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Effect of Moisture Stress on Sunflower Genotypes at Seedling Stage

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Abstract The experiment with thirty nine sunflower genotypes screened by subjecting them to water strss in the laboratory by treating with PEG (poly ethylene glycol) solution at different concentrations viz., 0.0, -0.2, -0.4, -0.6 and -0.8 MPa. Root length, shoot length and seedling dry weight were observed to be decreased with increase in osmotic stress. Increase in root length as a result of drought stress has also been observed due to higher osmotic adjustment ability of drought tolerant genotypes. The decline in seedling vigor was due to fall in mobilization of reserves to plumule thus preventing their growth under stress. These germination responses are not necessarily correlated with seedling growth response but the drought stress severely reduce the growth and biomass of the plant. However the genotypes differed in response to stress at different concentrations of PEG at various stages of development.

Keywords Sunflower, Drought, Water stress, PEG, Drought tolerance.

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Introduction

Sunflower is one of the fastest growing oilseed crops in India popularly known as "Surajmukhi." Sulflower (*Helianthus annuus* L.) has globally grown in an area of 20 m ha with total prpduction of 12–24 m tones. It is one of the few crop species that originated in North America. In India, sulflower as an oilseed crop was introduced in 1969. In India, sunflower is cultivated in an area of 21.6 m ha with an annual production 1.32 m tones. In fact, large area under sunflower is cultivated under rainfed situation, where intermittent moisture stress is most prevalent. Although the area under sunflower has increased over years in the country, the productivity is still lowest among the sunflower growing countries. Although sunflower has good potential to tolerate drought because of well developed root system. The productivity is still af-

Table 1. Effect of PEG induced stress on root length (cm) in sulflower genotypes.

Sl. No.	Genotypes	Root length (cm) Control 0.0 PMa	Stress -0.2 MPa	-0.4 MPa	-0.6 MPa	-0.8 MPa	Mean
1	GMU-452	13.1	8.3	6.1	3.8	1.77	6.6
2	GMU-519	9.9	7.5	5.1	4.8	3.54	6.2
3	GMU-437	8.5	4.7	4.2	2.2	1.18	4.2
4	GMU-345	8.2	4.4	2.4	1.8	1.47	3.7
5	GMU-310	11.3	6.4	3.9	3.0	2.54	5.4
6	GMU-439	10.6	6.8	5.7	4.3	1.50	5.8
7	GMU-442	9.1	8.8	5.3	2.6	1.21	5.4
8	GMU-337	6.2	6.0	5.0	2.9	1.75	4.6
9	GMU-358	10.0	9.6	5.2	1.9	1.33	5.6
10	GMU-386	5.5	3.2	2.3	1.9	2.19	3.0
11	GMU-520	9.7	5.7	2.8	2.2	1.20	4.3
12	GMU-434	10.6	7.3	4.9	1.8	1.49	5.2
13	GMU-488	11.8	9.3	4.7	2.4	1.67	6.0
14	GMU- 484	7.9	6.4	6.8	2.6	2.27	5.2
15	GP6-760	4.8	4.6	4.4	3.3	1.14	3.6
16	GP6-672	3.9	3.6	3.3	2.6	1.35	2.9
17	GP6-139	9.4	5.0	4.6	3.3	2.35	4.9
18	GP6-657	4.5	3.7	3.8	2.3	1.28	3.1
19	GP6-236	1`2.1	7.8	5.4	3.3	1.92	6.1
20	GP6-122	7.1	6.3	5.7	2.9	2.70	4.9
21	GP6-282	6.4	5.5	3.7	2.8	1.53	4.0
22	GP4-154	4.9	3.3	3.3	1.8	1.27	2.9
23	GP4-1723	6.0	3.5	2.5	2.2	1.31	3.1
24	GP4-2052	6.7	5.3	4.8	3.6	1.28	4.3
25	GP4-548	7.3	5.1	4.4	3.0	1.74	4.3
26	EC-623030	10.7	4.5	3.7	1.9	1.58	4.5
27	EC-512679	8.6	5.4	5.3	3.6	1.67	4.9
28	EC-602013	7.2	5.3	4.9	2.7	1.21	4.3
29	EC-602063	12.8	6.9	6.7	3.1	2.78	6.5
30	EC-601966	11.4	7.2	3.7	2.8	1.96	5.4
31	NDR-71	9.8	6.2	4.3	3.1	0.83	4.8
32	GP2-1746	4.6	3.4	2.8	2.1	0.81	2.7
33	GP-776-2B	5.2	4.2	2.6	2.0	1.52	3.1
34	6D-1	3.0	2.6	1.6	1.6	1.17	2.0
35	APSH-66	6.4	3.5	2.5	2.0	1.31	3.1
36	DRSH-1	7.0	5.2	1.7	1.1	1.40	3.3
37	DRSF-108	3.8	2.7	2.3	1.8	1.63	2.4
38	DRSF-113	8.1	3.3	2.8	1.8	1.30	3.5
39	KBSH-44	3.8	2.8	2.1	1.3	1.17	2.2
Mean		7.9	5.4	4.0	2.6	1.6	
Range		3–13.1	2.2–12.6	1.6–6.8	1.4–4.8	0.81–3.54	
CD (p=0.05)		0.91	0.85	1.06	1.01	0.98	

