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Morpho physiological parameters and their relation to seed yield in major seed spice crops

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Abstract

A study was undertaken to find out crop physiology of major seed spices during 2008-2012 at NRCSS, Ajmer. Two contrasting genotypes of fennel, fenugreek and cumin were used for the study. Both the genotypes of all seed spices showed variations in all studied parameters. Growth parameters viz. shoot weight, root weight, shoot length, root length, number of branches showed a definite growth pattern in all crops i.e. increase with age of the plant except shoot and root weight which decrease at maturity. All studied crops showed slow growth up to 60-80 Days After Sowing (DAS) and less variation in different morpho-physiological parameters but after that the variation was very much evident. In all the crops ratio of shoot to root weight, shoot to root length and fresh to dry weight showed direct effect on seed yield per plant. These ratios reveal useful information for yield predictions and screening of germplasm for yield. Among various measured parameters, canopy temperature and difference between canopy temperature and air temperature, ratio of shoot weight to root weight, ratio of shoot length to root length could be an important parameter for screening of germplasm for abiotic stress tolerance in seed spices crops.

Key words : Canopy temperature, cumin, growth parameters, fennel, fenugreek, morpho physiological parameters

Introduction

Seed spices, an important group of horticultural crops, are defined as vegetable products or mixture thereof, free from extraneous matter, primarily used for flavouring, seasoning and imparting aroma in foods. India produces as many as 63 spices owing to its varied agro-climatic regions out of which 20 are classified as seed spices with 36 per cent share in area and 17 per cent share in production of total spice in India. Seed spice crops are extensively cultivated in the arid and semi arid region of India during rabi season covering an area of 13.95 lakh ha with production of 12.34 lakh tones annually. In India, major area covered under different seed spices is 5.47 lakh ha in coriander, 5.94 lakh ha in cumin, 0.93 lakh ha in fenugreek, 0.99 lakh ha in fennel and 0.35 lakh ha in ajwain with their production in the country is 5.28, 3.94, 1.12, 1.42 and 0.26 lakh tones respectively. The productivity of coriander, cumin, fenugreek, fennel and ajwain was 9.63, 6.63, 12.12, 14.33 and 7.57 q/ha respectively (Anonymous 1). Rajasthan and Gujarat states have emerged as "Seed Spices Bowl" and together contribute more than 80% of the total seed spices production in the country.

Seed spice cultivation remains neglected for a long time since holdings under seed spice are small and lands are marginal in fertility. The pace of research on developing new and improved genotypes was also slow. Most of the varieties developed through selection of superior genotypes among available germplasm. During the last decade and half, considerable research has been done on collection, conservation and evaluation of germplasm and production technologies of seed spices. Very little or no work has been carried out on physiological aspects of these crops. Study of crop physiology of major seed spices will be helpful in better understanding of crop behaviour particularly under abiotic stress conditions. Identification of suitable physiological parameter will be useful in evaluating seed spice germplasm for developing stress tolerant varieties. In a previous publication we reported physiological parameters and their relation to seed yield in coriander (Saxena *et al*., 8). In present communication we are reporting morpho-physiological parameters and their relation to seed yield in other three major seed spice crops viz. fennel, fenugreek and cumin.

Materials and methods

An experiment was conducted during 2008 to 2011 at National Research Centre on Seed Spices, Ajmer to work out crop physiology of cumin, coriander, fennel and fenugreek. Morpho-physiological and plant water relation

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parameters were recorded and their relation with seed yield was calculated.

