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Performance of Yield and Yield Attributes of Ten Indian Mustard (*Brassica juncea* L.) Genotypes under Drought Stress

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ABSTRACT

Drought is considered as one of the key limiting factor for oil seed production and productivity in Rajasthan. Therefore, the present piece of work was carried out at S.K.N.U. Agriculture College, Jobner (Rajasthan), to examine the effect of drought stress in 10 Indian mustard (Brassica juncea L.) cultivars. Yield and yield attributes were thoroughly investigated in the mustard cultivars under control and water stress condition. Plant height, days to 50 % flowering, number of silique/plant, number of seed/ siliqua, seed yield, biological yield, oil content and oil quality were observed in both with irrigation and drought conditions. Yield and yield attributes were decline in all cultivars under drought condition compare to control. Yield and yield attributes data revealed that under irrigation condition performance of genotype RH-0749 and RH-0406 was better than other selected genotype.RB-50 and RGN-48 maintain higher seed yield and oil quantity under drought situation due to lesser reduction in yield attributes and tolerance mechanism. Therefore, selection of drought tolerance genotype based on yield attributes can significantly enhance yield potential under adverse environmental situations.

Key words: *Days to 50% flowering. Drought. Yield attributes .Sliliqua. Drought tolerance*

INTRODUCTION

Mustard (*Brassica juncea* L. Czern & Coss) is an important Rabi season oilseed crop; belongs to family Cruciferae and genus *Brassica*[16]. Mustard seed is the world's second leading source of vegetable oil, after soybean[7]. It is also the second most leading source of protein meal in the world after soybean. It is mainly grown in northern part of India, Rajasthan is the largest producing state followed by Uttar Pradesh. Mustard crop required lower water requirement (240–400 mm) for completing life cycle, therefore it is fits well for rain fed cropping system[11,22].

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Mustard seed contains average 34-43 % oil content and contributes for 32% of total edible oil. The total production of this crop in India is 8.08 m tones with a productivity of 1420 kg/ ha. In Rajasthan, rapeseed and mustard occupies prime place amongst all the oilseed crops grown in the state, occupying 6.5 m. hectares area, with production of 3.5 m tones and 1208 kg/ha average yield[2].

Drought stress is considered as one of the primary factor responsible for looming agricultural productivity, because of linking with other major abiotic stresses such as salinity and heat stress etc[9,14]. In India mustard mainly grown on light textured soils using water conserved from monsoon rains, it inevitably suffers from drought stress during its reproductive stage, when stored water becomes depleted[12,22]. Water stress during and after flowering stage has a more adverse effect on seed yield than during other stages of plant development probably due to susceptibility of pollen development, anthesis and fertilisation leading to lower seed yield[5,8,15]. Gunasekera[10] concluded that water stress after flowering adversely affects dry matter and seed yield of both mustard and canola confirming that the reproductive period is the most susceptible to stress. The effect of drought stress is a function of genotype, intensity and duration of stress, weather conditions, growth and developmental stages of rape seed[19,20]. Zakirullah *et al*[24]., observed that under water stress conditions, the number of siliquae in the main stem and the number of seeds per siliqua of drought-sensitive rapeseed lines had a sharp drop, while in drought-tolerant lines this reduction was not significant. Ali *et al*[1]., also reported a strong correlation between harvest index and seed yield. Nasri *et al*[17]., observed that applying drought stress caused a significant reduction in the number of siliquae per plant, the number of seeds per siliqua, 1000-seed weight, seed yield, the seed oil content, and the oil yield of five rapeseed cultivars.

Drought tolerance is a complex trait controlled by numerous genes and their intraction[3,18]. Therefore, it is necessary to develop varieties which can tolerate water stress to increase planted area and yield of the oilseed crops. The present study was proposed to achieve these goals and to characterized the varieties of Indian mustard which can withstand well in drought spells and also to estimate correlation among different traits. The information derived from the study will be helpful in Indian mustard breeding for drought tolerance and early selection of genotypes with the desirable traits to be used in the breeding programs under drought stress.

