



Effect of Harvesting Stages on Seed and Oil Yield of Rapeseed-mustard to Suitable in a Cropping Pattern

A. H. M. Motiur Rahman Talukder^{1*}, Mrityunjoy Biswas²,
Mohammad Noor Hossain Miah³, M. A. Kashem⁴ and Lutfun Nahar⁵

¹Plant Physiology Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur-1701, Bangladesh.

²Department of Agro Product Processing and Technology, Jashore University of Science and Technology, Jashore-7408, Bangladesh.

³Agronomy and Haor Agriculture Division, Sylhet Agricultural University, Sylhet-3100, Bangladesh.

⁴Soil Science Division, Sylhet Agricultural University, Sylhet-3100, Bangladesh.

⁵Agricultural Botany Division, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh.

Authors' contributions

This work was carried out in collaboration among all authors. Authors AHMMRT and MB contributed in planning of experiment. But especially author AHMMRT contributed in designing, conducting, statistical analysis and report writing. Authors MNHM and MAK contributed in searching of literature and editing of the manuscript. Author LN contributed in monitoring the experiment. All authors read and approve the manuscript.

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ABSTRACT

Aim: To find out the optimum harvesting stage of high yielding rapeseed-mustard varieties to fit in rice based cropping pattern.

Study Design: The field study was arranged following RCB (factorial) design with three replications.

Place and Duration of the Study: Agronomy field of Regional Agricultural Research Station, Jamalpur (located between 24°34' and 25°26' North latitude and 89°40' and 90°12' East longitude), Bangladesh during 2015-2016 and 2016-2017.

*Corresponding author: E-mail: motiurbari@yahoo.com;

Methodology: Seeds of mustard varieties viz. BARI Sarisha-11, BARI Sarisha-14, BARI Sarisha-15, Binasarisha-4 & Tori-7 were sown in line maintaining 30cm spacing on 02 November, 2015 and 06 November, 2016. This varieties were harvested at four different harvesting stages viz. H₁= Green stage of siliquae, H₂= Pale yellow stage of siliquae, H₃= Golden yellow stage of siliquae and H₄= Full maturity stage of siliquae. Green stage of siliquae was determined just at seven to ten days after all flower droppings of crop while the pale and golden yellow stage of siliquae was determined when 40%-50% and 70%-80% bearing turned into light yellow and deep yellow in color respectively. Full maturity stage of siliqua was determined when lower bearing just burst out.

Results: BARI Sarisha-14, BARI Sarisha-15 (*B. campestris*) and Binasarisha 4 (*B. napus*) may be harvested at pale yellow stage of siliquae at 73, 82 and 78 DAS (average of two years) considering 11.0% seed and 3.15% oil yield; 10.0% seed and 1.56% oil yield; 6.60% seed and 3.90% oil yield loss respectively than full maturity stage of siliquae.

Conclusion: BARI Sarisha-14, BARI Sarisha-15 and Binasarisha 4 need to be sown within first week of November in districts named Mymensingh (located 24°15' and 25°15' N and 90°49' E longitudes), Jamalpur (located 24°34' and 25°26' N latitude and 89°40' and 90°12' E longitude) and Tangail (located 24°01' and 24°47' N latitudes and 89°44' and 90°18' E longitudes) and the crop should be harvested at pale yellow stage of siliquae (within 73-82 days period) sacrificing seed and oil yield loss to some extent to introduce HYVs of rapeseed-mustard in rice based cropping pattern.

Keywords: Harvesting stages; seed yield; oil content; rapeseed-mustard; cropping pattern.

1. INTRODUCTION

Identification of maturity stage is an important factor for all Agricultural crops to their management of maximum economic yield. Harvesting at the optimum maturity moment is an important issue not only for quality and quantity development for attaining maximum yield and the longest post-harvest life, but also for the designing of crop rotation for sustainable farming system. To increase the farm productivity, researchers are generally emphasize on incremental adaptation to existing cropping systems through the adjustment of optimum harvesting stages with longer growing periods of cultivars for successful cultivation of succeeding crop. On the other hand, cropland availability in Bangladesh has been declined by 0.73% since 1976 [1] to establishment of new roads and highways, buildings, industries, markets etc. Since, the cropland area is decreasing day by day, that is why there is no option of horizontal expansion. But intensification of land use system can be done through multiple cropping or by growing more and more crops on the same piece of land in a calendar year. In Bangladesh, the production of rice, the dominant cropping pattern Fallow-Boro (dry season rice)-T. Aman (wet season rice) plays an important role which cover about 27% of net cropped area [2]. Rapeseed-mustard is an oilseed crop usually grown in last week of October or 1st week of November. Oilseed crops can able to supply the nutrition especially fatty acids that build-up a healthy nations. On an average now the country is

producing about 0.36 million tons of edible oil year⁻¹ as against the requirement of 22 g capita⁻¹ day⁻¹ of the total requirement of 1.4 million tons for 153 million people [3] that indicates the large gap between supply and demand. Under this fact, if high yielding rapeseed-mustard crop is intended to grow in fallow period of Boro (dry season rice) and T. Aman (wet season rice) should be sown within mid-November and harvested in before last week of January for successful cultivation of the succeeding Boro crop (dry season rice). High yielding rapeseed-mustard varieties having 80-110 days growth duration available at present if sown in the mid November may not attain maturity last week of January with 80-85 days field duration.

