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EFFECT OF SALINITY STRESS ON SEED YIELD THROUGH PHYSIOLOGICAL PARAMETERS IN SUNFLOWER GENOTYPES

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SUMMARY

Sunflower is an important oilseed crop grown under rain-fed situation during winter/summer seasons in Northern Karnataka, India. Most of rain-fed areas have salinity problem resulting in poor yields of sunflower crop. An effort was made to screen available sunflower germplasm against graded salinity levels and relate their yield performance to various physiological parameters. Among the genotypes tested, PAC-36 recorded the highest seed yield (20.9 q/ha) followed by KBSH-1 (19.65 q/ha), MSFH-17 (17.5 q/ha) and Morden (9.95 q/ha). Among the physiological parameters, leaf temperature increased with increasing salinity while osmotic potential, stomatal conductance and transpiration rate decreased with increase in soil salinity in all the sunflower genotypes tested. Dominance of one or more of the physiological attributes in promising germplasm indicated genetic variability in mechanisms of salt-tolerance in sunflower.

Key words: ***Helianthus annus*** **L., soil salinity, yield, physiological parameters**

INTRODUCTION

Soil salinity has become a major factor limiting crop productivity worldwide, especially in arid and semi arid regions. High salt concentration in the soil solution is bound to create high osmotic pressure in the root zone and reduce availability of water and nutrients to plants. Such conditions are known to affect plant physiological activities, which determine crop yield. Under the aegis of ICAR scheme (AICRP) on Management of Salt-Affected Soils and Use of Saline Water in Agriculture, major crops grown in Northern Karnataka have been screened for salt-tolerance (Patil *et al.*, 1992; Uma *et al.*, 1992, 1994; Hebbara *et al.*, 1992, 1996a, 1996b and Muralid-

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harudu *et al.*, 1998). Sunflower is an important oilseed crop grown during winter/summer seasons in this region. An effort was made to screen (on-farm) the best sunflower germplasm available and evaluate them physiologically against salinity stress.

MATERIAL AND METHODS

Both field and pot culture studies were conducted at Agricultural Research Station, Gangavati, Karnataka, India, during winter/summer season of 2001-2002 to evaluate the soil salinity effects on seed yield and physiological parameters in sunflower crop. The field investigation was conducted on farmers' fields with salinity levels of ≅4.0 and ≅6.0 dS/m to evaluate effect of salinity on seed yield. The performance of different sunflower genotypes in field was evaluated through their physiological attributes under pot culture experiment. The pot culture study included five soil salinity levels, from ECe ≅2.0 to ≅10.0 dS/m. Six sunflower genotypes viz., KBSH-1, PHI-64A43, Morden, MFSH-17, APSH-11 and PAC-36 were used in both studies.

Physiological parameters such as leaf temperature, stomatal conductance, and transpiration rate were measured at peak flowering stage using steady state porometer. Osmotic potential in cell sap was estimated as per Janardhan *et al.* (1975). The split plot design was used for field experiments, wherein salinity levels were used as main treatments and genotypes as sub treatments with a plot size of 100 m^2. Yield values from the field experiments were statistically analyzed, whereas only mean values were compared in case of physiological parameters, as supportive data.

RESULTS AND DISCUSSION

The field experimental data indicated that the mean seed yields of all the genotypes decreased from 17.41 to 15.53 q/ha as salinity increased from 4.0 to 6.0 dS/m (Table 1) indicating the effect of salinity on yield. Among the genotypes tested, PAC-36 recorded highest seed yield (20.9 q/ha) followed by KBSH-1 (19.7 q/ha), PHI-64A43 (18.1 q/ha) and Morden (10.0 q/ha). Similar significant negative relationship was observed between soil salinity and sunflower yield by Hebbara *et al.* (1992). Muralidharudu *et al.* (1998) also reported inferiority of Morden in saline soils. The genotypes PAC-36 and KBSH-1 indicated their better performance under saline condition.

Varied yield performance in field by different genotypes was further intensified through variations in physiological parameters of plants under pot culture experiments.

Leaf temperature (°C) increased with increasing soil salinity from 2 to 10 dS/m, irrespective of genotype (Table 2). The leaf temperature was 36.1°C at 2 dS/m, which increased gradually at 4 (36.8°C), 6 (37.1°C), 8 (37.8°C) and at 10 dS/m

(38.4°C). Among the genotypes, PHI-64A43, MSFH-17, APSH-11 and PAC-36 recorded higher mean leaf temperature of >37°C. The genotype KBSH-1 recorded slightly lesser leaf temperature (36.9°C), compared with the others listed above.

