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Growth analysis and partitioning study of different promising lentil varieties under coastal saline zone of West Bengal

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Abstract
A field experiment was conducted to performance of different lentil (*Lens culinaris* Medik) varieties under saline soil of South 24 Parganas district of West Bengal during rabi season of 2021-2022 and 2022-23 at Instructional Farm, School of Agriculture and allied Sciences, The Neotia University, Jhinga, Sarisha, South 24 Parganas, West Bengal in saline soil. Three important physiological growth analysis parameter were measured namely Average Growth Rate (AGR), Crop Growth Rate (CGR), Relative Growth Rate (RGR). Along with that dry matter partitioning were also measured by measuring Leaf Weight Ratio (LWR), Stem Weight Ratio (SWR) and Root Weight Ratio (RWR). In AGR, RGR and CGR, at 80 DAS, the values reduced considerably in all the varieties. Among the varieties, Maitree, Subrata, BM 8 shown good growth rate. The reduction trend of 80 DAS was not same with 50 DAS. In dry matter portioning, Subrata shown highest stem weight ratio (SWR) and root weight ratio (RWR) in most of the cases whereas, Precoz, Maitree, Hul 57 had comparatively lower value of SWR and RWR. In case of LWR, Precoz and BM 8 reported comparatively higher values. In RWR, the value decreased in second season in both 50 and 80 DAS whereas, in SWR reverse trend is being observed. In LWR, in 50 DAS, the value decreased in second year whereas, reverse trend observed in 80 DAS.

Keywords: Dry matter partitioning, growth, lentil, physiological parameters, variety

Introduction
Among the various cool season food legumes (CSFLs), lentil, chickpea, lathyrus and pea are an integral part of the Indian food habit (Saxena *et al.*, 2000) [8]. Lentil (*Lens culinaris* Medikus) is a self-pollinating, diploid (2n=14) annual, cool-season legume crop. Lentil is produced throughout the world and is highly valued as a high protein food. The crop is bushy annual in nature and seeds are lens-shaped. Lentil is one of the most important *rabi* pulses in India grown mainly in Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Bihar and West Bengal. These states all together account for 80-90% of the total area under lentil. Lentil seed contains about 24-26% protein, 1.3% fat, 2.1% minerals, 3.2% fibre and 57% carbohydrate (Ali *et al.*,2012) [1]. In West Bengal, lentil is largely grown on alluvial soil in the districts of Murshidabad, Nadia, Dakshin Dinajpur, North 24 Parganas, and South 24 Parganas etc. Major varieties of lentil under cultivation are WBL-58, WBL 77, Asha, Ranjan etc. In the Indo-Gangetic plains, rice-lentil is a very important cropping system and second to the rice-wheat system. In West Bengal lentil seeds are mainly broadcasted before the harvest of rice, and grown as paira crop to utilize residual soil moisture. The growth rates of ten promising lentil varieties *viz*. B-77 (Asha), WBL-58 (Subrata) and WBL-77 (Moitree), Precoz, Ranjan were studied in saline zone of West Bengal through different growth analysis formulas like Crop Growth Rate, Absolute Growth Rate, and Relative Growth Rate. The allocation pattern of the cultivars is also being studied through measuring leaf weight ratio (LWR), stem weight ratio (SWR) and root weight ratio (RWR). Among these varieties, Subrata, Moitree, BM 8 has shown good growth rates. The objectives of the experiment were to find out the suitable varieties of lentil under the saline soil region of West Bengal and to study the growth response of different lentil varieties and dry matter partitioning pattern.

Materials and Methods
A field experiment was conducted to performance of different lentil varieties under saline soil of South 24 Parganas district of West Bengal during *rabi* season of 2021-2022 and 2022-23 at Instructional Farm, School of Agriculture and allied Sciences, The Neotia University, Jhinga, Sarisha, South 24 Parganas, West Bengal in saline soil.

The farm was situated at 22°11′28″ N latitude and 88°11′26″ E longitude with an average altitude of 8 m above mean sea level under coastal saline region of West Bengal. As per analysis of soil samples, the experimental field was a medium land with well-drained gangetic soil (order: Inceptisol), that belonged to the class of clay loam with medium fertility, slightly alkaline in reaction, organic carbon 0.43%, available nitrogen 201.23 kg ha^{-1}, phosphorus 18.63 kg $ha^{-1}$and potassium 137.45 kg ha^{-1}. Organic carbon content in the soil was determined by the volumetric weight combustion method commonly known as Walkley Black method given by Walkley and Black (1934) [30]. Available N content of soil samples was estimated by alkaline permanganate method given by Subbiah and Asija (1956) [9] and presented as kg N ha^{-1}. Available P content of the soil samples was estimated by the Olsen method (Olsen *et al*., 1954) [7]. Available K content was determined by Flame photometer method given by Muhr *et al.* (1965) [6]. Soil pH content was determined with the help of pH meter in 1: 2.5 ratio of soil: water suspension as recommended by Jackson (1973) [4].