MATERIAL AND METHOD

A field experiment was carried out at Agronomy Farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during *Rabi* season 2014-15, to investigate response of yield and yield attributes in Indian mustard under drought stress. Homogeneous composite soil sampling from 0-30 cm depth were subjected to mechanical, physical and chemical analysis and reported data for soil sample were EC(Electrical conductivity) (dSm-1) - 1.10, pH - 8.20, SAR (Sodium adsorption ratio) - 12.5, field capacity (%) - 11.8 and permanent wilting point - 2.8. The experiment was conducted in randomized block design with three replications. The following 10 genotypes of Indian mustard namely RB 50, RGN 48, Urvashi, Geeta, RH 819, RGN 229, RH 0406, RH 0749, NRCHB 101 and NRCDR 02 were used for investigation under control and water stress conditions. Under control condition the plants were irrigated at flowering and pod formation stages while in water stress the plants were maintained under rain-fed condition by withdrawing irrigation.

Following growth and yield attributing characters were measured and recorded at the time of crop standing stage, at harvesting and after harvesting stage. The plants were observed daily to see the appearance of first flowering. When 50 percent flowers appeared in the plot, the date were recorded and number of days from the date of planting was calculated and the number of siliquae of the five randomly selected plants was counted and their mean was computed to express as number of siliquae per plant at standing crop. At harvest the height and number of seeds per siliqua were recorded in five randomly selected plants and their mean was computed. After harvest the test weight, seed yield, biological yield and harvest index were recorded.

Oil content: The oil content was recorded on per cent basis using nuclear magnetic resonance apparatus at Shri Subhum Logistic, Merta City, Nagaur (Rajasthan).

- **Oil yield (Kg/ha)** $= \frac{\text{Seed Yield}\left(\frac{\text{Kg}}{\text{ha}}\right)\text{x Oil Content \%}}{100}$
- **Harvesting yield** = Economical yield/ Biological yield*100[6]
- **% Reduction** = (Mean value (control)- Mean value (Drought)/ Mean value (Drought)*100

Statistical Analysis:

Mean values were taken from each treatment of three independent replications; and Statistical Package for Social Science (SPSS Version 16.0) was used for the analysis of random block design (RBD). Significant differences among various treatments were determined using Duncan's test.

RESULTS

Results of plant height, days to 50 % flowering, number of silique/plant, no of seed/siliqua, test weight, seed yield, biological yield, and harvesting index in 10 Indian mustard landraces are followed.

Plant height (cm): Plant heights were observed at harvesting stage under both control and drought conditions. The highest plant height was observed in NRCDR-02 196.2 cm (control) and RGN-219 (176.5cm) under drought, while lowest in URVASHI 158.3 cm (control) and NRCHB-101 146.4 cm. Under drought condition percent reduction was highest in NRCDR-02 24.17% and lowest in URVASHI 0.57%. SPSS analysis showed significant variance between genotype under control and drought condition are showed alphabetically in **Fig.1a**.

Days to 50 % flowering: Days to 50 % flowering were observed at flowering stage under both control and drought conditions. The highest day to 50% flowering were observed in RH-0406 69days (control) and RB-50 (62.4 days) under drought, while lowest in URVASHI 58.25 days (control) and NRCHB-101 46.5 days (Drought). Under drought condition percent reduction was highest in NRCDR-02 31.74 % and lowest in URVASHI 1.30%. SPSS analysis showed significant variance between genotype under control and drought condition are showed alphabetically in **Fig.1b**.

No of silique/plant: No of silique/plant were observed at pod formation stage under both control and drought conditions. The highest no of silique/plants were observed in RH-0749 225.6 (control) and RGN-48 (210.8) under drought, while lowest in Geeta 210 (control) and NRCHB-101 180.3(Drought). Under drought condition percent reduction was highest in RH-0749 21.68 % and lowest in RGN-48 3.79%. SPSS analysis showed significant variance between genotype under control and drought condition are showed alphabetically in **Fig.2a**.

No of seed/siliqua: No of seed/siliqua were observed at after harvesting stage under both control and drought conditions. The highest no of seed/siliqua were observed in RH-0749 16.3 (control) and RGN-48 (13.75) under drought, while lowest in Geeta 12.7 (control) and NRCHB-101 10.33(Drought). Under drought condition percent reduction was highest in RH-0749 38.72 % and lowest in RB-50 1.88%. SPSS analysis showed significant variance between genotype under control and drought condition are showed alphabetically in **Fig.2b**.