fected by drought. If drought tolerant sunflower hybrids/varieties are developed, sulflower can be grown successfully under water limiting conditions. In this direction, several seedling, physiological, morphological and biochemical traits have been shown to play a significant role in crop adaptation to water stress.

Materials and Methods

The first experiment was a laboratory experiment conducted from October to December, 2013. A total of 39 sunflower genotypes were screened in laboratory. They were tested against drought stress at germination and seedling stages under laboratory conditions (25±3°C) from October to December, 2013.

Polyethylene glycol with a molecular weight of 6000 (PEC-6000) was used as a drought simulator and four water stress levels of zero (control), -0.2, -0.4, -0.6, and -0.8 MPa were developed by dissolving 0, 11.96, 17.80, 22.36 and 26.19 g of PEG per 100 ml distilled water [1]. Seeds were surface sterilized with 10% Sodium hypochlorite solution for five minutes and then washed three times with distilled water. The seeds of each sunflower genotype were planted in each Petri plate of same size containing filter papers. The experiment was laid out in a completely randomized disign with three replications. A seed was considered germinated when both plumule and radicle had emerged to 5 mm. Root length and shoot length were recorded on 7th day from the start of the experiment. Plant dry weight were recorded after drying seedlings at 70°C to a constant weight. The data were subjected to statistical analysis by following analysis of variance technique.

Results and Discussion

Root length (cm)

Effect of PEG induced stress on root length in sunflowe genotypes is presented in Table 1. Repressing effect of PEG induced stress was observed on root length. Mean root length was 7.9, 5.4, 4.0, 2.6 and 1.6 cm under 0.0, -0.2, -0.4, -0.6 and -0.8 MPa of moisture stress respectively. Reduction in the osmotic potential from 0.0 to -0.8 MPa led to a significant decrease in the root length in the genotypes examined. In control, the difference in root length ranged from 3.0 cm (6D-1) to 13.1 cm (GMU-452), in -0.2 MPa, it ranged from 2.2 (GP6-672) to 12.6 cm (GMU-337), in -0.4 MPa, it ranged from 1.6 (6D-1) to 6.8 cm (GMU-

Table 2. Effect of PEG induced stress on shoot length (cm) in sulflower genotypes.