The seeds of two popular and contrasting genotypes of cumin (GC 4 and RZ 209), fenugreek (AM 1 and RMt 305) and fennel (AF 1 and RF 41) were obtained from seed store of NRCSS, Ajmer and sown at NRCSS farm in randomized block design with three replications during rabi season of 2008, 2009, 2010. Morphological parameters viz. fresh weight, dry weight, shoot weight, shoot length, root weight, root length, number of branches, seed yield per plant (gm) were recorded at 45 Days After Sowing (DAS), 60 DAS, 90 DAS and at harvest. From these primary data ratio of fresh weight to dry weight, shoot weight to root weight and shoot length to root length have been worked out. The data were analyzed for genotypic and temporal variation using randomized block design (Panse and Sukhatme, 8). Photosynthetic parameters viz. rate of photosynthesis ($\mu m\ m^{-2}\ s^{-1}$), rate of transpiration ($\mu m\ mol\ m^{-2}\ s^{-1}$), leaf temperature ($^oC$), difference between air to leaf temperature (^oC) and Photosyntheticaly Active Radiation ($\mu\ mol\ m^{-2}\ s^{-1}$) were recorded with the help of CID Photosythesis System. Chlorophyll 'a', chlorophyll 'b' and total chlorophyll (mg g^{-1} fwt) was measured as per Hiscox and Israelstam 3**.** Plant water relation parameters viz. water potential (Mpa), osmotic potential (Mpa) and turgor potential (Mpa) were also recorded at pre flowering and flowering stages. Twig water potential was determined by soil moisture analysis system (Plant Water Status Console, Soil moisture equipment corporation, USA) as described by Scholander *et al.,*(9). Three samples were taken per treatment. Leaves from the same twig were placed in a disposable syringe and put in deep freezer at -4ºC. On next day the syringes were put at room temperature for thawing of frozen leaves. After thawing one drop of cell sap was extracted by pressing the piston of syringe and directly placed on chamber of Vapour Pressure Osmometer (Wescor 5500, USA) to measure osmomolality (OSM Kg^{-1}). A devisor (400) was used to compute osmotic potential in MPa. Turgor potential was calculated by subtracting osmotic potential from water potential (Lange *et al.,* 4). Pearsons Correlation of morpho-physiological parameters with seed yield was worked out using statistical programme of Microsoft excel.

Results and discussion

Fennel (*Foeniculum vulgare* Mill)

Table 1 revealed temporal variation in growth parameters of fennel genotypes. Genotype RF 101 showed more fresh weight ranging from 16.35 g (45 DAS) to 102.26 g at harvest as compare to genotype AF 1. At harvest both the genotypes showed at par fresh weight. RF 101 showed more shoot and root weight up to 90 DAS but at harvest shoot weight of AF 1 was more and root weight was at par. There is no significant variation in number of branches till 60 DAS, however, at 90 DAS and harvest genotype RF 101 showed more (24.91) $plant^{-1}$ branches than AF 1 (23.79 $plant^{-1}$) (Table 4). Shoot length of genotype RF 101 was more than AF 1 throughout the growth period while root length of both the genotypes was at par up to 90 DAS and then genotype RF 101 showed more root length (61.64 cm) than genotype AF 1 (58.26 cm). Dry weight was more in RF 101 (17.59 g $plant^{-1}$at harvest) than AF 1 (17.08 g $plant^{-1}$). Seed yield was, however more in genotype AF 1 being observed 25.38 g $plant^{-1}$ than RF 101 (18.56 g $plant^{-1}$). This may be due to efficient dry matter partitioning in genotype AF 1, hence yielded more as compare to RF 101.

Table 2 showed temporal variations in photosynthetic parameters in two genotypes of fennel. Rate of photosynthesis was more at 60 DAS in both the genotypes. Both the genotypes showed at par transpiration rate at all the stages while genotype RF 101 showed less rate of conductance at 45 and 80 DAS as compare to AF 1. Leaf temperature of genotype AF 1 remained less than RF 101 at 45 and 60 DAS and maintained more difference between air to leaf temperature throughout the growth period.

In fennel up to harvest stage no significant difference was observed in both genotypes. More shoot to root length ratio resulted in higher yield in fennel. Less ratio of shoot to root weight and fresh to dry weight resulted in higher yield. All growth parameters showed positive correlation with yield in both the genotypes which is also reflected at 60 DAS. Fresh to dry weight ratio in both genotypes was negatively correlated with yield (Table 3).

Fenugreek (*Trigonella foenum-graecum* L.)

Table 4 revealed temporal variation in growth parameters of fenugreek genotypes. Genotype RMt 305 showed more fresh weight ranging from 2.809 g at 45DAS to 33.091 g at harvest as compare to genotype AM 1. The difference in fresh weight was more pronounced at harvest where AM 1 genotype showed significantly less weight (24.619 g) as compared to RMt 305. Up to 90 DAS there was no differences in shoot and root weight of both the genotypes, however, genotype RMt 305 attributed less biomass in roots compared to AM 1 but at harvest both shoot and root weight was more in genotype AM 1 than RMt 305. Similar results were obtained for shoot and root length. There was no significant variation in number of branches till 90 DAS, however, at harvest genotype RMt 305 showed more branches (11.75 $plant^{-1}$) than AM 1 (8.29 $plant^{-1}$) (Table 4). No significant variation was observed in dry weight of both the genotypes throughout the growth period. Seed yield was, however more in genotype RMt 305 being observed 6.96 g $plant^{-1}$ than AM 1 (5.39 g $plant^{-1}$). This may be due to efficient dry matter partitioning and more number of branches in genotype

RMt 305, hence yielded more as compare to AM 1.