Test weight (gm): Test weight was observed at after harvesting stage under both control and drought conditions. The highest test weight was observed in RH-0749 5.85gm (control) and RGN-48 (5.25gm) under drought, while lowest in Geeta 5.1gm (control) and Urvashi 4.1gm (Drought). Under drought condition percent reduction was highest in URVASHI 29.26 % and lowest in RB-50 2.74%. SPSS analysis showed significant variance between genotype under control and drought condition are showed alphabetically in **Fig.3a**.

Harvesting index (%): Harvesting index was observed at after harvesting stage under both control and drought conditions. The highest HI was observed in RH-0749 32.03% (control) and RGN-48 (28.47%) under drought, while lowest in GEETA 26.68% (control) and NHCHB-101 25.68% (Drought). Under drought condition percent reduction was highest in NHCHB-101 18.54 % and lowest in RH-819 0.17%. SPSS analysis showed significant variance between genotype under control and drought condition are showed alphabetically in **Fig.3b**.

Seed yield (SY) and biological yield (BY) (gm/plant): Seed yield was observed at after harvesting stage under both control and drought conditions. The highest SY was observed in RH-0749 11.5gm (control) and RGN-48 (9.4) under drought, while lowest in GEETA 8.7gm (control) and NHCHB-101 7.5gm (Drought). The highest BY was observed in RH-0749 35.9gm (control) and RGN-48 32.9 gm (Drought) while lowest were in RGN-229 32.3 gm and NHCHB-101 29.2 gm (Drought).Under drought condition percent reduction was highest in RH-0749 and lowest in RGN-229in both SY and BY. SPSS analysis showed significant variance between genotype under control and drought condition are showed alphabetically in **Table1**.

Oil content (%) and Oil quantity (Kg/ha): Oil content was observed at after harvesting stage under both control and drought conditions. The highest oil content was observed in URVASHI 42.9% (control) and NRCDR-02 (40.3%) under drought, while lowest in RH-0749 38.2% (control) and GEETA 34.2% (Drought). The highest oil quantity was observed in RH-0749 651Kg/ha (control) and RGN-48 543kg/ha (Drought) while lowest were in URVASHI 460 kg/ha and GEETA 421Kg/ha (Drought). SPSS analysis showed significant variance between genotype under control and drought condition are showed alphabetically in **Table1a**.

Table I: is representing the seed yield (g/plant) and biological yield (g/plant) of Indian mustard genotypes at harvesting stage. Presented datain table are the mean of three replication and ± represent standard deviation between replication. Within each genotypes different alphabetically letters indicate significant difference by Duncan`s multiple test at P<0.05

		Seed yield (g/plant)		Biological yield (g/plant)	
Sr.No	**Genotype**	**Control**	**Stress**	**Control**	**Stress**
1	RB 50	$10.2\pm0.40^{c,d,e}$	9.3 ± 0.36^{d}	34.1 ± 4.45^{a}	32.6 ± 4.41^{a}
2	RGN 48	$10.7\pm0.43^{d,e,f}$	9.4 ± 0.61^{d}	34.5 ± 4.77^{a}	32.9 ± 4.90^{a}
3	URVASHI	$9\pm0.60^{a,b}$	$8.4\pm0.53^{a,b,c,d}$	32.8 ± 5.63^{a}	31.1 ± 4.00^{a}
4	GEETA	8.7 ± 0.30^{a}	$8.3\pm0.55^{a,b,c,d}$	32.6 ± 3.99^{a}	31.3 ± 2.56^{a}
5	RH 819	9.5 ± 0.78^{c}	$9.2\pm0.46^{c,d}$	33.4 ± 3.74^{a}	32.4 ± 5.04^{a}
6	RGN 229	$9.2\pm0.62^{a,b,c}$	$9.1\pm0.65^{b,c,d}$	32.3 ± 4.87^{a}	32.2 ± 3.86^{a}
7	RH 0406	$10.9\pm0.81^{e,f}$	$8.1\pm0.56^{a,b,c}$	34.8 ± 4.10^{a}	29.8 ± 3.53^{a}
8	RH 0749	11.5 ± 0.42^{f}	$8\pm1.08^{a,b}$	35.9 ± 3.85^{a}	29.6 ± 1.63^{a}
9	NR CHB 101	$9.6\pm0.46^{a,b,c}$	7.5 ± 0.53^{a}	33.6 ± 3.86^{a}	29.2 ± 3.86^{a}
10	NRC DR 02	$9.8\pm0.46^{b,c,d}$	7.9 ± 0.36^{a}	33.9 ± 3.48^{a}	29.6 ± 4.27^{a}

