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DEMONSTRATION OF GROWTH IMPROVEMENT IN SUNFLOWER (*HELIANTHUS ANNUUS* L.) BY THE USE OF ORGANIC FERTILIZERS UNDER SALINE CONDITIONS

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Abstract

Field experiment was performed with an objective to evaluate the effect of organic fertilizers viz., vermicompost and biogas slurry on various parameters of vegetative and reproductive growth of sunflower irrigated with different concentration of sea salt. Application of only biogas slurry or vermicompost enhanced the vegetative and reproductive yield of sunflower but the highest yield was recorded in combined treatment of the both. Hence this study revealed that application of biogas slurry and vermicompost could be undertaken to replace chemical fertilizers in organic farming for cultivation of sunflower.

Introduction

Organic farming is considered a remedy to cure the ills of modern chemical agriculture. It is essential to develop a strong workable, compatible package of nutrient management through organic resources for various crops, capable of providing all the essential minerals for promoting growth. Vermicomposting is being used increasingly as plant growth media and soil amendments. In vermicompost, accelerated bioxidation of organic matter is achieved mostly by high-density earthworm populations (Dominguez *et al*., 1997; Subler *et al*., 1998). It produces peat like material with high porosity, aeration, drainage water holding capacity and microbial activity which is stabilized by interactions between earthworm and micro-organisms in a non thermophilic process (Edwards & Burrows, 1988). Nutrients present in vermicompost are readily available for plant uptake (Orozco *et al*., 1996; Edwards, 1998).

Its large particulate surface areas provide many sites for microbial activity and retention of nutrients (Shi-Wei & Fu-Zhen, 1991). It comprises of rich microbial populations and diversity, particularly fungi, bacteria and actinomycetes (Edward, 1998; Tomati *et al*., 1987). Because of independence of chemical nutrients, vermicompost promote biological activity, which help in seed germination and provide better root environment. Sainz *et al*., (1998) reported that addition of vermicompost to soil resulted in increased mineral contents i.e., Ca, Mg, Cu, Mn and Zn in shoot tissues of Red Clover and cucumber. Vermicompost contain plant growth regulators and other plant growth influencing materials including humates, produced by microorganism (Tomati *et al*., 1988; Grappelli *et al*., 1987; Atiyeh *et al*., 2002b). Krishnamoorthy & Vajrabhiah (1986) reported the production of cytokinins and auxin in organic wastes that were processed by earthworms. Vermicompost also is reported to contain large amount of humic substances (Senesi *et al*., 1992; Masciandaro *et al*., 1997). Some of the effects of which on plant growth are similar to those of soil applied plant growth regulators (Muscolo *et al*., 1999).

The biogas slurry, a by-product of biogas production generating from cattle dung, is a good source of nitrogen, which can improve crop yield and soil properties (Smith & Elliote, 1990; Prasad & Power, 1991; Pathak *et al*., 1992). As this residue contain considerable amount of other plant nutrients and its use as soil amendments may offer a promissing opportunity to improve crop production Some investigator reported that organic fertilizer increased salt tolerance of some vegetable crops, in cabbage and spinach (El-missery, 2003) and in onion (Saleh *et al*., 2003).

Keeping in view the importance of organic fertilizers, present study was conducted with the following objectives.

a) To determine the productivity of Sunflower by the application of Vermicompost (VC) and Biogas slurry (BGS) as fertilizer.
b) To study the role of these organic manures in increasing the salt tolerance of the crop.

Materials and Methods

Plants were grown in earthen pots (0.28m in diameter and 0.30m deep) having basal holes for leaching irrigation water, filled with 20 kg of sandy loam, to study the effects of vermicompost and biogas slurry with two different levels of salinity created in rooting medium with irrigation of sea salt dilutions. The EC of these three irrigation water were maintained at ECiw (Electrical Conductivity of irrigation water): 0.5dS/m (Control), ECiw: 4.8dS/m (0.3% sea salt solution), ECiw: 8.6dS/m (0.6% sea salt solution). There were five replicate for each treatment. The resultant EC of sand remained at lower side due to 40% leaching practice.

Vermicompost 1kg/pot and biogas slurry 1 litre/pot were mixed with top 10cm of soil. Since seed germination was found irregular under saline conditions, the saline water irrigation was started about two and half week after germination at five-leaf stage. This practice would be equivalent to transfer of young seedling at saline soils. Second and third doze of vermicompost (1/2 kg/pot) and biogas slurry (1/2 lit/pot) was applied at incipient of floral head and seed formation. Seed heads were harvested, threshed after air-drying.

Plant samples of three replicates of each treatment were randomly taken for measuring different vegetative, physiological and biochemical parameters at grand period (after 90 days of sowing) and that of reproductive parameters and mineral analysis of plant parts at harvest.