Table 1: Effect of salinity stress on seed yield* of sunflower (q/ha)

Genotype	Soil salinity level (ECe dS/m)		Mean
	4.00	6.00	
KBSH-1	20.1	19.2	19.7
PHI-64A43	19.0	17.2	18.1
Morden	10.3	9.6	10.0
MSFH-17	18.1	16.9	17.5
APSH-11	13.9	11.6	12.8
PAC-36	23.1	18.7	20.9
Mean	17.4	15.5	16.5
* mean of 3 locations			
	Salinity	Genotype	Salinity × Genotype
C.D. at 5 %	4.8	2.8	3.75

Table 2: Effect of salinity stress on leaf temperature (°C)

Genotype	Soil salinity level (ECe, dS/m)					Mean
	2.00	4.00	6.00	8.00	10.00	
KBSH-1	36.4	36.5	37.1	37.5	-*	36.9
PHI-64A43	36.3	35.9	37.5	38.1	38.6	37.3
Morden	35.7	36.2	36.4	37.7	38.5	36.9
MSFH-17	35.6	36.9	37.4	37.8	38.6	37.3
APSH-11	36.7	37.9	37.0	37.9	37.7	37.4
PAC-36	35.7	37.5	37.4	37.9	-*	37.1
Mean	36.1	36.8	37.1	37.8	38.4	37.2

Stomatal conductance decreased as salinity in the growing medium increased which, under normal conditions (2 dS/m), was 131.0 mmol/m^2/s and it increased marginally to 135 mmol/m^2/s at 4 dS/m. However, it declined with further increase in salinity and reached 59.9 mmol/m^2/s at 10.0 dS/m. Among the genotypes, Morden and PAC-36 recorded higher mean stomatal conductance (120.9 and 120.4 mmol/m^2/s, respectively), while APSH-11 and KBSH-1 recorded the lowest (79.8 and 87.5 mmol/m^2/s, respectiveli). The genotypes KBSH-1, Morden, MSFH-17 and PAC-36 recorded slightly higher stomatal conductance at 4 dS/m compared with 2 dS/m. Further, with increase in salinity the stomatal conductance in these genotypes decreased. However, PHI-64A43 recorded decreased stomatal conductance with increasing salinity from 2 to 10 dS/m. Both KBSH-1 and PAC-36 registered higher yields but one recorded lower stomatal conductance (KBSH-1) and the other higher

(PAC-36). This indicated that more than one mechanism operate in salt-tolerant germplasms.

Table 3: Effect of salinity stress on stomatal conductance (m mol/m^2/s)

Genotype	Soil salinity level (ECe, dS/m)					Mean
	2.00	4.00	6.00	8.00	10.00	
KBSH-1	147.5	157.0	39.0	6.5	-*	87.5
PHI-64A43	153.5	124.0	98.5	95.5	50.5	104.4
Morden	134.0	149.5	135.5	120.0	65.5	120.9
MSFH-17	88.0	122.0	182.0	102.5	47.0	108.3
APSH-11	120.5	64.0	31.0	107.0	76.5	79.8
PAC-36	142.5	193.5	74.5	71.0	-*	120.4
Mean	131.0	135.0	93.4	83.8	59.9	103.6

Similar trend in transpiration rate as that in stomatal conductance (positively correlated) was observed in all the genotypes at all the salinity levels. It was 19.9 mmol/m^2/s at 2 dS/m, to increase to 32.5 mmol/m^2/s at 4 dS/m. Further, it tended to decline with increasing salinity, reaching 6.9 mmol/m^2/s at 10 dS/m. Among the genotypes, transpiration rate was high in PAC-36 (29.3 mmol/m^2/s) followed by Morden (23.6 mmol/m^2/s) and the lowest value was in KBSH-1 (16.6 mmol/m^2/s).

Table 4: Effect of salinity stress on transpiration rate (m mol/m^2/s)

Genotype	Soil salinity level (ECe, dS/m)					Mean
	2.00	4.00	6.00	8.00	10.00	
KBSH-1	25.9	25.9	10.5	4.2	-*	16.6
PHI-64A43	27.4	28.3	18.0	16.2	4.6	18.9
Morden	26.0	38.5	23.3	21.9	8.2	23.6
MSFH-17	22.8	29.1	23.6	19.6	9.2	20.9
APSH-11	32.6	30.8	16.5	12.2	5.4	19.5
PAC-36	44.8	42.4	16.3	13.7	-*	29.3
Mean	29.9	32.5	18.0	14.6	6.9	21.5

Table 5: Effect of salinity stress on osmotic potential (- bars)

Genotype	Soil salinity level (ECe, dS/m)					Mean
	2.00	4.00	6.00	8.00	10.00	
KBSH-1	29.1	31.1	38.4	40.4	-*	34.8
PHI-64A43	32.4	27.1	30.2	35.4	35.1	32.0
Morden	32.2	32.9	33.6	35.4	35.7	34.0
MSFH-17	34.5	21.5	29.0	28.3	28.3	28.3
APSH-11	19.8	21.6	34.1	37.7	26.6	28.8
PAC-36	23.5	26.8	26.6	33.7	-*	27.6
Mean	28.6	26.8	32.0	35.2	31.4	30.8