Table Ia: is representing the oil content (%) and oil yield (Kg/ha) of Indian mustard genotypes after harvesting stage. Presented datain table are the mean of three replication and ± represent standard deviation between replication. Within each genotypes different alphabetically letters indicate significant difference by Duncan`s multiple test at P<0.05

		Oil content (%)		Oil yield (Kg/ha)	
Sr.No	**Genotype**	**Control**	**Stress**	**Control**	**Stress**
1	RB 50	39.8±4.02^{a,b}	38.9±4.15^{a,b}	601±24.63^{b,c,d}	535±29.81^{d}
2	RGN 48	40±2.54^{a,b}	39±2.64^{a,b}	634±36.75^{c,d}	543±39^{d}
3	URVASHI	42.9±1.15^{b}	39.66±2.51^{a,b}	572±30.19^{b,c}	498±27.62^{c,d}
4	GEETA	35.7±4.07^{a}	34.2±3.41^{a}	460±36.05^{a}	421±19.51^{a}
5	RH 819	38.6±3.84^{a,b}	36.2±2.50^{a,b}	543±29.81^{b}	493±27.62^{b,c,d}
6	RGN 229	40.2±2.05^{a,b}	38.4±3.53^{a,b}	598±27.22^{b,c,d}	518±30^{c,d}
7	RH 0406	38.6±3.60^{a,b}	36±3^{a,b}	623±24.51^{c,d}	432±28.93^{a}
8	RH 0749	38.2±3.62^{a,b}	37.2±3.27^{a,b}	651±48.56^{d}	441±28.58^{a,b}
9	NRCHB101	40.6±3.17^{a,b}	39.1±2.62^{a,b}	577±29.51^{b,c}	434±31.04^{a}
10	NRC DR 02	41.4±1.44^{a,b}	40.3±2.04^{b}	601±28.82^{b,c,d}	472±35.55^{a,b,c}

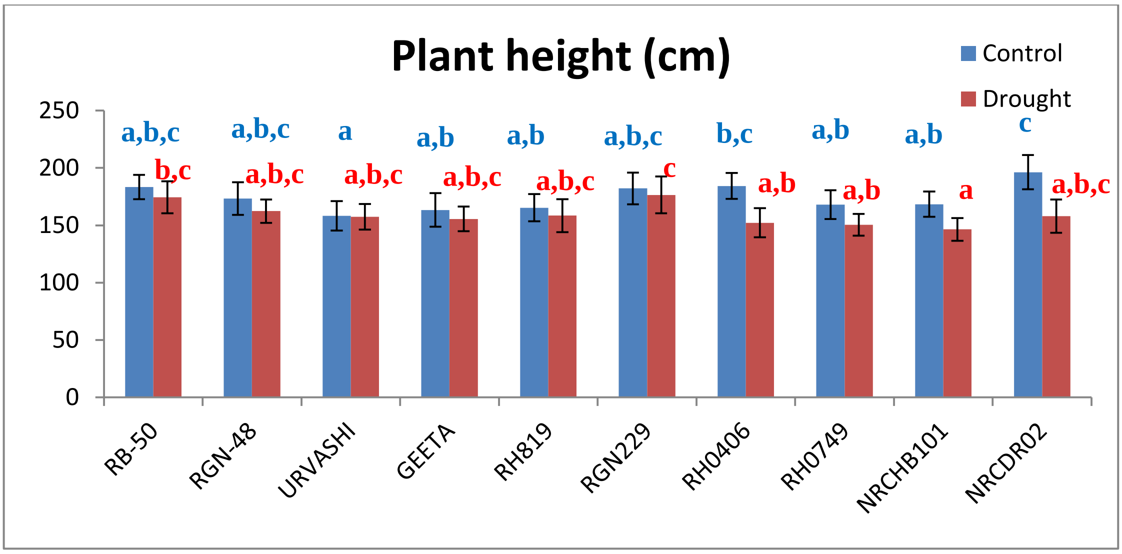

Fig. 1a: is representing the plant height (cm) of Indian mustard genotype at harvesting stage. Presented data in graph are the mean of three replication and error bar represent standard deviation between replication. Within each genotypes different letters indicate significant difference by Duncan`s multiple test at P<0.05.