The monthly rainfall recorded during rabi season of both the years was very scanty in nature. Maximum and minimum rainfall occurred during cropping period of 2021-22 (45.3 & 3.0 mm) and 2022-23 (38.8 & 0.0 mm) was recorded in the month of March and January respectively. The experiment was laid out in randomized block design involving ten lentil varieties (Subrata, Asha, Ranjan, HUL-57, Bari Masoor 4, Bari Masoor 6, Bari Masoor 7, Bari Masoor 8, Moitree and Precoz) which were replicated thrice. The seeds were sown on plot of 4 × 3 m area in line. Lentil varieties were sown with a spacing of 25 cm × 10 cm after harvesting of kharif rice. Fertilizer was thoroughly mixed with the soil at the time of land preparation @ 20:40:40 kg ha^{-1} N: P_2O_5: K_2O. The data on plant growth were recorded from 5 plants, selected randomly from each plot at 50 DAS and 80 DAS stage of crop. The data obtained in the study were analyzed using 'Analysis of Variance' technique (ANOVA) following standard statistical procedures (Gomez and Gomez, 1984) [3].

Physiological growth parameters

a. Absolute growth rate: It referred to dry weight increase per unit of time. It is expressed as gm.day^{-1}.

$$AGR = \frac{W2-W1}{t_2-t_1}$$

Where,

W_1 = Weight of dry matter (g) at time t_1 W_2 = Weight of dry matter (g) at time t_2

t_2-t_1 = The interval in days

b. Relative growth rate (RGR)

The increase in dry matter of plants is a process of continuous compound interest, wherein the increment in any interval adds to the capital for subsequent growth.

The rate of increment is known as relative growth rate. It was computed by using the Fisher (1971) [11] formula. It is expressed as gm^{-1}.day^{-1}.

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where,

W_1 = Weight of dry matter (g) at time t_1 W_2 = Weight of dry matter (g) at time t_2

t_2-t_1 = The interval in days

$\log_e$ = Natural logarithms (logarithms to the base of 2.3026)

c. Crop growth rate (CGR)

The CGR is the rate of dry matter production per unit ground area per unit time. It is used for the estimation of production efficiency of crop. The CGR was estimated by using the formula of Watson (1952) [12] and expressed in gm.m^{-2}.day^{-1}.

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P}$$

Where,

W_1 and W_2 = whole plant dry weight at time interval t_1 and t_2 respectively.

P = Ground area occupied by the plant (m^2)

d. Leaf weight ratio: Leaf weight ratio was coined by Kvet *et al*., 1971 [5]. Leaf weight ratio is expressed as the dry weight of leaves to whole plant dry weight and is expressed in g g^{-1}.

e. Stem weight ratio: Stem weight ratio is expressed as the dry weight of stem to whole plant dry weight is expressed in g g^{-1}.

f. Root weight ratio: The term root weight ratio is expressed as the dry weight of root to whole plant dry weight is expressed in g g^{-1}.

Results and Discussion

The data of two years showed that the effect of genotypes on different growth parameters were statistically significant. The Absolute Growth Rate (AGR) was recorded two times both the year. First data was taken at 50 days after sowing and another at 80 days after sowing. In the first year of experiment (2021), the (AGR) range at 50 DAS was from 0.022 to 0.041 g/day. The AGR range was little increased in the second year of experiment (2022) at 50 DAS was from 0.028-0.043. In both the year Variety Ranjan show highest AGR at 50DAS 0.041 and 0.043 respectively. Interestingly at 80 days after sowing the rate of AGR was highest in Maitree variety in both the years (0.262 and 0.179 g/day). In second year the AGR at 80 DAS were decreased in each varieties in comparison with the first year. Notably there was no single rainfall in the whole lentil season in the second year. Maitree shown highest Relative growth rate at 50 DAS in both the year (0.539 and 0.538 g/g/day) whereas variety Asha had least RGR after 50 DAS in both the years (0.348 and 0.440 g/g/day). At 80 DAS in the first year Subrata surpassed Maitree and became highest RGR variety with 0.428 g/g/day. In the second year the 80 DAS RGR were decreased in each of the varieties just like AGR. Maitree variety had highest RGR at 80 DAS in the second year of experiment (0.232 g/g/day). Hul 57 and Ranjan had least RGR in the first year and second year of the experiment respectively with 0.312 and 0.281 g/g/day. Ranjan and Precoz had highest Crop Growth Rate (CGR) values at first and second year 50 DAS (0.039 and 0.057 g/m^2/day respectively) whereas Bari Masoor 7 and Asha had least CGR in first and second year with 0.031 and 0.040 respectively. In the first year after 80 DAS Subrata secured highest CGR like RGR also with 0.354 g/m^2/day. In the second year Maitree had highest CGR with 0.232 g/m^2/day. At 80 DAS Hul 57 and