So, inclusion of these long duration rapeseed-mustard varieties after T. Aman (wet season rice) will cause delay transplanting of Boro (dry season rice) beyond 1st week of February which in turn results poor yield. Hence, field duration of rapeseed-mustard crop needs to be reduced through agronomic manipulation to grow within the stipulated period in between T. Aman (wet season rice) and Boro rice (dry season rice). The possible agronomic management practice might be the harvesting of rapeseed-mustard crop at early stage before attainment of the full maturity of siliquae. On the other hand, researches on different crops were conducted on different harvesting stages effect on yield and quality of seed of the crops like pea, soybean, rice etc. [4,5,6]. With this perception researches on harvesting stages of rapeseed-mustard

depending on the siliquae maturity like green, pale yellow, golden yellow, full maturity stages etc. was performed to reduce field duration for successful transplanting of Boro (dry season rice) rice by optimum time, last week of January.

2. MATERIALS AND METHODS

2.1 Experimental Site, Design and Treatment

The experiment was conducted at Regional Agricultural Research Station, Jamalpur (located between 24°34' and 25°26' North latitude and 89°40' and 90°12' East longitude) on 02 November, 2015-2016 and 06 November, 2016-2017 respectively. The experiment was laid out in a split-plot design. The unit plot size was 5 m × 3 m. Mustard varieties viz. BARI Sarisha-11 (*Brassica juncea*), BARI Sarisha-14 (*Brassica campestris*), BARI Sarisha-15 (*Brassica campestris*), Binasarisha-4 (*Brassica napus*) & Tori-7 (*Brassica campestris*) were used as a test crop in this study. The test crops were harvested at four different harvesting stages viz. H₁= Green stage of siliquae, H₂= Pale yellow stage of siliquae, H₃= Golden yellow stage of siliquae and H₄= Full maturity stage of siliquae. Green stage of siliquae was determined just at seven to ten days after all flower droppings of crop while the pale yellow stage of siliquae was determined when 40%-50% bearing turned into light yellow in color. The golden yellow stage of siliquae was determined when 70%-80% bearing turned into deep yellow in color and full maturity stage of siliqua was determined when lower bearing just burst out. According to harvesting stages varieties were harvested as per following dates (Table 1).

2.2 Cultural Management

Before sowing the seeds were treated with Provax 200-EC @ 2.5 g (gram) for kg⁻¹ seeds. Seeds were sown continuously in furrows made by an iron made hand rake maintaining 30cm spacing between the lines @ seven kg seeds ha⁻¹. The crops were fertilized with soil Test Based (STB) dose as per [7] by using the following formula:

$$F_r = U_f - \frac{C_i}{C_s} \times (S_t - L_s)$$

where,

F_r = Fertilizer nutrient required for given soil test value

U_f = Upper limit of the recommended fertilizer nutrient for the respective STVI class

C_i = Units of class intervals used for fertilizer nutrient recommendation

C_s = Units of class intervals used for STVI class

S_t = Soil test value

L_s = Lower limit of the soil test value within STVI class

Fertilizers were applied for the variety BARI Sarisha-11 and Binasarisha 4 at the rate of 132-14-87-15-0.71-0.7 kg ha⁻¹ N-P-K-S-Zn-B, for BARI Sarisha-14, BARI Sarisha-15 and Tori-7 at the rate of 99-10.6-58-8.71-0.48-0.7 kg ha⁻¹ N-P-K-S-Zn-B through urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid respectively. Half urea and all other fertilizers were applied as basal during final land preparation. Irrigation was applied at the flowering stage of the crop while remaining urea fertilizer was top dressed at joe condition. The crop plants was sprayed with malathion 57 EC @ 2 ml in litre⁻¹ and fungicide Rovral @ 2 g in litre⁻¹ of water during flowering and siliqua setting stages to prevent insect and pest.

2.3 Data Collection

Data on field duration (Days to harvest), Seed and stover yield, oil yield in percentage were recorded. Field duration (Days to harvest) was determined by counting the day from sowing date when the field crops reached the definite harvesting stages. Crop plants were collected from individual plot according to different harvesting stage, and then threshed, cleaned and seeds were dried in the field laboratory under sunny days to record data on grain yield. Stover weight was taken also from individual plots after drying the plants in the sunny days. Seed and Stover weights were recorded from individual plot than converting into t ha⁻¹.