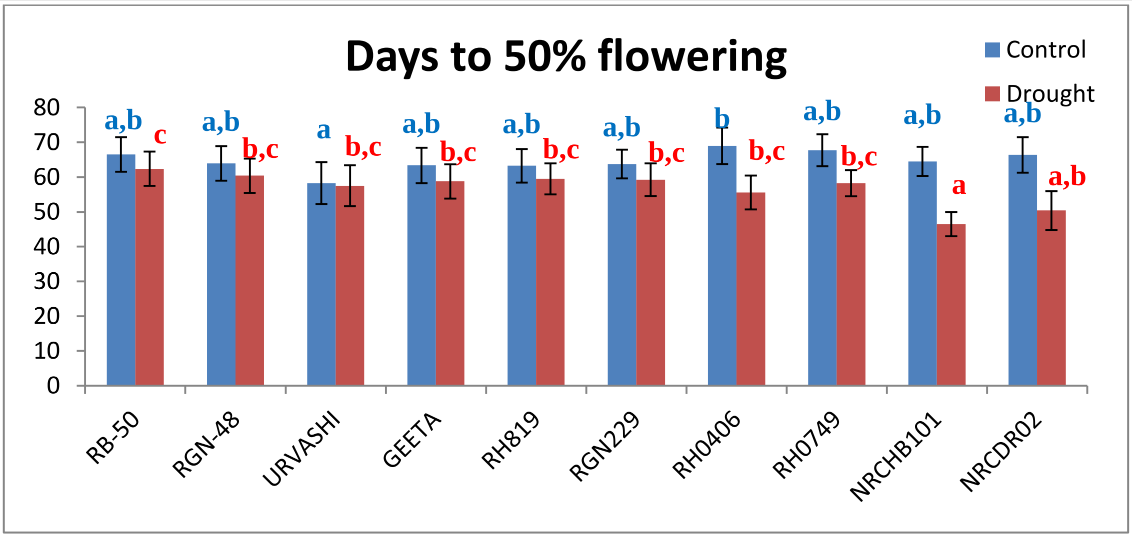

Fig. 1b: is representing the days to 50 % flowering of Indian mustard genotype at flowering stage. Presented data in graph are the mean of three replication and error bar represent standard deviation between replication. Within each genotypes different letters indicate significant difference by Duncan`s multiple test at P<0.05.