Sl. No.	Genotypes	Shoot length (cm) Control 0.0 PMa	Stress -0.2 MPa	-0.4 MPa	-0.6 MPa	-0.8 MPa	Mean
1	GMU-452	7.2	5.5	4.8	1.7	1.7	3.4
2	GMU-519	8.3	4.5	2.1	1.8	1.3	3.6
3	GMU-437	5.3	1.9	1.8	1.9	0.8	2.3
4	GMU-345	7.5	3.5	1.0	0.9	0.9	2.8
5	GMU-310	7.9	6.4	5.2	1.8	1.4	4.5
6	GMU-439	8.4	4.5	0.7	2.6	0.9	3.4
7	GMU-442	6.6	5.4	2.5	1.3	1.2	3.4
8	GMU-337	5.6	5.3	3.3	1.2	0.7	3.2
9	GMU-358	7.2	5.6	2.3	2.0	0.9	3.6
10	GMU-386	6.5	4.4	2.7	2.4	2.0	3.6
11	GMU-520	8.3	4.7	2.6	1.6	0.7	3.6
12	GMU-434	9.3	5.5	3.1	1.1	1.2	4.0
13	GMU-488	10.5	6.6	3.3	1.9	1.5	4.8
14	GMU-484	9.7	5.5	3.7	2.9	2.1	4.8
15	GP6-760	7.8	6.1	4.4	2.8	1.4	4.5
16	GP6-672	7.3	3.7	2.9	2.3	1.6	3.6
17	GP6-139	9.3	5.5	4.1	2.8	2.5	4.8
18	GP6-657	5.2	4.4	3.9	2.6	1.3	3.5
19	GP6-236	9.8	6.5	4.4	2.7	1.5	5.0
20	GP6-122	6.6	6.4	5.1	2.7	1.1	4.4
21	GP6-282	7.6	4.7	5.1	2.8	1.8	4.4
22	GP4-154	3.7	3.6	3.0	1.5	1.1	2.6
23	GP4-1723	6.1	5.7	2.5	1.8	1.4	3.5
24	GP4-2052	8.4	5.6	4.6	2.7	1.1	4.5
25	GP4-548	5.7	4.4	3.6	2.4	1.5	3.5
26	EC-623030	9.3	4.4	2.7	1.6	1.6	3.9
27	EC-512679	7.5	6.4	4.2	3.4	1.0	4.5
28	EC-602013	6.6	5.6	3.0	1.6	1.1	3.6
29	EC-602063	11.2	6.5	5.9	2.4	1.8	5.6
30	EC-601966	8.3	6.3	2.9	1.9	1.1	4.1
31	NDR-71	6.4	4.1	2.6	2.3	2.0	3.5
32	GP2-1746	4.6	3.5	2.6	2.0	1.1	2.8
33	GP-776-2B	7.4	4.6	2.9	2.0	1.7	3.7
34	6D-1	3.5	3.3	1.9	1.8	1.7	2.4
35	APSH-66	6.6	4.3	2.6	2.3	2.0	3.6
36	DRSH-1	7.4	5.7	3.2	1.8	1.3	3.9
37	DRSF-108	4.5	2.9	2.5	1.8	1.8	2.7
38	DRSF-113	8.4	2.6	3.1	2.7	1.6	3.7
39	KBSH-44	3.6	3.5	2.2	1.8	1.3	2.5
Mean		7.2	4.9	3.2	2.1	1.4	
Range		3.5– 11.2	1.9– 8.4	0.7– 5.9	0.9– 3.4	07– 2.5	
CD (p=0.05)		1.72	1.64	0.95	0.40	0.65	

484), in -0.6 MPa, it ranged from 1.1 (DRSH-44) to 4.8 cm (GMU-519) and in -0.8 MPa, it ranged from 0.81 (GP2-1746) to 3.54 cm (GMU-519).

With increase in the osmotic stress, the root length decreased in genotypes. Increase in root length may be due to the diversion of dry matter to the root in search of moisture [2]. Increase in root length as a result of drought stress has also been observed due to higher osmotic adjustment ability of drought tolerant genotypes [3, 4]. Chun et al. [5] reported increase in root length occurred at the expense of lateral root number. At maximum stress, reduction in total root length occurred.

Therefore, it can be concluded that longer root length helps to explore moisture and nutrients from deeper soil profile. This phenomenon is important especially when water supply is limited.

Shoot length (cm)

Effect of PEG induced stress on shoot length in sunflower genotypes is presented in Table 2. Shoot length decreased under osmotic stress. The mean shoot length of sunflower genotypes was 4.9, 3.2, 2.1 and 1.4 cm in -0.2, 04.4, -0.6 and -0.8 MPa osmotic stress treatments respectively, when compared to 7.2 cm in control. Genotypes showed variation in shoot length in response to the PEG induced stress. At -0.2 MPa osmotic stress treatment, GMU-488 was found to be superior (6.6 cm), while minimum shoot length was recorded GMU-437 (1.9 cm). At -0.4 MPa osmotic stress, EC-602063 was found to be superior (5.9 cm), while minimum shoot length was recorded by GMU-439 (0.7 cm). At -0.6 MPa osmotic stress, EC-512679 was found to be superior (3.4 cm), while minimum shoot length was recorded by GMU-345 (0.9 cm). At -0.8 MPa osmotic stress, GP6-139 was found to be superior (2.5 cm), while minimum shoot length was recorded by GNU-337 (0.7 cm).

Shoot length decreased under osmotic stress. Genotypes showed variation in shoot length in response to the PEG induced stress. Singh and Singh [6] reported that decline in seedling vigor was due to fall in mobilization of reserves to plumule thus preventing their growth under stress.

Seedling dry weight (g)

Effect of PEG induced stress on seedling dry weight in sunflower genotypes is presented in Table 3. Total

Table 3. Effect of PEG induced stress on seedling dry weight (mg) in sulflower genotypes.