To estimate the oil contents (%), approximately 150-200 g well dried and cleaned seeds were taken irrespective of harvesting stages of tested varieties and grounded by a blender machine to make powder. The blending powder of rapeseed-mustard product was dried at 105°C temperature about one hour in a pre-heated oven. The oven dried product was kept in open air for cooling. Then nine m³ sized filter paper and a piece of ribbon was weighed by an electric balance. The open air cooled 2 g powder sample was taken in a filter paper and binding was done by ribbon to make small bag. Each filter paper with grinding powder of rapeseed-mustard seed was

submerged in petroleum ether about 24 hours. Then the submerged product in filter paper was placed in hexane solution in soxhlet apparatus for about 65 minutes to extract the full oil from mustard cake. After 65 minutes mustard cake was dried in an oven at 105°C temperature about one hour. Then the mustard cake was kept in open air to become cool. The cooled cake was weighed by an electric balance and finally oil was calculated by using following formula:

$$\text{Oil percentage} = \frac{(T + S) - (T + R)}{\text{Sample weight (g)}} \times 100$$

Where, T= Weight of ribbon and filter paper, S= Sample weight, T+R= dry weight of sample.

2.4 Statistical Procedures

Collected data of each plot and oil percentage were compiled and tabulated in proper form for statistical analysis. Statistical analysis was done for analyzing the significance differences among the yield and other agronomic characters of the crop was made following analysis of variance technique with the help of computer based program MSTAT-C developed by Russell [8]. Mean differences among the treatments were tested with Least Significant Difference (LSD) test at 5% level of significance wherever F values were significance.

3. RESULTS

3.1 Effects of Rapeseed-mustard Varieties Days to Harvest

Days require to attain definite harvesting stages were varied significantly among the different varieties. Days to harvest of BARI Sarisha-11 (V_1) were significantly higher (92.0 days, average of two years) than other varieties. Days to harvest of the variety BARI Sarisha-15 (V_3) was 82.0 days (average of two years) followed by Binasarisha 4 (V_4) which took 81.0 days (average of two years). Average days to harvest of the varieties BARI Sarisha-14 (V_2) and Tori-7 (V_5) were 77.0 and 74.0 days respectively (Table 2).

3.2 Seed and Stover Yield of Rapeseed-mustard Varieties

BARI Sarisha-11 (V_1) produced significantly the highest seed yield of 1.55 and 1.81 t ha⁻¹ during 2015-16 and 2016-17, respectively. The lowest

seed yield 0.96 and 1.07 t ha⁻¹ was recorded from the local variety Tori-7 (V_5) during 2015-16 and 2016-17, respectively. During both growing seasons Binasarisha 4 (V_4) produced the second highest seed yield 1.31 in 2015-16 and 1.43 t ha⁻¹ in 2016-17 which was at par with BARI Sarisha-14 (V_2) and BARI Sarisha-15 (V_3) (Table 2). The variety BARI Sarisha-11 (V_1) produced significantly the highest stover yields of 5.87 t ha⁻¹ in 2015-2016 and 6.04 t ha⁻¹ in 2016-2017 growing seasons. During both seasons Binasarisha 4 (V_4) produced the second highest stover yield (4.11 and 4.50 t ha⁻¹ in 2015-2016 and 2016-2017 respectively). The average stover yield of two growing seasons was 3.45 and 4.02 t ha⁻¹ of the variety BARI Sarisha-14 (V_2) and BARI Sarisha-15 (V_3) respectively. The lowest stover yield, 1.96 and 2.10 t ha⁻¹ in 2015-2016 and 2016-2017 seasons respectively was obtained from the local variety Tori-7 (Table 2).

3.3 Oil Content (%) of Rapeseed-mustard Seed

The result presented in (Table 2) revealed that oil content in rapeseed-mustard seed varied significantly among the different varieties during both growing seasons. The variety BARI Sarisha-15 (*B. campestris*) had significantly the highest oil content of 39.4% (average of two years) while the variety of same group BARI Sarisha-14 had the second highest oil content of 37.4% (average of two years). During both years the variety BARI Sarisha-11 (*B. juncea*) produced the lowest oil content of 31.3% (average of two years).

3.4 Effects of Harvesting Stages on Days to Harvest, Seed and Stover Yield

Days to harvesting differed significantly among the different harvesting stages (Table 3). The highest 91.0 days (average of two years) required when the crop was harvested at full maturity stage of siliquae and the lowest 69.0 days (average of two years) required when the crop was harvested at green stage of siliquae. Seed and Stover yield showed significant variation among the different harvesting stages (Table 3). The highest seed yield of 1.42 t ha⁻¹ and 1.63 t ha⁻¹ was obtained from the full maturity stage of siliquae (H_4) during first and second years respectively that was statistically at par with harvesting at golden yellow siliquae stage (H_3) and pale yellow siliquae stage (H_2) only in the first season but significantly lower in the second season. The crop harvested at green stage of siliquae (H_1) produced the lowest seed

yields of 0.92 t ha⁻¹ and 0.96 t ha⁻¹ during the first and second years respectively. The green siliquae harvesting stage (H₁) produced the highest stover yield during both growing seasons and it showed decreasing trends onwards later harvesting stages. The crop harvested at full maturity stage (H₄) gave the lowest stover yields of 3.49 t ha⁻¹ and 3.88 t ha⁻¹ respectively in 2015-2016 and 2016-2017 cropping seasons respectively.