Table 5 showed temporal variations in photosynthetic parameters in two genotypes of fenugreek. Rate of photosynthesis was more at initial growth stage of both the genotypes. It was more in genotype RMt 305 at 45 and 75 DAS. Photosynthesis rate is directly proportional to PAR absorbed by genotypes. Both the genotypes showed at par transpiration rate at all the stages while genotype RMt 305 showed less rate of conductance at 60 and 75 DAS as compare to AM 1. More conductances provide congenial conditions for transpiration but in present study no defined relations were observed between stomatal conductance and transpiration rate. Leaf temperature of genotype AM 1 remained less than RMt 305 at 60 DAS and harvest and maintained more difference between air to leaf temperature throughout the growth period. Leaf temperature and difference between air to leaf temperature may be an indicator of cool and warm genotype. More difference is attributed to cooler genotypes which transpire more as compare to warm genotypes.

Ratio of shoot to root weight, shoot to root length and fresh to dry weight showed no direct relation with seed yield in fenugreek, however more shoot length and number of branches were recorded in the genotype giving higher yield. Both genotypes differ in the correlation between growth parameters and seed yield. Correlations at 45, 60 and 90 DAS were found non significant while at 120 DAS strong positive correlation between some growth parameters and yield was observed in both the genotypes. Ratio of FWt/DWt and SWt/RWt was negatively correlated with seed yield in genotype AM 1 but not in RMT 305 (Table 6).

Cumin (*Cuminum cyminum* L.)

Table 7 revealed temporal variation in growth parameters of cumin genotypes. Genotype GC 4 showed more fresh weight ranging from 0.539 g at 45DAS to 5.989 g at harvest as compare to genotype RZ 209. The difference in fresh weight was more pronounced at harvest where genotype GC 4 showed significantly more weight (5.989 g) as compared to RZ 209. Up to 90 DAS there were no differences in shoot weight of both the genotypes, however, at harvest GC 4 showed more (4.00 g) as compared to RZ 209 (3.073 g). Genotype GC 4 attributed more biomass to the roots compared to RZ 209. At 75 DAS root weight was significantly more in GC 4 than RZ 209. Shoot length of GC 4, however, less up to 75 DAS but after that it was more as compared to RZ 209. Root length of both the genotypes was at par up to 90 DAS but at harvest it was more in genotype GC 4. There was no significant variation in number of branches till 90 DAS, however, at harvest genotype GC 4 showed more branches (9.49 plant^{-1}) than RZ 209 (8.085 plant^{-1}). Dry weight of genotype GC 4 was significantly more throughout the growth period. Seed yield was significantly more in genotype GC 4 being observed 1.636 g plant^{-1} than RZ 209 (0.678 g plant^{-1}). Genotype GC 4 is having bushy type while RZ 209 is of erect type with less number of branches. Morphology of GC 4 favours better establishment and more yield (1.363 g/plant) than RZ 209 (0.678 g/plant).

Table 8 showed temporal variations in photosynthetic parameters in two genotypes of cumin. Rate of photosynthesis was more at initial growth stage of both the genotypes. GC 4 showed higher rate of photosynthesis at 60 and 75 DAS as compared to RZ 209. Photosynthesis rate is directly proportional to PAR absorbed by genotypes which was more in genotype GC 4. Transpiration rate was higher in RZ 209 than GC 4 at all the stages. In present study no defined relations were observed between stomatal conductance and transpiration rate. Leaf temperature of genotype GC 4 remained less than RZ 209 at 45 DAS but at 60 and 75 DAS GC 4 showed more leaf temperature. Genotype RZ 209 maintained more difference between air to leaf temperature throughout the growth period. Seed yield was almost double in GC 4 (0.60 g/plant) than RZ 209 (0.36 g/plant)

In cumin fresh weight, shoot weight and dry weight is invariably more in genotype GC 4 and produced more seed yield. High ratio of shoot to root weight and shoot to root length showed direct relation with seed yield in cumin, however fresh to dry weight ratio showed no relation with yield. All studied crops showed slow growth up to 60-80 DAS and less variation in different physiological parameters but after that the variation was very much evident. Growth parameters at 60 and 90DAS in genotype RZ 209 reflected same correlation as at 120DAS (Table 9).