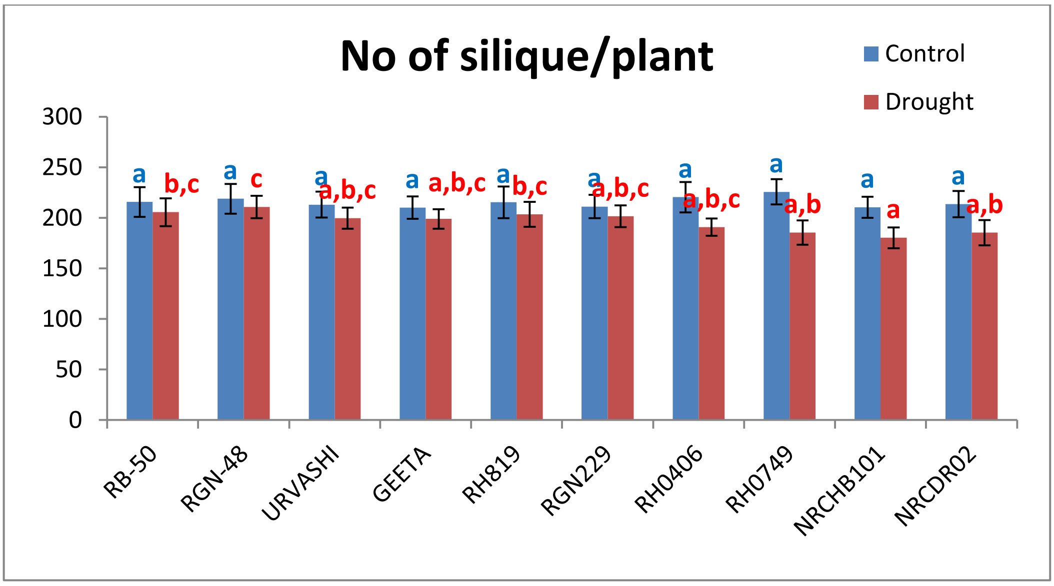

Fig. 2a: is representing the number of silique/plant of Indian mustard genotype at pod formation stage. Presented data in graph are the mean of three replication and error bar represent standard deviation between replication. Within each genotypes different letters indicate significant difference by Duncan`s multiple test at P<0.05.

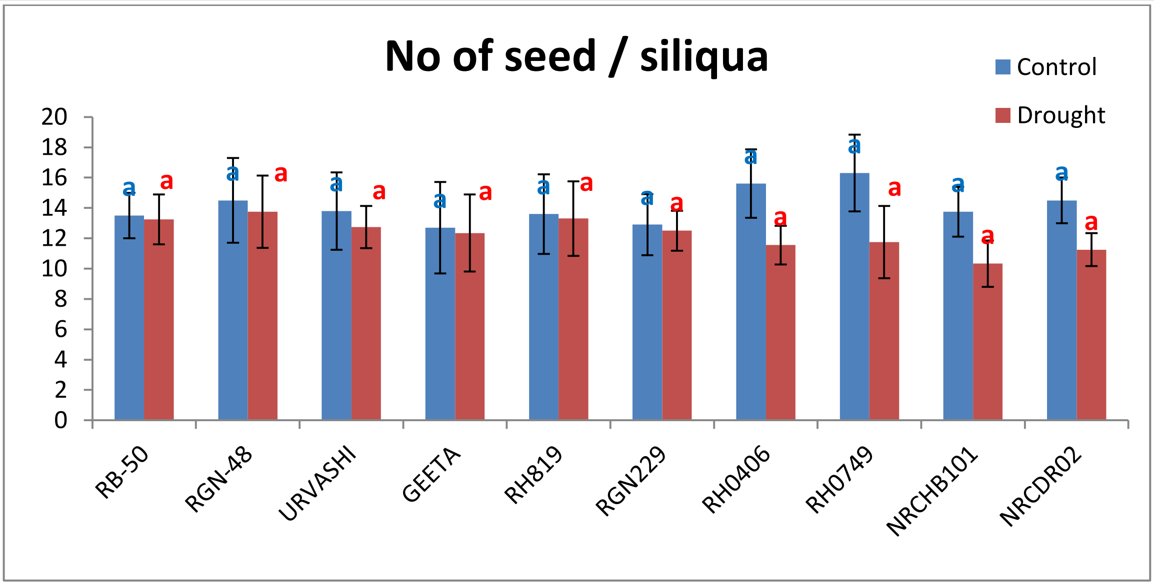

Fig. 2b: is representing the number of seed/ siliqua of Indian mustard genotype at harvesting stage. Presented data in graph are the mean of three replication and error bar represent standard deviation between replication. Within each genotypes different letters indicate significant difference by Duncan`s multiple test at P<0.05