* crop failed at 10 dS/m

The osmotic potential (OP) decreased from -28.58 to -31.43 bars as salinity increased from <2 to 10 dS/m. It was slightly higher (negative absolute) at 2 and 4 dS/m, while it declined at 6, 8 and 10 dS/m. Similar findings were also reported by Janardhan *et al.* (1975). Among the genotypes, genetic variations in the response to salinity stress through osmo-regulation were observed. The genotype PAC-36, though it registered high transpiration rate, accumulated less salts (OP, -27.6 bars) in the plant system probably through a salt exclusion mechanism. In case of KBSH-1 with low stomatal conductance, low transpiration rate and high osmotic potential, cytoplasmic osmo-regulation seemed to be the reason behind its better yield performance under saline conditions.

The study revealed large genetic variation amongst the studied sunflower genotypes. They responded differently to salinity stress as measured through various physiological attributes. Various tolerance mechanisms are thought to operate in promising genotypes. Regulation of stomatal conductance and thereby transpiration losses (lower stomatal conductance and transpiration rate) to maintain favorable cell turgidity and ability to withstand relatively higher leaf temperature seem to impart salt-tolerance in genotypes PAC-36 and MSFH-17. In KBSH-1, low stomatal conductance and transpiration loss coupled with its ability to accumulate high concentration of osmolytes (osmo-regulation) in the cytoplasm might have contributed for increased yields under saline conditions.

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INFLUENCIA DEL ESTRÉS PROVOCADO POR SALINIDAD DEL SUELO EN EL RENDIMIENTO DE SEMILLA DE GIRASOL, CONSIDERADO POR LOS PARÁMETROS FISIOLÓGICOS

RESUMEN

El girasol es un cultivo oleaginoso importante, que se cultiva en el cultivo seco, durante la temporada invernal y veraniega, en el estado Carnataca del Norte, La India. La mayor parte de la superficie, que se utiliza para el cultivo seco, tiene problema con salinidad, lo que lleva hasta bajos rendimientos de girasol. Por ello, la germoplasma completa del girasol, ha sido probada a la reacción de varios niveles de salinidad del suelo, y sus rendimientos respectivos, vinculados con diferentes parámetros fisiológicos. Entre los genotipos investigados, PAC-36 e, tuvo el mayor rendimiento de semilla (20.9 q/ha), y luego KBSH-1 (19.65 q/ha) y MSFH-17 (17.5 q/ha). El más bajo rendimiento, lo tuvo Morden (9.95 q/ha). De los parámetros fisiológicos, la temperatura de la hoja se aumentó con el incremento del nivel de salinidad, mientras que el potencial osmótico, la conductibilidad de estomas y el tamaño de transpiración, iban disminuyéndose con el incremento del nivel de salinidad en todos los genotipos investigados. La dominación de uno o más atributos fisiológicos en la germoplasma utilizable, demuestra que en girasol existe una variabilidad genética, en cuanto a los mecanismos de resistencia según la salinidad del suelo.

EFFET DU STRESS SALIN SUR LE RENDEMENT EN GRAINES DE GÉNOTYPES DE TOURNESOL OBSERVÉ AU MOYEN DE PARAMÈTRES PHYSIOLOGIQUES

RÉSUMÉ

Le tournesol est une culture oléagineuse importante des régions alimentées par la pluie en hiver et en été dans l'État du Nord Karnataka, en Inde. La plupart des régions alimentées par la pluie ont des problèmes de salinité qui résultent en un faible rendement. C'est la raison pour laquelle les réactions du germoplasme du tournesol à un niveau supérieur de salinité du sol ont été examinées et le rendement relié à différents paramètres physiologiques. Des génotypes testés, c'est le PAC-36 qui a montré le plus grand rendement en graines (20.9 q/ha), il était suivi du KBSH-1 (19.65/ha) et du MSFH-17 (17.5 q/ha). C'est le Morden (9.95 q/ha) qui a eu le rendement le plus faible. Quant aux paramètres physiologiques, les résultats ont été les suivants : la température de la feuille a augmenté avec un niveau plus élevé de salinité tandis que le potentiel osmotique, la perméabilité des stomates et la transpiration ont diminué avec l'augmentation du niveau de salinité pour tous les génotypes examinés. La prédominance de l'un ou de plusieurs attributs physiologiques dans le germoplasme utilisable montre qu'une variabilité génétique existe dans le tournesol quant aux mécanismes de résistance à la salinité du sol.