Ranjan had lowest CGR in first and second year respectively with 0.306 and 0.183 gm/sq. m/day. All the varieties have lower CGR in comparison with the first year CGR at 80 DAS. Interestingly this trend is absent in case of 50 DAS for CGR, RGR and AGR.

The data pertaining to the Table 2. exhibited that effect of genotypes on partitioning of the total dry matter content was significant. Leaf weight ratio (LWR) was highest (0.507) in Precoz at 50 DAS in the first year of field experiment whereas, Asha had lowest LWR (0.370) at the same. Next year, Ranjan and BM 8 have lowest (0.329) and highest (0.411) LWR respectively. The LWR value was reduced in second year in all the varieties at 50 DAS.

In 80 DAS, the LWR value ranges from 0.179 to 0.221 in the first year and 0.203 to 0.286 in the second year of the experiment. Asha and Precoz are the varieties with highest LWR at first and second year respectively whereas, Ranjan recorded lowest LWR in 2021-2022 and BM 7 reported lowest LWR at 2022-2023. At 50 DAS, stem weight ratio ranges 0.209 to 0.329 in first year and 0.259 to 0.395 at second year. Precoz and Hul 57 are the varieties with lowest SWR (0.209, 0.259) in the respective seasons at 50 DAS whereas, Subrata secured highest SWR in both the seasons (0.329, 0.395). At 80 DAS, Hul 57 was with lowest SWR (0.200) and Precoz secured highest SWR (0.245). In the next year, Ranjan was with least SWR (0.261) and Subrata was highest with 0.317. In both years, at 80 DAS, the SWR value increased regardless the varieties. Maitree had lowest root weight ratio (0.230, 0.210) at 50 DAS in both the seasons and Subrata secured highest RWR (0.373, 0.324) in both the seasons. Interestingly, at 50 DAS, RWR reduced in all the varieties in the last year of experiment. At 8o DAS, Precoz was the variety with least RWR (0.136, 0.076) and like 50 DAS, Subrata was with highest RWR (0.173, 0.117). At 80 DAS also same trend of reduction of RWR at second year was followed.

Table 1: Absolute Growth Rate (AGR), Relative Growth Rate (RGR), and Crop Growth Rate (CGR) of different lentil genotypes at 50 and 80 DAS

Genotypes	Absolute growth rate (AGR) g/day				Relative growth rate (RGR) g/g/day				Crop growth rate (CGR) $g/m^{-2}/day^{-1}$			
	50 DAS		80 DAS		50 DAS		80 DAS		50 DAS		80 DAS	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
Asha	0.030	0.039	0.251	0.160	0.348	0.440	0.401	0.330	0.033	0.040	0.333	0.215
Ranjan	0.041	0.043	0.256	0.137	0.434	0.528	0.387	0.281	0.039	0.053	0.342	0.183
Subrata	0.030	0.038	0.238	0.157	0.403	0.502	0.428	0.329	0.031	0.041	0.354	0.206
Maitree	0.033	0.041	0.262	0.179	0.539	0.538	0.381	0.337	0.038	0.052	0.309	0.232
Hul 57	0.025	0.032	0.230	0.139	0.388	0.488	0.312	0.284	0.032	0.040	0.306	0.198
BM 4	0.028	0.032	0.228	0.148	0.402	0.504	0.345	0.302	0.037	0.049	0.330	0.212
BM 6	0.022	0.028	0.240	0.160	0.380	0.470	0.319	0.290	0.034	0.042	0.316	0.204
BM 7	0.030	0.034	0.232	0.154	0.396	0.494	0.422	0.329	0.031	0.041	0.354	0.206
BM 8	0.030	0.038	0.251	0.175	0.450	0.523	0.377	0.328	0.040	0.054	0.306	0.227
Precoz	0.032	0.039	0.240	0.172	0.455	0.529	0.349	0.308	0.057	0.057	0.319	0.230
CD (P=0.05)	0.006	0.003	0.010	0.015	0.042	0.026	0.019	0.025	0.006	0.007	0.019	0.022
SE (m)±	0.002	0.001	0.003	0.004	0.014	0.009	0.006	0.008	0.002	0.002	0.006	0.007