3.5 Effects of Different Harvesting Stages on Oil Content (%) of Seeds

Average of two years results showed that the lowest oil percent 29.1 was found when the crop was harvested at green stage of siliquae. On the other hand, the highest oil percent 38.9 was found when the crop was harvested at full maturity stage of siliquae (Table 3).

3.6 Interaction Effects of Varieties and Harvesting Stages on Days to Harvesting, Seed and Stover Yield

Significantly, the average highest duration 104.0 days required when the variety BARI Sarisha-11 (*B. juncea*) was harvested at full maturity siliquae stage while the average lowest duration 62.0 days required when the variety Tori-7 (*B. campestris*) was harvested at green siliquae stage (Table 4).

During both growing seasons seed yield increased statistically as the crop advanced to maturity in all varieties except Binasarisha-4 (V₄). Seed yield decreased in BARI Sarisha-14 (V₂), BARI Sarisha-15 (V₃) and Tori-7 (V₅) when the crops were harvested at green siliquae stage (H₁). The stover yield was gradually decreased towards the later harvesting stages. The variety Tori-7 (V₅) produced the lowest stover yield at all harvesting stages compared to other varieties irrespective of harvesting stages.

3.7 Interaction Effects of Varieties and Harvesting Stages on Oil Content (%) of Seeds

Statistically significant variations were found for the interaction of varieties and harvesting stages on oil content of seeds during both years (Table 5). The two years results revealed that, BARI Sarisha-15 content the highest oil 41.8% (average of two years) with harvesting at golden yellow siliquae stage *i.e.* harvest at 87 days

(average of two years) after sowing, which was almost similar to the variety BARI Sarisha-14 (*B. campestris*) with harvesting at full maturity stage *i.e.* harvest at 86 days (average of two years) after sowing, BARI Sarisha-15 (*B. campestris*) with harvesting at full maturity siliquae stage *i.e.* harvest at 90 days (average of two years) after sowing, BARI Sarisha-15 (*B. campestris*) with harvesting at pale yellow siliquae stage *i.e.* harvest at 82 days (average of two years) after sowing, BARI Sarisha-14 (*B. campestris*) with harvesting at golden yellow siliquae stage *i.e.* harvest at 83 days (average of two years) after sowing. The lowest oil content was found 27.0% (average of two years) in the variety BARI Sarisha-11 (*B. juncea*) with harvesting at green stage of siliquae *i.e.* harvest at 77 days (average of two years) after sowing, it was almost similar with the rest varieties harvested at green stage of siliquae. Only the variety Binasarisha-4 (*B. napus*) showed the decreased oil content of 27.5% (average of two years) at full maturity stage compared to the others.

3.8 Yield Loss (%) at Green and Pale Yellow Siliquae Stages than Golden Yellow and Full Maturity Stages of Siliquae

The result presented in Table 5 revealed that seed yield of all varieties was drastically reduced when the crop was harvested at green stage of siliquae. Average field duration of two years research revealed that for full maturity 104.0, 86.0, 90.0, 89.0 and 84.0 days required for BARI sarisha-11, BARI sarisha-14, BARI sarisha-15, BINA sarisha 4 and Tori-7 respectively. The variety BARI sarisha-11 may be harvested at pale yellow stage with 7.23% yield loss (average of two years) than the full maturity stage of siliquae and the field duration can be reduced for early sowing of the next crops. BARI Sarisha-14 may be harvested at pale yellow stage of siliquae at 73.0 days (average of two years) after sowing considering 11.0% (average of two years) yield loss than full maturity stage and 7.96% (average of two years) yield loss than golden yellow stage of siliquae (H₃). The variety BARI Sarisha-15 can be harvested at pale yellow stage of siliquae at 82.0 days (average of two years) after sowing considering 11% (average of two years) yield loss than golden yellow stage of siliquae. The variety local Tori-7 may be harvested at golden yellow stage of siliquae at 80 days (average of two years) after sowing considering 5% (average of two years) more yield than the full siliquae maturity stage. It might be shattering of siliquae

due to over maturity. The field duration of BARI Sarisha-14 and BARI Sarisha-15 can be reduced by 9.0 and 6.0 (average of two years) days than golden yellow siliquae stage if crops were harvested at pale yellow siliquae stage. The variety Binasarisha-4 can be harvested at pale yellow siliquae stage at 78.0 days (average of

two years) considering 6.60% yield loss than full maturity siliquae stage. In case of BARI Sarisha-11 and Binasarisha-4 field durations can be reduced by 7-13 days and 8-11 days if the crop is harvested at pale yellow siliquae stage than golden yellow and full maturity siliquae stages.