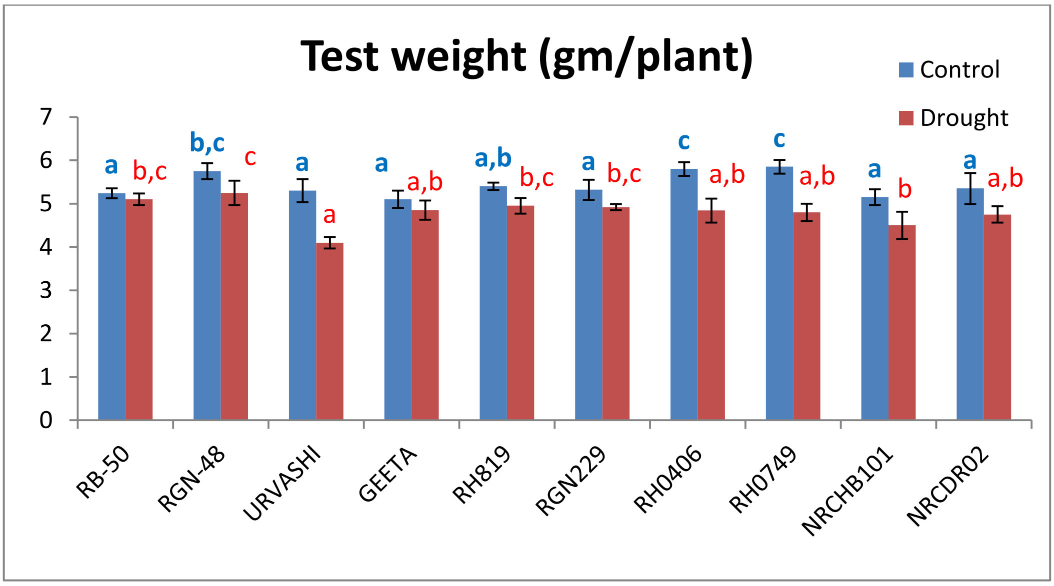

Fig. 3a: is representing the test weight (gm/plant) of Indian mustard genotype at flowering stage. Presented data in graph are the mean of three replication and error bar represent standard deviation between replication. Within each genotypes different letters indicate significant difference by Duncan`s multiple test at P<0.05.

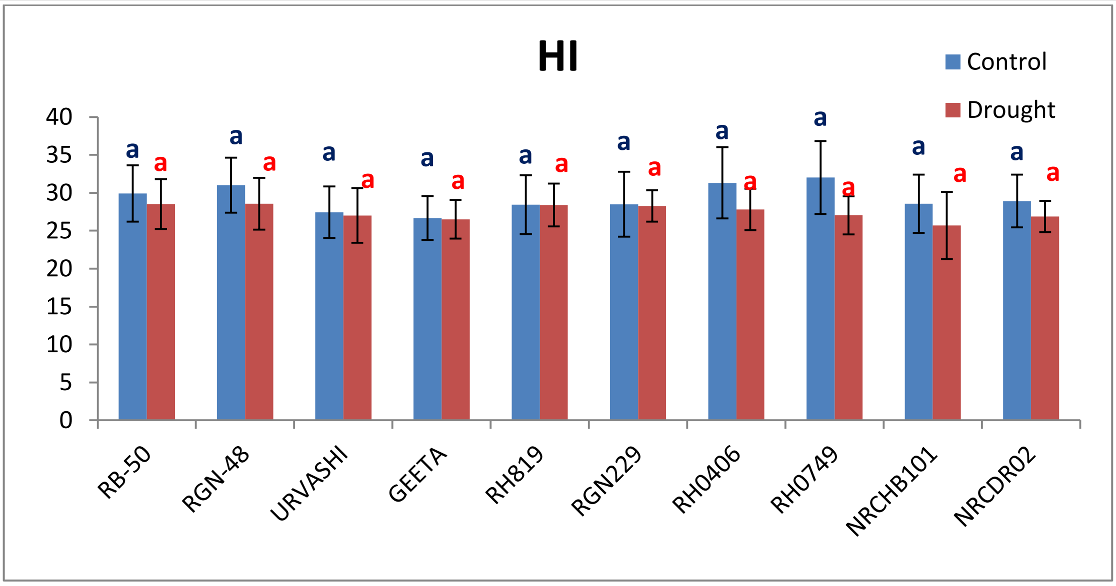

Fig. 3b: is representing the harvesting index of Indian mustard genotype after harvesting stage. Presented data in graph are the mean of three replication and error bar represent standard deviation between replication. Within each genotypes different letters indicate significant difference by Duncan`s multiple test at P<0.05.

