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Genotypic Variations of Morpho-physiological Parameters of Rapeseed (*Brassica rapa* var. Toria) under Rainfed Condition of Assam

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ABSTRACT

Background: Among the North-Eastern states, Assam is the highest in terms of area of cultivation of rapeseed and has the potential to increase productivity to a great extent. To fulfil the increasing demand for edible oils, appropriate interventions must be paid for introduction of new oilseed varieties. The suitable genotype for a particular region has to be identified based on physiological efficiency and yield.

Methods: The field experiment was carried out at the Instructional-cum-Research (ICR) Farm, Assam Agricultural University, Jorhat-13, Assam during *rabi* seasons of 2021-22 and 2022-23. The experiment was laid out in randomized block design with three replications comprising of 22 different genotypes of rapeseed (*Brassica rapa*, var. Toria), *viz.,* TS-38 (Check), TS-46, TS-67, TS-36, TS-29, TS-75-1, TS-75-1TL, TS-75-2ME, TS-75-2-MM, TS-76-1, TS-76-2, JT-90-1, Panchali, Bhawani, CG Toria-4, TKM-20-1, TKM-20-2, JT-14-5, PT-2018-09, CG Toria-3, Tapeshwari and PT-303. The crops were grown following the recommended package of practice. All the parameters were taken following the standard methodologies. The parameters under study were plant height, number of primary branches, number of green leaves, stem diameters, root lengths and root volumes, proline content, nitrate reductase activity, protein content, oil content, specific leave weight, leaf area index, net assimilation rate and seed yield.

Result: The results of the study indicated a significant variation of all the morpho-physiological parameters among the genotypes. The genotype TS-75-2ME and TS-38 exhibited morpho-physiological superiority in terms of number of primary branches, green leaves and SLW. The same genotypes also recorded significantly higher seed yield.

Key words: Genotypes, Morpho-physiological parameters, Rapeseed, Seed yield.

INTRODUCTION

Rapeseed (*Brassica rapa* var. Toria) belongs to genera brassica, species rapa with chromosome number of 2n=20 (Mahendra *et al*., 2020). The crop is one of the most popular and widely used oil seed crops among the people of Assam and North-East India. In Assam, the crop accounts for nearly one-third of the oil produced in India, making the state as country's key edible oilseed producer. The total area under rapeseed in Assam is 2.89 lakh hectares with a total production of 1.86 lakh tones and the productivity is 6.44 quintal per hectare (Anonymous, 2022). Among the North-Eastern states, Assam is the highest in terms of area of cultivation of rapeseed and has the potential to increase productivity to great extent (Deka *et al*., 2018). To fulfil the increasing demand of edible oils, appropriate interventions must be paid for improvement of existing oilseed genotypes or by introducing new genotypes. The suitable genotype for a particular region has to be identified based on physiological efficiency and higher productivity. Important physiological characteristics, such as the leaf area index (LAI), net assimilation rate (NAR), specific leaf weight (SLW) *etc*. can govern the productivity of a variety (Malek *et al.,* 2012, Mondal *et al.,* 2013). A systematic research works on physiological aspects of rapeseed genotypes in Assam is limited. Only a few research works on the existing rapeseed varieties with regard to physiological efficiency has been conducted. Indeed, there is a need to identify the most important physiological parameters which governs the productivity of rapeseed. However, there is a great scope

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for boosting up the productivity of rapeseed through increased understanding of the physiological processes. Further, the existence of variability with respect to physiological traits will assist the plant breeders to develop new improved varieties of rapeseed. In this context, the research was conducted.

MATERIALS AND METHODS

The present experiment was carried out at the Instructional-cum-Research (ICR) Farm, Assam Agricultural University, Jorhat-13, Assam during *rabi* seasons of 2021-22 and 2022-23. The experimental farm is situated at 26°47 N latitude and 94°12 E longitudes at an elevation of 86.6 m above mean sea level (MSL). The climate of experimental site is characterized by subtropical, humid with dry summer and cold winter. The soil was sandy-loam, acidic pH with medium levels of N, P and K. The seeds were collected from the Zonal Research Station, AAU, Shillongani, Nagaon, Assam. The experiment was laid out in randomized block design with 3 replications and the crops were raised following the recommended package of practices. The statistical analysis was done by the method of Panse and Sukhatme (1967). The data of both the years were pooled and analysed.

Five numbers of plants were randomly selected from each replication, tagged and all the data related to morphological, physiological, quality parameters and yield were taken from these plants and average values were computed.

Plant height was measured at harvest from the ground level upto the tip of the upper most leaf using meter scale. The number of primary branches at harvest was recorded. The number of young, actively growing green leaves was counted from the base to the top of the plant at 60 DAS. Newly emerging underdeveloped young leaves and senesced leaves were avoided. Stem diameter at harvest was measured at the base of the main stem with the help of Vernier caliper. Root lengths of the main roots were measured with the help of measuring scale after uprooting the plants. Root volume was measured at harvest by using measuring cylinder.