Table 1. Days to harvest, seed and stover yield, oil content in seed (%) of rapeseed-mustard varieties irrespective of harvesting stages during *rabi* (winter) seasons 2015-16 and 2016-17

Varieties (V)	Days to harvest		Seed yield (t ha ⁻¹)		Stover yield (t ha ⁻¹)		Oil content in seed (%)	
	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂
V ₁	98.0 a	85.0 a	1.55 a	1.81a	5.87 a	6.04 a	30.82 e	31.7 e
V ₂	81.0 cd	72.0 c	1.25 b	1.41b	3.31 c	3.60 c	36.73 b	38.1 b
V ₃	86.0 b	78.0 b	1.28 b	1.45b	3.74 b	4.30 b	38.66 a	40.1 a
V ₄	83.0 c	78.0 b	1.31 b	1.43b	4.11 b	4.50 b	32.58 d	33.3 d
V ₅	79.0 d	69.0 d	0.96 c	1.07c	1.96 d	2.10 d	34.73 c	35.0 c
CV (%)	2.60	0.89	13.2	9.85	10.6	7.42	2.09	1.75
LSD _{0.05}	2.10	0.64	0.16	0.13	0.38	0.29	1.01	0.86

Note: Y₁= 2015-16; Y₂= 2016-17; V₁= BARI Sarisha-11; V₂= BARI Sarisha-14; V₃= BARI Sarisha-15; V₄= Binasarisha 4; V₅= Tori-7

Table 2. Harvesting dates of different rapeseed-mustard varieties on the basis of different harvesting stages

Variety	Harvesting stages	First cropping season (2015-16)		Second cropping season (2016-17)	
		Days after sowing	Dated	Days after sowing	Dated
BARI Sarisha-11	Green stage of siliquae	83	24.01.2016	71	15.01.2017
	Pale yellow stage of siliquae	96	06.02.2016	83	27.01.2017
	Golden yellow stage of siliquae	105	15.02.2016	88	01.02.2017
	Full maturity stage of siliquae	110	20.02.2016	97	10.02.2017
BARI Sarisha-14	Green stage of siliquae	66	07.01.2016	62	06.01.2017
	Pale yellow stage of siliquae	79	20.01.2016	67	11.01.2017
	Golden yellow stage of siliquae	88	29.01.2016	77	21.01.2017
	Full maturity stage of siliquae	92	02.02.2016	80	24.01.2017
BARI Sarisha-15	Green stage of siliquae	74	15.01.2016	66	10.01.2017
	Pale yellow stage of siliquae	84	25.01.2016	79	23.01.2017
	Golden yellow stage of siliquae	91	01.02.2016	83	27.01.2017
	Full maturity stage of siliquae	94	04.02.2016	85	29.01.2017
Binasarisha 4	Green stage of siliquae	74	15.01.2016	64	08.01.2017
	Pale yellow stage of siliquae	82	23.01.2016	74	18.01.2017
	Golden yellow stage of siliquae	86	27.01.2016	85	29.01.2017
	Full maturity stage of siliquae	90	31.01.2016	88	01.02.2017
Tori-7	Green stage of siliquae	64	05.01.2016	59	03.01.2017
	Pale yellow stage of siliquae	77	18.01.2016	67	11.01.2017
	Golden yellow stage of siliquae	86	27.01.2016	73	17.01.2017
	Full maturity stage of siliquae	89	30.01.2016	78	22.01.2017

Table 3. Days to harvest, seed and stover yield, oil content in seed (%) of rapeseed-mustard as influenced by harvesting stages irrespective of varieties during rabi (winter) seasons 2015-16 and 2016-17

Harvesting stages (H)	Days to harvest		Seed yield (t ha ⁻¹)		Stover yield (t ha ⁻¹)		Oil content in seed (%)	
	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂
H ₁	72.0 d	65.0 d	0.92 b	0.96 c	4.23 a	4.35 a	27.7 d	30.7 d
H ₂	84.0 c	74.0 c	1.34 a	1.49 b	3.84 b	4.20 ab	34.9 c	35.2 c
H ₃	91.0 b	81.0 b	1.42 a	1.66 a	3.63 bc	3.94 bc	37.6 b	37.3 b
H ₄	95.0 a	86.0 a	1.42 a	1.63 a	3.49 c	3.88 c	38.6 a	39.4 a
CV (%)	1.46	0.85	10.7	7.51	9.70	8.36	2.31	1.73
LSD _{0.05}	0.93	0.48	0.103	0.08	0.28	0.25	0.76	0.58

Note: Y₁ = 2015-2016; Y₂ = 2016-2017; H₁ = Green stage of siliquae; H₂ = Pale yellow stage of siliquae; H₃ = Golden yellow stage of siliquae; H₄ = Full maturity stage of siliquae

Table 4. Yield loss (%) at green stage and pale yellow stage than golden yellow stage and full maturity stage of siliquae of rapeseed-mustard varieties during rabi (winter) seasons 2015-2016 and 2016-2017