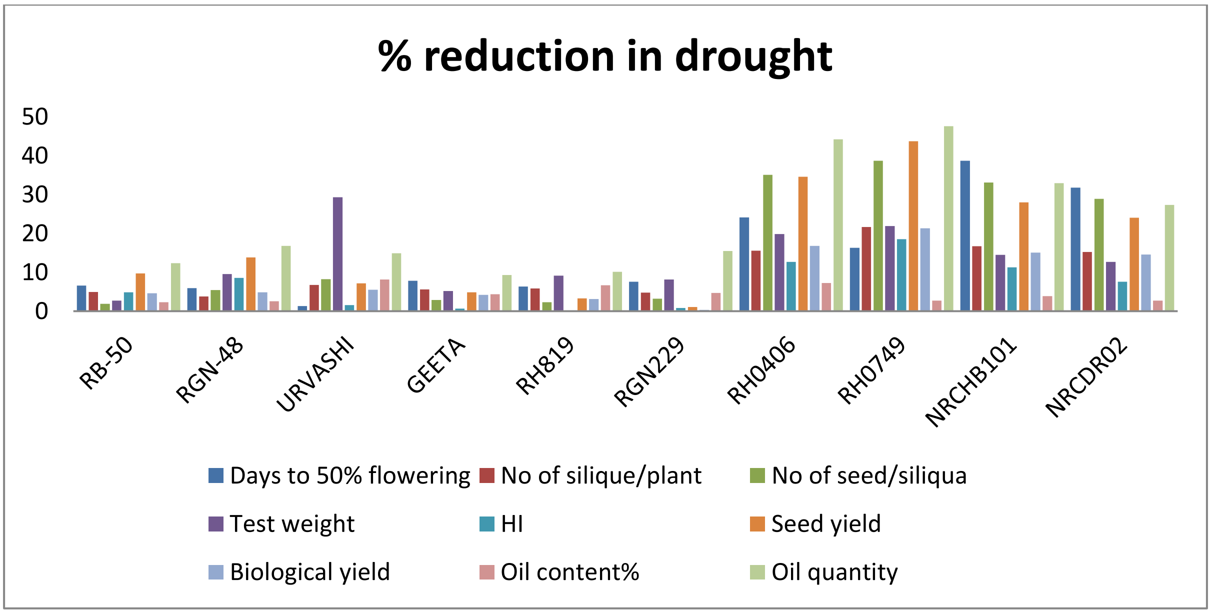

Fig. 4: is representing the % reduction of Days to 50 % flowering, No of silique/plant, No of seed/ siliqua, test weight, HI, Seed yield, Biological yield, Oil content (%), and oil quantity under drought stress in ten Indian mustard genotype .

DISCUSSION

Plant yield or economic biomass production is very crucial for agriculturist point of view to feed food for exponentially growing population. Drought is considered as major factor for looming or yield penalty for all important major agricultural crops. Various yield-determining physiological traits in plants are responding to drought situation. Yield integrates many of these physiological trait in a complex way therefore integration and response of yield trait under drought are extremely important to develop drought tolerance variety and reduce yield penalty under stress environmental conditions. It is strongly accepted that understanding of a physiological and molecular basis may help target the key traits that limit yield. Such an approach may complement conventional breeding programs and hasten yield improvement[4]. SPSS analysis significantly revealed on plant height, days to 50% flowering, test weight, HI, SY, BY, oil content and oil quantity among different landraces. Time of flowering is an important trait of a crop adaptation to the changing environment, particularly when the crop season is restricted by terminal drought and heat. Developing short-duration varieties has been an effective strategy for minimizing yield loss from terminal drought, as early maturity helps the crop to avoid the period of stress mainly in winter crop[13,21]. However reduction in crop duration below optimum especially during reproductive stage would pay yield penalty. Seed yield in GEETA and NHCBH-101 were lowest due to number of seed/ silique, number of siliqua/plant, test weight and HI supported work of Champolivier *et al*[5]. Seed yield in RH-0749 and RGN-48 were higher under control condition because of maintain higher number of seed/siliqua, number of siliqua/plant, TW, and HI. Oil content was observed higher in URVASHI because of negative correlation between test weight and oil content. Percent reductions under drought in observed trait **(Fig.4)** were higher in case of URVASI and NHCBH-101 which lead to more susptibility to drought. Furthermore, lower pay of yield component under drought was observed in RB-50 and RGN-48 lead to drought tolerance mechanism. Therefore, increasing no of siliqua, seed, TW, and HI has been a challenge in front of plant breeder to improve yield and oil quantity under drought condition[23]. Therefore, selection of genotype RH-0749 and RH-0406 under irrigated condition and RGN-48 and RB-50 are suitable for drought condition foe better yield.

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