The specific leaf weight (SLW) includes the leaf thickness and it was determined as per the formula of Radford (1967). Leaf Area Index (LAI) was calculated using the formula of Watson (1952). Net Assimilation Rate (NAR) is the rate of dry weight increase per unit leaf area per unit time. It was calculated by the formula of Radford (1967).

Leaf proline content was estimated by the methodology of Bates *et al*. (1973). The nitrate reductase activity (NRA) *in vivo* was assayed by the method of Saradhambal *et al*. (1978). The oil extraction was done according to official methods of Januszewska *et al*. (1999). Protein was estimated by using Bradford's method (1976).

RESULTS AND DISCUSSION

Morphological parameters

The pooled values of two years on plant height, primary branches, green leaves (at 60 DAS), stem diameter, root length and volume at harvest, days to seedling emergence, 50% flowering and physiological maturity presented in Table 1

Table 1: Genotypic variations of morphological parameters in rapeseed.

Genotypes	Plant height at harvest (cm)	Primary branches at harvest	Green leaves at 60 DAS	Stem diameter at harvest (cm)	Root length at harvest (cm)	Root volume at harvest (cc)
PT-303	84.00	5.00	8.80	0.58	17.73	1.85
PT-2018-09	91.48	4.70	8.57	0.67	19.97	1.66
Panchali	87.30	4.87	8.50	0.62	20.12	1.29
Bhawani	78.33	4.63	8.34	0.57	16.61	1.07
TS-29	75.12	4.13	8.44	0.52	16.34	1.19
TS-36	79.16	4.47	8.40	0.52	15.8	1.15
TS-46	82.40	4.00	8.83	0.57	16.61	1.65
TS-67	83.97	4.37	8.14	0.63	14.90	1.33
TS-75-1	80.98	4.87	8.84	0.53	15.76	0.84
TS-75-1TL	83.52	4.07	8.14	0.54	18.88	1.23
TS-75-2ME	83.61	5.90	9.20	0.68	17.38	2.23
TS-75-2MM	84.82	5.63	8.47	0.58	16.25	1.97
TS-76-1	80.98	4.93	8.17	0.67	16.90	1.87
TS-76-2	75.66	4.20	8.27	0.39	14.65	1.11
JT-90-1	73.22	4.90	8.10	0.51	14.60	1.82
JT-14-5	74.17	5.20	9.03	0.52	13.94	1.17
TKM-20-1	87.32	4.27	8.07	0.49	17.48	1.02
TKM-20-2	89.04	4.57	7.50	0.46	15.92	1.32
Tapeswari	83.39	4.03	8.13	0.58	17.45	1.29
CG-Toria-3	78.85	4.87	8.37	0.58	16.38	1.64
CG-Toria-4	67.26	4.97	8.20	0.51	12.71	0.86
TS-38(Check)	78.81	5.30	9.14	0.66	18.02	1.71
Mean	84.00	4.72	8.44	0.56	16.56	1.42
C D (0.05)	1.44	0.46	0.47	0.05	2.09	0.27

indicated significant differences of all the mentioned parameters among the genotypes. Among the genotypes, significantly higher plant height (91.48 cm) was found in the genotype PT-2018-09 at harvest followed by TKM-20-2 (89.04 cm). On the other hand, minimum plant height were recorded in the genotype CG Toria-4 (67.26) followed by JT-90-1(73.22). Significantly higher number of primary branches at harvest was recorded in the genotype TS-75-2ME with the pooled value of 5.90 followed by TS-75-2MM (5.63). On the other hand, minimum number of primary branches was found in the genotype TS-46. Significantly higher leaf number was found in the genotype TS-75-2ME with the pooled value of 9.20 followed by TS-38 (9.14) although the values were statistically at par. The genotypes TKM-20-2 followed by TKM-20-1 had the minimum number of green leaves.

Rashid *et al.* (2010) reported a significant difference of plant height among different varieties of *Brassica campestris* L. which might be associated with the varietal characters or genetic makeup of the plant. The findings were in corroboration with the findings of the current study. Awal and Fardous (2014) reported significant differences in plant height, number of primary branches and green leaves in different species of *Brassica campestris*. The result of the present study is in corroboration with the above findings. Helal *et al*. (2016), Nem *et al*. (2020) and Yadav and Lallu (2021) also reported similar results of significant variation of the above parameters among different genotypes of rapeseed.