Varieties (V)	Yield decreased (-) / Increased (+) than full maturity stage							
	Harvesting stage							
	H ₁		H ₂		H ₃		H ₄	
	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂
V ₁	(-) 29.0	(-) 33.0	(-) 6.97	(-) 7.50	(-) 1.16	(+) 2.50	1.72	2.00
V ₂	(-) 52.9	(-) 51.0	(-) 11.7	(-) 10.20	(-) 7.18	(+) 1.00	1.53	1.67
V ₃	(-) 38.8	(-) 51.0	(-) 6.25	(-) 13.0	(+) 4.16	(-) 2.30	1.44	1.74
V ₄	(-) 38.0	(-) 18.3	(-) 2.81	(+) 5.60	(+) 2.11	(+) 6.30	1.42	1.60
V ₅	(-) 26.5	(-) 37.0	(+) 8.0	(-) 3.40	(+) 9.00	(+) 1.00	0.98	1.19

Note: Y₁ = 2015-2016; Y₂ = 2016-2017; V₁ = BARI Sarisha-11; V₂ = BARI Sarisha-14; V₃ = BARI Sarisha-15; V₄ = Binasarisha 4; V₅ = Tori-7; H₁ = Green stage of siliquae; H₂ = Pale yellow stage of siliquae; H₃ = Golden yellow stage of siliquae; H₄ = Full maturity stage of siliquae

4. DISCUSSION

4.1 Effect of Varieties

The crop phenology is largely dependent on genetic and environmental factors including temperature, relative humidity, sunshine hours, rainfall etc. was reported by Venkataraman and Krishnan [9]. For each variety, a definite day was required to attain certain harvesting stage. Number of days for attainment of different harvesting stages differed from variety to variety under this study. Many researchers including [10] and [11] have reported significant differences for days to maturity for a variety or species. The present study revealed that first year planted crop took comparatively longer period regarding days to maturity than second year planted crop. It might be due to heavy foggy weather and rainfall during the crop growing period. The present study also revealed that BARI Sarisha-11 (*B. juncea*) took the highest duration to attain field maturity followed by Binasarisha 4 (*B. napus*). The local variety Tori-7 took the lowest duration. Similarly, A studied with 30 rapeseed-mustard varieties/genotypes of *B. campestris*,

B. juncea, *B. napus* was conducted and found that *campestris* group required lowest days to maturity followed by *napus* group while *juncea* group took the highest days to maturity [12].

Significant differences were observed among the studied rapeseed-mustard varieties in terms of seed and stover yield might be due to the genetic × environment interaction effects. [13] and [14] compared among different rapeseed-mustard cultivars and reported that all cultivars differed significantly for seed yields. In present study, the variety BARI Sarisha-11 produced the highest seed yield that was mainly attributed by the highest number of siliquae plant⁻¹. [15] And [16] in their experiments found that the effect of varieties on oil percentage trait was significant. In the present study, investigation on the effect of varieties revealed that the variety BARI Sarisha-15 (*B. campestris*) showed the highest oil content in rapeseed-mustard seed while the variety Binasarisha 4 (*B. napus*) showed the second highest oil content. During the both growing seasons the variety BARI Sarisha-11 produced the lowest oil percentage. Zaman et al. [17] concluded that *B. campestris* cultivars had higher

oil contents than *B. juncea*. Numerous experiments suggested that oil yield in canola is influenced by the variety, as [18] found in an experiment on 12 canola lines, that there was a significant difference between the studied cultivars in terms of oil percentage trait.

4.2 Effect of Harvesting Stages

Days to harvest of crop were gradually increased onwards harvesting stages. Irrespective of varieties the green siliquae harvesting stage took the lowest days while the full maturity harvesting stage took the longest duration. Seed yield variation was significant during both years among the harvesting stages. The results revealed that, green siliquae harvesting stage yielded the lowest and gradually increased onwards to harvesting stages which were remarkably different from other harvesting stages. Because, [19] stated that, seed size and color, dry weight, moisture content and germination, oil, protein and carbohydrate and vigor and viability changes occur from the time of

fertilization until the seeds are ready for harvest. Under this study, maximum seed yield was found at full maturity siliquae harvesting stage occurred at 91.0 days after sowing depending on cultivar. Under this study during both growing seasons the oil content of different rapeseed-mustard seeds varied significantly among the different harvesting stages. The seeds collected from the green siliquae stage showed the lowest oil percentage and then gradually increased towards development of seed maturity *i.e.* pale yellow, golden yellow, full maturity stages of siliquae. The results are in agreement with Mohammad and Ahmed [20] who observed that the most rapid development of oil begins when the seed is about 20 days old and continues for another 20 days following fertilization. Similarly, [21,22,23] reported that, oil and protein content were increased by delaying the harvesting time. Singh [24] stated that formation of oil in *Brassica* commences at the time of seed formation *i.e.* after the ovary was fertilized and its content increased with the maturity of seed. The highest oil content in Raya (*B. juncea*) was found when

Table 5. Days to harvest, seed and stover yield, oil content in seed (%) of rapeseed-mustard as influenced by interaction effects of varieties and harvesting stages during *rabi* (winter) seasons 2015-16 and 2016-17