Table 10 and 11 showed total chlorophyll content and plant water relation parameters in fennel, fenugreek and cumin. In fennel, total chlorophyll content was more in both RF 101 anf AF 1 at 100 DAS. At both the stages genotype RF 101 showed more turgor pressure (0.570 and 0.543 at pre flowering and flowering stages respectively as compared to 0.286 and 0.273 in AF 1). Though, water potential at both the stages was higher in genotype AF 1. Water relations changed dramatically when plants were exposed to water or salinity stress. Lower water potential under stress conditions is an established plant response to water stress. (Greenway and Munns, 2). The situation regarding turgor potential is also in conformity with earlier inferences. The turgor potential was invariability positive. This may be attributed to a favourable water balance (Morgan, 5).

Chlorophyll a, b and total chlorophyll was more in genotype RMT 305 at 75 and 90 DAS. Genotypic variation was not significant at both the stages. A slight negative turgor

was observed in genotype AM 1 at pre flowering stage and in RMt 305 at flowering stage. However, no difference was observed in water potential of both the genotypes at both stages.

In cumin, total chlorophyll was more in genotype RZ 209 at 75 and 90 DAS (0.98 and 1.629 mg/g FWt) as compared to genotype GC 4 where total chlorophyll was 0.854 and 1.28 mg/g FWt at 75 and 90 DAS. Interestingly, genotype RZ 209 was able to maintain more turgor potential (0.285) up to flowering stage while at flowering stage GC 4 showed more turgor potential (0.322).

Conclusion

This is the first study on crop physiology of seed spices. The information generated will be very useful for screening of germplasm for various characters including abiotic stress. A large number of germplasm can be screen with one or two selected physiological parameters.

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Table 1. Temporal variation in growth parameters in fennel

Variety	Fresh weight (g)	Shoot weight (g)	Root weight (g)	No. of branches	Root length (cm)	Shoot length	Dry weight (g)	Seed yield (g/plant)
45 DAS								
RF 101	1.41	0.91	0.48	3.09	6.93	16.20	0.28	
AF 1	1.06	0.71	0.34	3.09	6.84	14.94	0.24	
60 DAS								
RF 101	5.66	4.12	1.50	3.53	9.30	26.91	0.62	
AF 1	4.89	2.33	2.55	3.53	9.70	23.15	0.57	
90 DAS								
RF 101	16.35	6.34	10.00	4.40	12.96	38.89	1.86	
AF 1	14.01	5.74	9.11	3.87	12.96	33.27	1.73	
Harvest								
RF 101	102.26	65.49	32.68	24.91	61.64	102.54	17.59	18.56
AF 1	103.07	69.93	33.10	23.79	58.26	91.59	17.08	25.38

Table 2. Temporal variation in photosynthetic parameters in fennel

	PAR (µ mol/m^2/s)	TL (°C)	TA-TL (°C)	Photosynthesis (µ mol/m^2/s)	Transpiration (µ mol/m^2/s)	Conductance (µ mol/m^2/s)	Seed yield (g/plant)
45 DAS							
RF 101	1308.22	30.91	1.90	5.30	1.42	84.05	
AF 1	1145.22	29.86	2.49	4.34	1.34	360.93	
60 DAS							
RF 101	1173.21	32.89	0.66	6.45	1.25	285.07	
AF 1	791.80	31.78	1.42	6.08	1.35	282.55	
80 DAS							
RF 101	1198.46	30.01	0.25	4.18	0.72	66.29	22.23
AF 1	1086.26	30.38	1.28	3.16	0.77	133.06	33.33

Table 3: Growth parameters and their correlation with seed yield in fennel

	Seed Yield/plant (g)							
	45 DAS		60 DAS		90 DAS		120 DAS	
	RF 101	AF 1	RF 101	AF 1	RF 101	AF 1	RF 101	AF 1
FWt	0.153	0.244	0.366	0.085	-0.284	-0.025	0.884	0.837
RWt	-0.190	0.250	0.464	0.051	-0.250	0.089	0.276	0.043
SWt	0.044	0.219	0.297	0.087	-0.280	0.087	0.895	0.816
NuB	-	-	-	-	-0.121	-0.317	0.295	0.260
Rlen	-0.219	0.503	0.174	0.124	-0.344	-0.002	0.050	0.386
Slen	0.033	0.696	0.080	0.108	-0.090	0.225	0.505	0.595
DWt	0.148	0.166	0.164	0.174	-0.006	0.188	0.881	0.846
FWt/DWt	0.069	0.054	0.160	-0.119	-0.153	-0.048	-0.472	-0.585
SWt/RWt	0.242	0.009	-0.288	0.057	-0.176	-0.066	0.015	0.172
Slen/Rlen	0.261	0.357	-0.006	-0.058	0.315	0.191	0.278	0.211

