7 days after the first harvesting of each promising line, HarD$_3$= 15 days after the first harvesting of each promising lines, HarD$_4$= 21 days after the first harvesting of each promising lines, HarD$_5$= 30 days after the first harvesting of each promising lines

Table-4: Percentage of average grain yield (Kg/ha) shattering of Brassica napus promising lines during two rabi season 2011-12 & 2012-13

Promising Lines	[(HarD$_1$-HarD$_2$)/HarD$_1$]x100	[(HarD$_1$-HarD$_3$)/HarD$_1$]x100	[(HarD$_1$-HarD$_4$)/HarD$_1$]x100	[(HarD$_1$-HarD$_5$)/HarD$_1$]x100
10CBN001	6.70	15.80	21.74	28.40
10CBN002	5.75	11.84	19.31	27.84
10CBN004	7.19	14.72	21.25	28.83
11CBN005	7.37	16.91	24.80	32.33
11CBN006	5.61	11.12	16.53	22.25
11CBN010	4.82	9.64	14.72	21.17
11CBN013	4.94	10.45	16.57	24.26
12CBN004	5.68	10.57	16.15	23.43
12CBN008	4.18	9.96	15.98	22.08
Shiralee	5.52	10.58	16.46	22.33

HarD$_1$ = Harvesting at physiological maturity of crop, HarD$_2$= 7 days after the first harvesting of each promising line, HarD$_3$= 15 days after the first harvesting of each promising lines, HarD$_4$= 21 days after the first harvesting of each promising lines, HarD$_5$= 30 days after the first harvesting of each promising lines