Table 2: Leaf Weight Ratio (LWR), Stem Weight Ratio (SWR), and Root Weight Ratio (RWR) of different lentil genotypes at 50 and 80 DAS

Genotypes	Leaf Weight Ratio				Stem Weight Ratio				Root Weight Ratio			
	50 DAS		80 DAS		50 DAS		80 DAS		50 DAS		80 DAS	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
Asha	0.370	0.364	0.221	0.242	0.257	0.311	0.207	0.312	0.255	0.318	0.159	0.097
Ranjan	0.464	0.329	0.179	0.253	0.219	0.305	0.201	0.261	0.317	0.277	0.145	0.103
Subrata	0.417	0.380	0.184	0.204	0.329	0.395	0.270	0.317	0.373	0.324	0.173	0.117
Maitree	0.464	0.399	0.217	0.271	0.306	0.391	0.219	0.306	0.230	0.210	0.166	0.094
Hul 57	0.395	0.361	0.193	0.217	0.222	0.259	0.200	0.309	0.231	0.212	0.157	0.101
BM 4	0.408	0.377	0.214	0.232	0.232	0.277	0.211	0.288	0.245	0.221	0.149	0.080
BM 6	0.380	0.354	0.205	0.227	0.252	0.289	0.222	0.295	0.255	0.233	0.169	0.089
BM 7	0.402	0.367	0.188	0.203	0.217	0.261	0.202	0.301	0.260	0.231	0.171	0.094
BM 8	0.452	0.411	0.203	0.244	0.289	0.384	0.233	0.316	0.278	0.244	0.178	0.090
Precoz	0.507	0.383	0.187	0.286	0.209	0.300	0.245	0.307	0.283	0.317	0.136	0.076
CD (P=0.05)	0.055	NS	0.014	0.043	0.052	0.045	0.044	0.034	0.056	0.041	0.013	0.010
SE (m)±	0.018	0.014	0.005	0.014	0.017	0.016	0.015	0.011	0.019	0.016	0.004	0.003

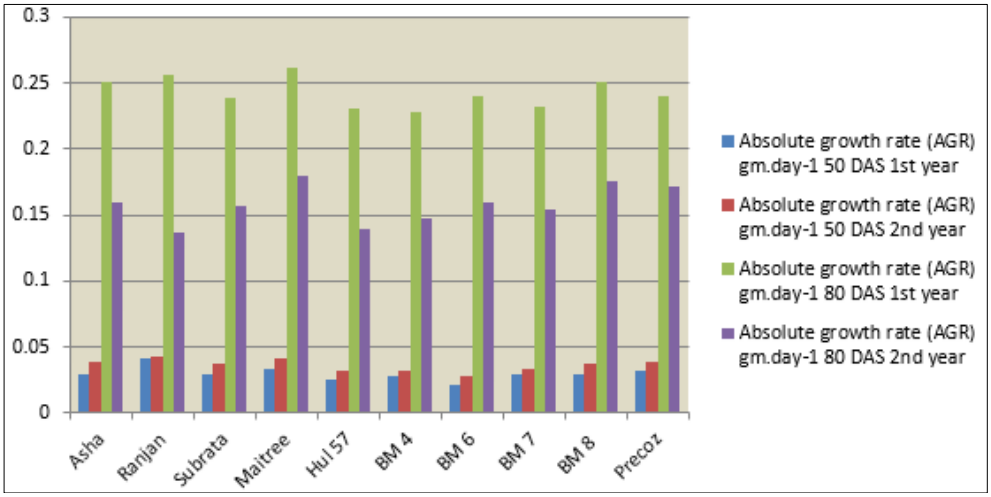

Fig 1: Absolute Growth Rate (AGR) of different lentil varieties at 50 days after sowing and 80 days after sowing at first year (2021-22) and second year (2022-23)