Interaction (V × H)	Days to harvest		Seed yield (t ha ⁻¹)		Stover yield (t ha ⁻¹)		Oil content in seed (%)	
	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂
V ₁ × H ₁	83.0 i	71.0 h	2.23 g	1.83i	6.64 a	6.56 a	26.0 h	28.0 k
V ₁ × H ₂	96.0 c	83.0d	2.83 d	2.60 c-f	5.92 b	6.04 ab	31.6 ef	32.0 hi
V ₁ × H ₃	105.0 b	88.0 b	3.25 a	2.71bc	5.50 b	5.89b	31.9 ef	33.0 gh
V ₁ × H ₄	110.0 a	97.0 a	3.20 a-c	2.81b	5.45 b	5.70bc	33.7 d	33.7 g
V ₂ × H ₁	66.0 l	62.0 k	1.75 h	1.54 jk	3.60 ef	3.93 f-h	26.9gh	29.4 j
V ₂ × H ₂	79.0 j	67.0 i	2.86 cd	2.42 gh	3.40 ef	3.55gh	37.5 b	39.5 d
V ₂ × H ₃	88.0 fg	77.0 f	3.50 a	2.61 c-e	3.20 f	3.43 h	41.8 a	41.0 bc
V ₂ × H ₄	92.0 d	80.0 e	3.30 a	2.70b-d	3.10 f	3.44 h	40.6 a	42.7 a
V ₃ × H ₁	74.0 k	66.0 i	1.55 h	1.45 k	4.73 c	4.91 de	30.6 f	36.2 ef
V ₃ × H ₂	84.0 hi	79.0 e	2.45e-g	2.54d-g	3.60 ef	4.10 fg	41.1 a	40.6 cd
V ₃ × H ₃	91.0 d	83.0 d	2.34 fg	2.62 c-e	3.45 ef	4.01 fg	41.8 a	41.9a-c
V ₃ × H ₄	94.0 c	85.0 c	2.45e-g	2.65 b-e	3.21 f	4.10 fg	41.0 a	42.0 ab
V ₄ × H ₁	74.0 k	64.0 j	2.59 d-f	1.65 j	3.96 de	4.10 fg	26.3 h	28.8 jk
V ₄ × H ₂	82.0 i	74.0 g	2.86 cd	2.37 h	4.40 cd	5.20 cd	31.4 ef	32.8 gh
V ₄ × H ₃	86.0 g	85.0 c	2.90b-d	3.10 a	4.23 cd	4.45 ef	37.2 c	35.1 f
V ₄ × H ₄	90.0de	88.0 b	3.23 ab	3.23 a	3.90 de	4.22 f	35.4 b	36.6 e
V ₅ × H ₁	64.0 l	59.0 l	2.15 g	1.98 i	2.25 g	2.25 i	28.5 g	31.2 i
V ₅ × H ₂	77.0 j	67.0 i	2.40 fg	2.44 f-h	1.97 g	2.10 i	32.9de	30.9 i
V ₅ × H ₃	86.0 gh	73.0 g	2.80 d	2.51e-h	1.81 g	1.92 i	37.3 bc	35.8 ef
V ₅ × H ₄	89.0 ef	78.0 f	2.80 de	2.57 c-g	1.79 g	2.01 i	40.2 a	42.1 ab
CV (%)	1.46	0.85	7.50	4.21	9.70	8.36	2.31	1.73
LSD _{0.05}	2.08	1.07	0.33	0.17	0.62	0.57	1.70	1.31

Note: Y₁= 2015-2016; Y₂= 2016-2017; V₁= BARI Sarisha-11; V₂= BARI Sarisha-14; V₃= BARI Sarisha-15; V₄= Bina sarisha 4; V₅= Tori-7; H₁= Green stage of siliquae; H₂= Pale yellow stage of siliquae; H₃= Golden yellow stage of siliquae; H₄= Full maturity stage of siliquae

the crop was harvested at 155 days after sowing was stated by Singh et al. [25]. It has been reported by [26] that premature harvesting of groundnut pods lowered the yield, oil content and seeds quality of groundnuts due to immature pods and seeds.