Significantly higher stem diameter at harvest was observed in the genotype TS-75-2ME followed by PT-2018-09 with the values of 0.68 and 0.67, respectively. However, there was no statistical difference between the two. Whereas significantly lower value was observed in the genotype TS-76-2 (0.39 cm) followed by TKM-20-2 (0.46). Zirgoli and kharizi (2015) also reported difference in stem diameter under different moisture treatments. Maximum root length was recorded in the genotype Panchali (20.12 cm) followed by PT-2018-09 (19.97 cm). On the other hand, minimum was found in CG-Toria-4 (12.71 cm) followed by JT-14-5 (13.94 cm). Significantly high root volume was recorded in TS-75-2ME with the value of 2.23cc followed by TS-75-2MM (1.97cc). On the other hand, significantly lower root volume was observed in TS-75-1 (0.84cc) followed by CG-Toria-4 (0.86cc) although both were statistically at par. Jan *et al.* (2016) and Chandra *et al.* (2018) also reported similar result in rapeseed (*Brassica napus* L.) plants.

Physiological parameters

There was significant difference among the genotypes for proline and nitrate reductase activity at 60 DAS, protein and oil content, seed yield and harvest index as presented inthe Table 2.

Table 2: Genotypic variations of physiological, quality and yield parameters in rapeseed.

Genotypes	Proline content at 60 DAS ($\mu mol.g^{-1}$)	Nitrate reductase activity at 60 DAS ($\mu mole\ NO_3^-\ g^{-1}\ fr.wt.\ hr^{-1}$)	Protein content (%)	Oil content (%)	SLW at 60 DAS ($g\ cm^{-2}$)	LAI at 60 DAS	NAR 30-60 DAS ($g.\ dm^{-2}.day^{-1}$)	Seed yield ($q\ ha^{-1}$)
PT-303	2.66	5.62	21.58	41.97	2.52	1.83	0.024	10.43
PT-2018-09	2.48	3.80	21.94	41.93	1.69	1.40	0.026	6.52
Panchali	2.63	2.82	20.98	37.60	2.13	1.91	0.023	8.34
Bhawani	2.27	2.09	22.93	33.74	2.90	1.71	0.032	9.21
TS-29	2.22	1.82	18.89	38.68	2.76	1.75	0.024	8.05
TS-36	2.59	5.00	20.16	39.01	3.15	1.52	0.025	9.99
TS-46	2.21	3.84	18.93	35.75	2.69	1.88	0.037	8.97
TS-67	2.37	4.95	21.13	34.71	2.78	2.28	0.016	8.16
TS-75-1	2.15	5.92	22.42	43.77	2.68	1.50	0.029	7.18
TS-75-1TL	2.30	2.86	19.29	34.97	2.85	1.70	0.041	4.99
TS-75-2ME	2.31	7.28	19.43	42.37	4.13	1.78	0.044	12.59
TS-75-2MM	2.22	3.87	21.72	39.11	1.97	2.03	0.024	8.40
TS-76-1	2.32	6.80	19.08	36.74	2.20	1.96	0.028	9.76
TS-76-2	2.17	4.86	20.87	38.68	2.12	1.90	0.019	6.30
JT-90-1	2.18	5.76	19.49	36.80	2.19	1.61	0.026	5.14
JT-14-5	2.37	6.67	20.70	34.85	1.68	1.87	0.022	9.56
TKM-20-1	2.59	6.15	21.95	40.07	2.50	1.81	0.020	5.79
TKM-20-2	2.15	5.78	21.24	36.77	2.15	1.78	0.019	4.23
Tapeswari	2.49	4.65	19.96	35.67	2.32	1.60	0.043	8.91
CG-Toria-3	2.57	6.00	21.03	38.48	2.44	1.61	0.036	8.10
CG-Toria-4	2.50	5.26	20.36	38.03	2.98	1.63	0.022	6.94
TS-38 (Check)	2.31	4.79	20.70	39.70	3.39	1.85	0.041	10.85
Mean	2.36	4.84	20.68	38.15	2.55	1.77	0.028	8.10
C D (0.05)	0.08	0.09	0.017	3.53	0.86	0.44	0.004	1.62

Significantly higher proline content was found in the genotype PT-303 followed by Panchali with the values of 2.66 and 2.63 at 60 DAS. On the other hand, lowest value was found in TKM-20-2 and TS-75-1 with the values of 2.15 for both. Jan *et al.* (2016) reported variation in increment in proline content in different rapeseed varieties. Chaghakaboodi *et al*. (2021) also reported significant variation of leaf proline content among 14 genotypes of rapeseed, which is in corroboration with the findings of the current study.

The genotype showing significantly higher nitrate reductase activity was TS-75-2ME (7.28) followed by TS-76-1 (6.28). There was no significant difference found among the genotypes. Genotype showing significantly lower value of nitrate reductase activity was Bhawani and TS-29 with the value of 1.82 followed by TS-75-1TL (2.86). The finding is supported by Jain *et al.* (2011) who found variation of nitrate reductase activities in two wheat genotypes. Huang *et al.* (2013) and Irfan *et al*. (2014) also reported variation in nitrate reductase in different rapeseed genotypes under different treatments.