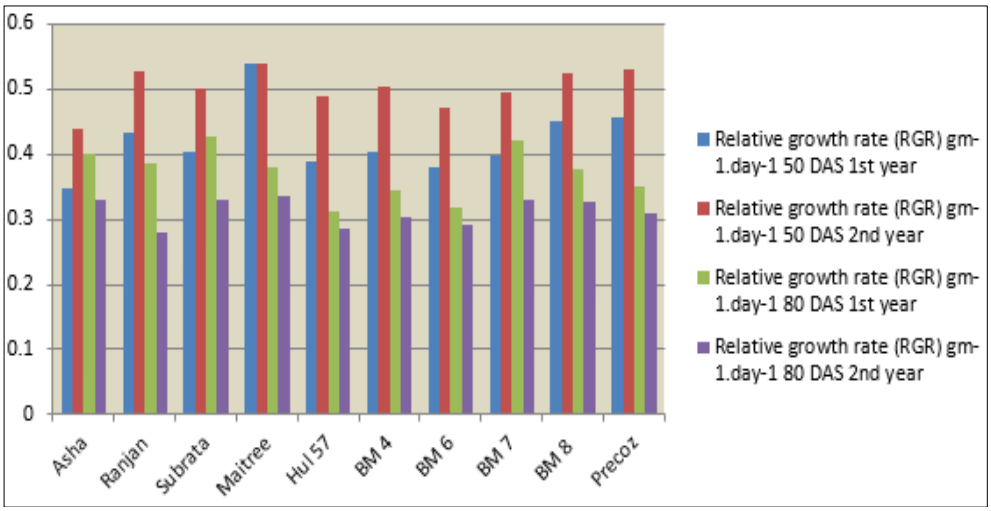

Fig 2: Relative Growth Rate (RGR) of different lentil varieties at 50 days after sowing and 80 days after sowing at first year (2021-22) and second year (2022-23)

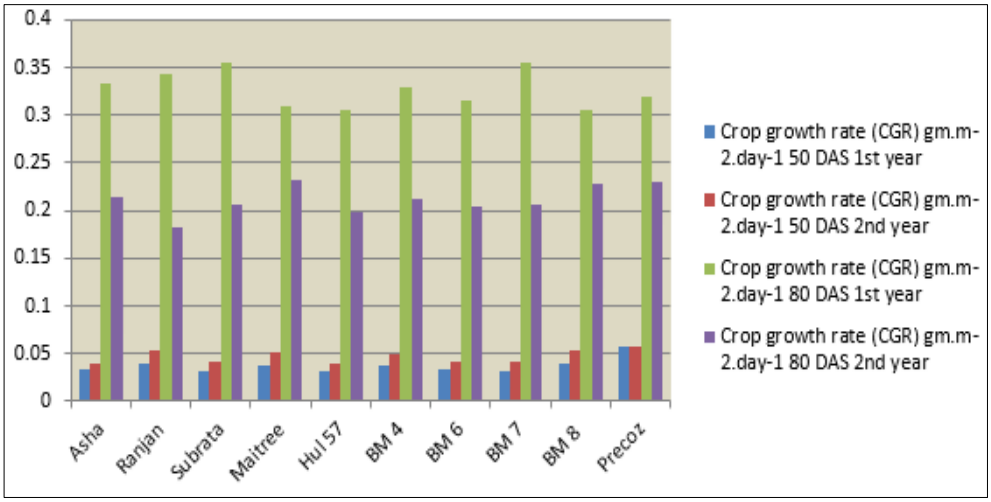

Fig 3: Crop Growth Rate (CGR) of different lentil varieties at 50 days after sowing and 80 days after sowing at first year (2021-22) and second year (2022-23)