Table 4. Temporal variation in growth parameters in fenugreek

variety	Fresh weight (g)	Shoot weight (g)	Root weight (g)	No. of branches	Root length (cm)	Shoot length (cm)	Dry weight (g)	Seed yield (g/plant)
45 DAS								
RMt 305	2.809	2.121	0.696	4.051	7.676	15.760	0.490	
AM 1	2.680	2.167	0.519	3.893	8.003	16.693	0.578	
60 DAS								
RMt 305	7.777	6.415	1.279	4.083	9.705	23.841	1.284	
AM 1	8.103	5.787	1.795	3.951	10.275	24.634	1.065	
90 DAS								
RMt 305	25.249	20.737	4.359	7.250	12.281	42.217	4.941	
AM 1	24.884	19.770	4.849	7.135	12.875	44.377	4.507	
Harvest								
RMt 305	33.091	26.767	4.214	11.750	12.623	54.153	10.097	6.960
AM 1	24.619	19.844	3.136	8.297	12.785	49.118	9.274	5.392

Table 5. Temporal variation in photosynthetic parameters in fenugreek

	PAR (µ mol/m^2/s)	T leaf (ºC)	TA-TL (ºC)	Photo synthesis (µmol/m^2/s)	Transpiration (µ mol/m^2/s)	Stomatal conductance (µmol/m^2/s)	Seed yield (g/plant)
45 DAS							
RMt 305	981.475	34.365	0.885	9.2	1.605	234.28	
AM 1	1236.37	34.145	1.155	5.425	1.475	77.3	
60 DAS							
RMt 305	1126.33	32.75	0.55	3.305	1.105	163.69	
AM 1	722.93	29.74	2.01	3.17	1.295	407.915	
75 DAS							
RMt 305	874.79	28.64	1.36	3.87	1.12	306.27	
AM 1	770.9	28.94	1.06	3.11	0.97	376.76	
Harvest							
RMt 305	1304.67	37.33	-3.33	2.17	0.74	14.09	3.34
AM 1	1318.49	36.51	-2.51	2.07	0.74	13.94	2.86

Table 6: Growth parameters and their correlation with seed yield in fenugreek

	Seed Yield/plant (g)							
	45 DAS		**60 DAS**		**90 DAS**		**120 DAS**	
	RMT 305	**AM 1**	**RMT 305**	**AM 1**	**RMT 305**	**AM 1**	**RMT 305**	**AM 1**
FWt	0.241	0.301	-0.033	0.036	-0.395	-0.393	0.669	0.835
RWt	-0.152	0.289	-0.123	0.512	-0.410	0.197	0.502	0.845
SWt	0.254	0.286	-0.034	0.437	-0.580	-0.441	0.378	0.635
NuB	0.273	-0.027	-0.156	0.188	-0.298	-0.177	0.694	0.792
Rlen	0.363	0.469	0.102	0.023	-0.144	-0.382	-0.247	0.282
Slen	0.136	-0.003	0.292	-0.054	0.100	-0.519	-0.040	0.670
DWt	0.275	-0.093	-0.307	-0.358	-0.187	-0.339	0.306	0.830
FWt/DWt	-0.2847	0.774	0.3440	0.512	-0.4190	-0.034	0.6100	-0.695
SWt/RWt	0.4270	-0.034	0.1413	0.081	-0.3671	-0.313	0.0882	-0.342
Slen/Rlen	-0.3407	-0.484	0.1648	-0.056	0.1820	-0.173	0.1589	0.569

Table 7. Temporal variation in growth parameters in Cumin

variety	**Fresh weight (g)**	**Shoot weight (g)**	**Root weight (g)**	**No. of branches**	**Root length (cm)**	**Shoot length (cm)**	**Dry weight (g)**	**Seed yield (g/plant)**
45 DAS								
GC 4	0.539	0.398	0.154	3.034	4.986	9.906	0.122	
RZ 209	0.533	0.405	0.124	2.733	5.103	11.682	0.127	
75 DAS								
GC 4	1.553	1.092	0.489	4.551	8.502	11.078	0.350	
RZ 209	1.715	1.446	0.224	4.168	8.217	15.266	0.244	
90 DAS								
GC 4	4.762	3.127	1.653	5.475	12.882	18.434	0.862	
RZ 209	4.071	3.492	0.581	5.483	12.008	14.877	0.425	
Harvest								
GC 4	5.989	4.005	1.397	9.493	15.632	26.099	1.437	1.636
RZ 209	3.313	3.073	0.470	8.085	13.525	24.468	0.863	0.678