The genotype, TS-75-2ME was found significantly higher SLW followed by the genotype TS-38 for both the years with the values of 4.13 and 3.39, respectively. On the other hand, significantly lower value of SLW was found in JT-14-5 followed by PT-2018-09 with the values of 1.68 and 1.69, respectively at 60 DAS. These differences in values might be due to genetical characteristics of different genotypes as reported by Rashid *et al.* (2010). Yadav and Lallu (2021) also reported significant differences in specific leaf weight among different mustard genotypes, SLW increased with advancement of plant age which was similar to that of the current study.

Genotype TS-67 and TS-75-2MM were found to be highest LAI at 60 DAS with the values of 2.28 and 2.03, respectively, at 60 DAS. On the other hand, PT-2018-09 and TS-75-1 showed significantly lower LAI at 60 DAS with the values of 1.40 and 1.50, respectively. Highest NAR value was recorded in the genotype TS-75-2ME (0.044) followed by Tapeswari (0.043). On the other hand, lowest value was performed by TS-67 (0.016) followed by TS-76-2 (0.019). Siddiqui and Fizor (2004) recorded significant difference of leaf LAI and NAR among different cultivars of rapeseed mustard as similar to that of the current findings. De *et al.* (2013) also reported similar result in rapeseed (*Brassica campestris*). Mondal *et al.* (2020) also reported increase in LAI till 65 DAS followed by a sharp decline because of leaf shedding.

Quality parameters and yield

Seed protein content was found to be highest in the genotype Bhawani followed by the genotype TS-75-1 with the values of 22.93% and 22.42%, respectively. On the other hand, significantly lower protein content was found in the genotype TS-29 followed by TS-46 with the values of 18.89% and 18.93%. Kumar (2015) reported higher protein content in TS-38 (19.33%) and TS-36 (19.02%) as compared to M-27 under different nutrient levels. Similar to our findings, Balalic *et al.* (2017) reported significant variation of protein content in four cultivars of rapeseed *viz.,* Banacanka, Slavica, Express and Valeska. Significantly higher protein content was recorded in the cultivar Valesca (21.54%) and lowest in Express (18.19%). Stolte *et al. (*2022) also reported genetic variation for seed storage protein in modern winter rapeseed cultivars (*Brassica napus*), which varied in the range of 17.5-18.3%.

Significantly higher value of seed oil content (43.77%) found in the genotype TS-75-1 followed by TS-75-2ME (42.37%). On the other hand, significantly lower values of seed oil content were found in the genotypes Bhawani and TS-67 with the values of 33.74% and 34.71%, respectively. Kumar (2015) also reported significant variation in oil content in rapeseed varieties. A significant variation of oil content ranging from 41.19% to 42.69% in four cultivars of rapeseed *viz*., Banacanka, Slavica, Express and Valeska was reported by Balalic *et al.* (2017). Yadav and Lallu (2021) reported that early sown mustard contained significantly higher seed oil content over the late sown mustard genotypes. The above findings are in conformity with the results of present experiment.

Among the genotypes, significantly higher yield was found in the genotype TS-75-2ME followed by TS-38 with the values of 12.59 and 10.85 q ha^{-1} respectively. On the other hand, lowest yield was found in the genotype TKM-20-2 with the value of 4.23 q ha^{-1}. Awal *et al.* (2014) reported significant variation in seed yield between the two species *Brassica campestris* and *Brassica napus* which is similar with the current study. Al-Juheishy *et al.* (2021) revealed significant varietal differences in two rapeseed varieties in terms of seed yield which in corroboration to the findings of the current experiment. Kumar (2015) found that among the Toria varieties, TS-38 and TS-36 produced significantly higher values of seed yield. Our findings was also in corroboration with the findings of Samant *et al.* (2015), Helal *et al.* (2016), Gogoi *et al.* (2018) and Tiwari *et al*. (2019) where genotypic variation of yield and yield attributes observed.

CONCLUSION

From the present study, it was observed that all the 22 different genotypes of rapeseed differed significantly with respect to all the morphological, physiological and quality parameters along with yield attributes and yield, indicating clearly the extent of variation among the genotypes. Among the genotypes, TS-75-2ME and TS-38 exhibited morpho-physiological superiority with regard to more number of branches, stem diameter, SLW and seed yield. Based on the physiological performance, the genotypes, TS-75-2ME and TS-38 may be regarded as superior genotypes suitable for growing under rainfed condition of Assam and North-Eastern states of India and may be used in further yield

improvement programme of rapeseed. However, more elaborate multidisciplinary studies may be required for confirmation of the same.

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Conflict of interest

The authors declare that we have no conflict of interest.

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