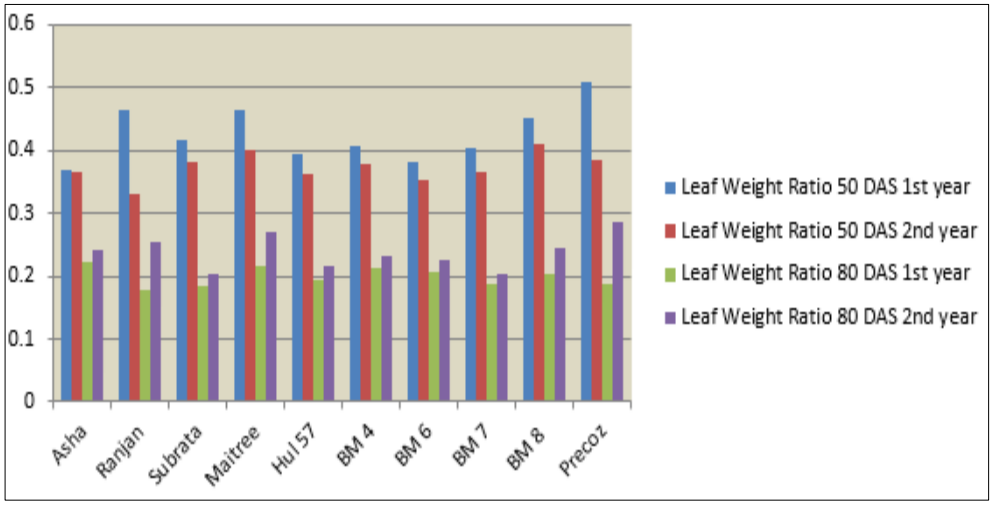

Fig 4: Leaf Weight Ratio (LWR) of different lentil varieties at 50 days after sowing and 80 days after sowing at first year (2021-22) and second year (2022-23)

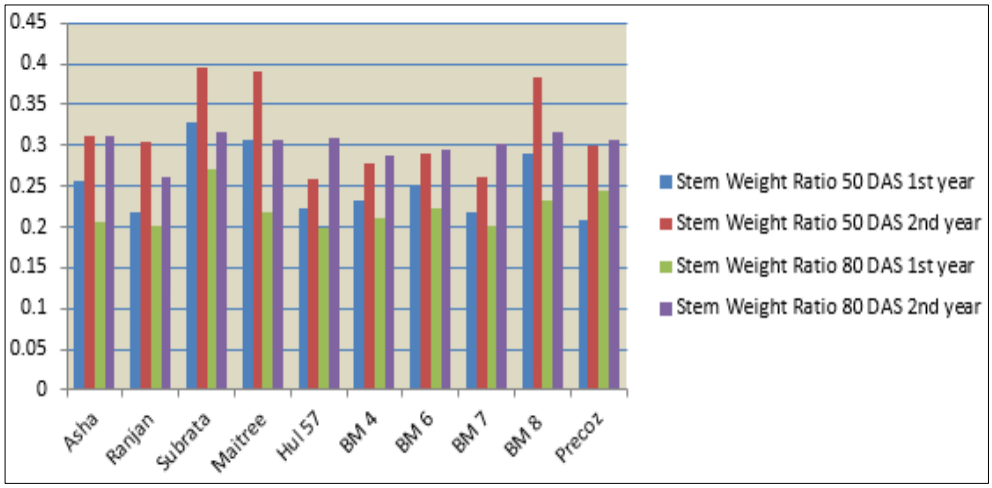

Fig 5: Stem Weight Ratio (SWR) of different lentil varieties at 50 days after sowing and 80 days after sowing at first year (2021-22) and second year (2022-23)

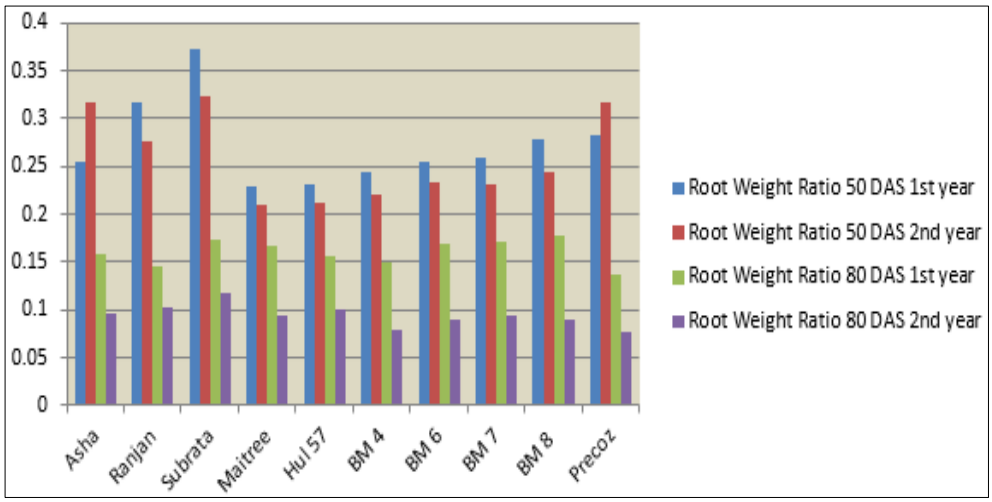

Fig 6: Root Weight Ratio (SWR) of different lentil varieties at 50 days after sowing and 80 days after sowing at first year (2021-22) and second year (2022-23)

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