Table 8. Temporal variation in photosynthetic parameters in Cumin

	PAR (µmol/m2/s)	**TL (°C)**	**TA-TL (°C)**	**Photo synthesis (µmol/m2/s)**	**Transpiration (µ mol/m2/s)**	**Conductance (µmol/m2/s)**	**Seed Yield (g/plant)**
45 DAS							
GC 4	943.71	32.82	0.99	5.38	1.50	176.12	
RZ 209	1197.73	35.41	1.30	5.17	1.68	95.24	
60 DAS							
GC 4	1155.04	33.41	0.94	5.12	1.15	184.67	
RZ 209	1035.31	33.00	1.80	4.65	1.49	490.60	
75 DAS							
GC 4	1343.40	31.36	2.34	3.91	1.03	132.14	0.60
RZ 209	1062.37	31.14	2.97	2.56	1.15	97.02	0.36

Table 9. Growth parameters and their correlation with seed yield in cumin

	Seed Yield/plant (g)							
	45 DAS		**60 DAS**		**90 DAS**		**120 DAS**	
	GC 4	RZ 209	GC 4	RZ 209	GC 4	RZ 209	GC 4	RZ 209
FWt	0.202	-0.329	0.047	0.089	-0.230	0.363	0.896	0.910
RWt	-0.229	-0.260	0.202	0.261	-0.110	0.326	0.732	-0.199
SWt	0.195	-0.351	0.053	0.093	-0.235	0.364	0.776	0.909
NuB	-	-	-0.159	0.471	0.354	0.256	0.461	0.763
Rlen	-0.343	-0.006	-0.322	0.008	0.479	0.737	0.821	0.623
Slen	-0.352	0.201	-0.370	0.155	-0.283	0.397	-0.122	0.284
DWt	0.249	-0.196	-0.145	0.053	-0.255	0.534	0.981	0.601
FWt/DWt	0.163	0.243	0.538	0.153	-0.111	-0.177	-0.411	0.713
SWt/RWt	0.163	-0.391	-0.309	-0.256	-0.289	0.089	0.345	0.257
Slen/Rlen	0.028	0.238	0.066	0.149	-0.467	-0.218	-0.712	-0.559

Table 10: Chlorophyll a, b and total chlorophyll in genotypes of fennel, fenugreek and cumin at two stages

	Chlorophyll 'a'		**Chlorophyll 'b'**		**Total chlorophyll (g/l)**		**Total chlorophyll (mg/g FWt)**	
	75 DAS	100 DAS	75 DAS	100 DAS	75 DAS	100 DAS	75 DAS	100 DAS
RMT 305	0.023	0.013	0.007	0.002	0.03	0.015	1.494	0.746
AM 1	0.022	0.012	0.004	0.003	0.025	0.015	1.266	0.741
RF 101	0.02	0.024	0.004	0.008	0.024	0.031	1.182	1.566
AF 1	0.021	0.025	0.004	0.008	0.025	0.033	1.24	1.652
GC 4	0.014	0.02	0.003	0.006	0.017	0.026	0.854	1.28
RZ 209	0.016	0.025	0.004	0.008	0.02	0.033	0.98	1.629
RCr 41	0.027	0.022	0.01	0.007	0.036	0.029	1.809	1.446
Acr 1	0.026	0.024	0.009	0.007	0.035	0.032	1.752	1.576

Table 11. Plant water relation parameters at two growth stages

	Pre flowering stage			**Flowering stage**		
	WP (Mpa)	OP (Mpa)	TP (Mpa)	WP (Mpa)	OP (Mpa)	TP (Mpa)
RF 101	0.934	1.501	0.570	1.029	1.575	0.543
AF 1	1.160	1.442	0.286	1.259	1.535	0.273
RCr 41	1.234	1.647	0.413	1.159	1.574	0.415
Acr 1	1.147	1.463	0.317	0.979	1.488	0.505
GC 4	1.212	1.307	0.095	1.176	1.501	0.322
RZ 209	1.121	1.409	0.285	1.219	1.395	0.173
RMT 305	1.337	1.379	0.038	1.410	1.373	-0.037
AM 1	1.377	1.366	-0.014	1.407	1.414	0.008

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