5. CONCLUSION

From the above result it may be concluded that rapeseed-mustard varieties BARI Sarisha-14, BARI Sarisha-15 and Binasarisha 4 need to be sown within first week of November and the crop should be harvested at pale yellow stage of siliquae (within 73-82 days period before Boro rice transplantation) sacrificing seed and oil yield loss to some extent to introduce HYVs of rapeseed-mustard varieties along with the agronomic manipulation either in the existing Mustard-Boro (dry season rice)-T.Aman (wet season rice) or during fallow period of the Fallow-Boro (dry season rice)-T. Aman (wet season rice) cropping pattern. Harvesting beyond the pale yellow stage of siliquae took more duration and this will cause late transplanting of Boro rice.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Hasan MNM, Hossain SM, Islam RM, Bari MA. Trends in the availability of agricultural land in Bangladesh. Soil Resource Development Institute (SERDI), Ministry of Agriculture, Bangladesh, Dhaka; 2013.
- Nasim M, Shahidullah SM, Saha A, Muttaleb MA, Aditya TL, Ali MA, Kabir MS. Distribution of crops and cropping patterns in Bangladesh. Bangladesh Rice Journal. 2017;21(2):1-55.
- Mallik MSA. Quality seed production of oilseed crops: An overview. Paper Presented in the Workshop on ‘Modern Techniques for Quality Seed Production of Oilseed Crops’. Oilseed Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh; 2013.
- Baktiar MHK, Siddique MA, Khalequzzaman M, Bhuiya A, Islam MZ. Effect of maturity period and harvesting time on quality and yield in breeder seed of rice (*Oryza sativa* L.). Eco-friendly Agricultural Journal. 2013;6(11):249-252.
- Prakobbon N, Naglor S. Harvesting time and post-harvest handling on quality of soybean seed produced by farmers. Thailand Journal of Agricultural Science. 1987;20:11-16.
- Chopra NK, Sinha JP, Nisha-Chopra, Chopra N. Effect of time of harvest on seed quality in paddy. Seed Research. 2002;30:67-69.
- FRG-Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka-1215. 2012;274.
- Russell DF. MSTAT-C Package Programme. Crop and Soil Science Department, Michigan University, USA; 1986.
- Venkataraman S, Krishnan A. Crops and weather. Publication and Information Division, Indian Council of Agricultural Research, Krishi Anusandhan Bhawan, Pusa, New Delhi; 1992.
- Sinha PSP, Singh, Pandey IDP. Character isolation and path analysis in *Brassica* species. Indian Journal of Agricultural Research. 2001;35:63-65.
- Zare M, Sharafzadeh S. Genetic variability of some rapeseed (*Brassica napus* L.) cultivars in Southern Iran. African Journal of Agricultural Research. 2012;7:224-229.
- Alam MM, Begum F, Roy P. Yield and yield attribute of Rapeseed-mustard (*Brassica*) Genotypes grown under late sown condition. Bangladesh Journal of Agricultural Research. 2014;39(2):311-336.
- Khoshanazar PR, Ahmadi MR, Ghanndha MR. A study of adaptation and yield capacity of rapeseed (*Brassica napus* L.) cultivars and lines. Iranian Journal of Agricultural Science. 2000;31:341-352.
- Kolte SJ, Awasthi RP, Vishwanath R. Divya mustard: A useful source to create *Alternaria* black spot tolerant dwarf varieties of oilseed *Brassica*. Plant Varieties and Seeds. 2000;13:107-111.

15. Kazerani AN, Ahmadi MR. Effect of genotype and planting date on the quantitative and qualitative traits in rapeseed (*Brassica napus* L.) in the Bushehr province. Scientific Data Base of Iran; 2008.
16. Fanaei HR, Ghloy M, Bonjar AG, Soloki M, Naruby-Rad MR. The effect of planting date and seeding rate on yield and yield components of two cultivars of rapeseed in the Sistan Region. Iranian Journal of Agricultural Science. 2008;10: 15-30.
17. Zaman MW, Ali Z, Awal HMA, Talukder MZI. Influence of different stages of harvesting on the yield, oil content and shattering loss in oleiferous *Brassica*. Bangladesh Journal of Scientific and Industrial Research 1994;29(4):25-32.
18. Motalebipour SHMR, Jokar L. Study of adaptability and compare the yield of rapeseed cultivars and lines in Zarghan (Fars). Iranian Journal of Crop Science. 2001;2-3.
19. Demir I, Balkaya A. Seed development stages of Kale (*Brassica oleracea* var. *acephala* L.) genotypes in Turkey. Horticultural Science. 2005;32:147-153.
20. Mohammad A, Ahmed S. Formation of oil in oliferous *Brassica*. Indian Journal of Agricultural Science. 1940;10:82-88.
21. Court WA, Roy RC, Hendel JG. Effect of harvest date on agronomic and chemical characteristics of Ontario Peanuts. Canadian Journal of Plant Science. 1984;64:521-528.
22. Lu KC, Yeh MS, Yang KH, Lu HS. Effects of genotype, population density and harvest date on yield and quality of peanut. Journal of Agricultural Research China. 1997;46(2):116-131.
23. Canavar Ö, Kaynak MA. Determination of yield and yield components and seed quality of peanuts (*Arachis hypogea* L.) at different harvest times. International Journal of Agronomy and Plant Production. 2013;4(S):3791-3803.
24. Singh DP. Rape and mustard. Indian Oilseeds Committee, Hyderabad. 1958;53.
25. Singh RP, Singh BP, Yadava TP. Effect of harvesting time on the grain and oil yield of raya "*Brassica juncea* L. Czern and Coss". Haryana Agricultural University Journal Research. 1975;4:354-357.
26. Singh F, Oswalt DL. Groundnut production practices. ICRISAT. SAT | e-journal. 1995;9:29-32. Young JH, Person NK, Donald JO, Mayfield WD. Harvesting, curing and energy utilization. In Peanut Science and Technology. (Eds HE Pattee, CT Young). American Peanut Research and Education Society Inc. 1982;458-48.

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