Sl. No.	Genotypes	Seedling dry weight (mg) Control 0.0 PMa	Stress -0.2 MPa	-0.4 MPa	-0.6 MPa	-0.8 MPa	Mean
1	GMU-452	450	360	320	340	270	348
2	GMU-519	440	350	340	310	270	342
3	GMU-437	440	350	340	380	230	348
4	GMU-345	550	550	500	400	390	478
5	GMU-310	910	810	690	560	430	680
6	GMU-439	620	400	450	370	220	430
7	GMU-442	440	420	370	330	290	370
8	GMU-337	450	440	430	350	460	426
9	GMU-358	560	520	530	440	430	496
10	GMU-386	540	410	390	460	440	448
11	GMU-520	650	530	490	440	450	512
12	GMU-434	860	690	530	530	460	614
13	GMU-488	360	360	360	350	330	352
14	GMU- 484	850	820	590	470	360	618
15	GP6-760	640	670	650	680	680	664
16	GP6-672	730	700	680	580	280	594
17	GP6-139	840	640	650	660	660	690
18	GP6-657	460	430	410	380	340	404
19	GP6-236	980	690	660	640	380	670
20	GP6-122	450	450	410	420	430	432
21	GP6-282	650	550	820	560	540	644
22	GP4-154	450	370	420	380	360	396
23	GP4-1723	640	580	770	540	560	618
24	GP4-2052	550	560	520	420	550	520
25	GP4-548	1000	860	820	740	530	790
26	EC-623030	750	540	490	370	280	486
27	EC-512679	620	370	320	260	250	364
28	EC-602013	850	600	520	520	510	600
29	EC-602063	860	670	680	660	610	696
30	EC-601966	360	360	430	360	330	368
31	NDR-71	1030	930	860	810	610	848
32	GP2-1746	750	640	680	580	590	648
33	GP-776-2B	450	400	510	370	460	438
34	6D-1	560	560	490	420	570	520
35	APSH-66	550	550	620	590	620	586
36	DRSH-1	630	550	560	420	370	506
37	DRSF-108	720	660	640	560	540	624
38	DRSF-113	640	690	660	630	610	646
39	KBSH-44	340	480	380	340	340	376
Mean		631	552	540	477	439	
Range		340–1030	350–930	320–860	260–810	220–680	
CD (p=0.05)		310	260	112	64	54	

dry matter decreased under osmotic stress. The average seedling dry weight on 7th day was tabulated. The average seedling dry weight was 552, 540, 477 and 439 mg on -0.2, -0.4, -0.6 and -0.8 MPa respectively as compared to 631 mg in control. At -0.2 MPa, total seedling dry weight differed from 350 mg (GMU-519 and GMU-437) to 930 mg (NDR-71) At -0.4 MPa, total seedling dry weight differed from 320 mg (GMU-452) to 860 mg (NDR-71). At -0.6 MPa, total seedling dry matter varied from 260 mg (EC-5122679) to 810 mg (NDR-71). At -0.8 MPa, total seedling dry weight differed from 220 mg (GMU-439) to 680 mg (GP6-760). The genotype NDR-71 showed significant higher total seedling dry weight, while GMU-452 recorded minimum value for this character.

Seedling dry weight decreased with the increase in water stress created by PEG-6000. However, different genotypes showed different response under stress environment. Water stress inhibiting seedling growth is also reported by some researchers in other crop like wheat [7] and castor [8]. Some of the genotypes with good germination percentage failed to record good total seedling dry matter. Similar findings were made by Shantha Nagarajan and Rane [9]. According to Salisbury and Floor [10] germination responses are not necessarily correlated with seedling growth response. The varieties having genetic potential to maintain the higher growth under stress conditions are drought toletant.

Conclusion

The present investigation aimed at studying the drought tolerance and mechanism of tolerance in sunflower genotypes. Root length, shoot length and seedling dry weight decreased with increase in osmotic stress. With increase in the osmotic stress, the root length decreased in genotypes. Larger root system of seedling may be useful in maintaining water availability under limited moisture supply. Shoot length also decreased under osmotic stress. Genotypes showed variation in shoot length in response to the PEG induced stress. This decline in shoot length is due to fall in mobilization of reserves to plumule thus preventing their growth under stress. Different genotypes showed different response with respect to seedling dry weight under stress environment. However there was decreasing effect shown.

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