Observations were taken on following parameters:

Plant height, Stem and disc diameter, leaf number, leaf area fresh and dry biomass of root and shoot were recorded after harvesting the plants. To determine the plant productivity number and weight of seeds per head, % of oil in seeds were estimated.

Leaf water potential and osmotic potential were determined by pressure chamber ARIMAD2 and micro osmette model 5004 respectively. Turgor potential calculated as the difference between water potential and osmotic potential.

Chlorophyll (Maclachlam & Zalik, 1963), total soluble protein (Bradford, 1976), total soluble carbohydrate (Yemm & Willis, 1956) was estimated for the above harvested plants samples.

For mineral analysis of leaf, bracts and seed coat, powdered samples were ashed at 550^{o}C for six hours. The white ash was digested in 2M hot HCL, filtered into a 50 ml of volumetric flask and made volume up to 50ml with distilled water. Na and K in these samples solutions were analyzed using flame photometer (JENWAY PFP7) (Chapman & Pratt, 1982).

The experiment was in completely randomized design with five replicates of each treatment. Data were analyzed by two-way ANOVA. Least significant difference (LSD; P=0.05) values were calculated for comparisons of treatment means.

Results and Discussion

A significant increase in growth is well demonstrated due to application of vermicompost and biogas slurry under non saline soil expressed in terms of plant height, leaf area, stem and disc diameter, fresh and dry biomass for vegetative parameters (Fig. 1) and with reference to number and weight of seeds per plant, weight of 100 seeds and percentage of oil in seeds for yield component (Fig. 2). This increase could be attributed to improvement of the soil structure by increasing the soil water holding capacity, good aeration and drainage, which encourage better root growth and nutrient uptake. Saleh *et al.*, (2003) while working on onion found that organic manure enhanced the availability of certain essential mineral elements and their uptake to the plant during growth period. Similarly Aracnon *et al*., (2004) found a positive effect of vermicompost on vegetative growth and reproductive yield of strawberries. Somasundaram *et al*., *(*2007) reported an increased yield in sunflower under biogas slurry. In the present investigation the best vegetative growth, higher yield of seeds and oil content was obtained under the combined effect of vermicompost and biogas slurry at normal (non saline soil). The increase in yield may be due to the rich nutrient pool, which contribute high seed yield (Lakshman *et al*., 1993; Garg *et al*., 2005).

Positive effects of organic manures on plant growth and yield were not only due to availability of essential minerals but also due to provision of plant growth influencing material such as auxin, amino acids and vitamins produced by their decay which promote the plant growth (Melo & De-Oliveira, 1999)

The vegetative as well as reproductive growth of sunflower was proportionally decreased by increasing salinity of irrigation water (Figs. 1, 2) Similar growth reduction has been reported in sunflower in response to salinity by others (Santos *et al*., 1999; El-Kheir *et al*., 2000). The seed yield was also significantly reduced by increasing salinity, which was reversed showing an increase due to application of above-mentioned fertilizers. Since the toxicity in seed filling, which is a factor related with photosynthesis, could not be controlled by these fertilizers as shown by weight of 100 seeds, the increase in weight of seeds or amount of oil per disc appear to be due to increase in number of seeds only. The reduction in yield was about 39% at soil irrigated with saline water ECiw 4.8 dS/m and 68% at ECiw of 8.6 dS/m which in turn led to decrease seed oil content, which is about 75 % in the highest salinity level (0.6% conc. of sea salt). El-Kheir *et al*., (2000) and Flagella *et al*., (2004) also observed a significant reduction in seed oil yield with increasing salt level in sunflower grown in saline condition.

It is clear from the data shown in Figs. 1&2 that application of organic manures decreased the adverse effects of salinity on vegetative growth as well as on the yield of sunflower. This resultant vigor has not only over come sodium induced toxicity of substrate but also helped in restoring growth up to certain extent. Recovery from sodium induced toxicity by supplement of above mentioned organic fertilizer was comparatively more in plants irrigated with 0.3% sea salt solution (ECiw: 4.8dS/m) than those irrigated with 0.6% sea salt solution (ECiw: 8.6dS/m), due to higher salt content in later.

The application of organic manure under salinity increased the number and weight of seeds per floral disc, which resulted in an increase in seed yield and oil content per floral disc. Amount of oil showed a marked increase from 4.71g to 11.33g in 0.3% sea salt conc. and from 1.92g to 5.35g in 0.6% sea salt conc. of irrigation water.

The results in Figs. 1 & 2 suggest that improvement in growth by the application of vermicompost alone at saline rooting medium was more pronounced than that of biogas slurry.

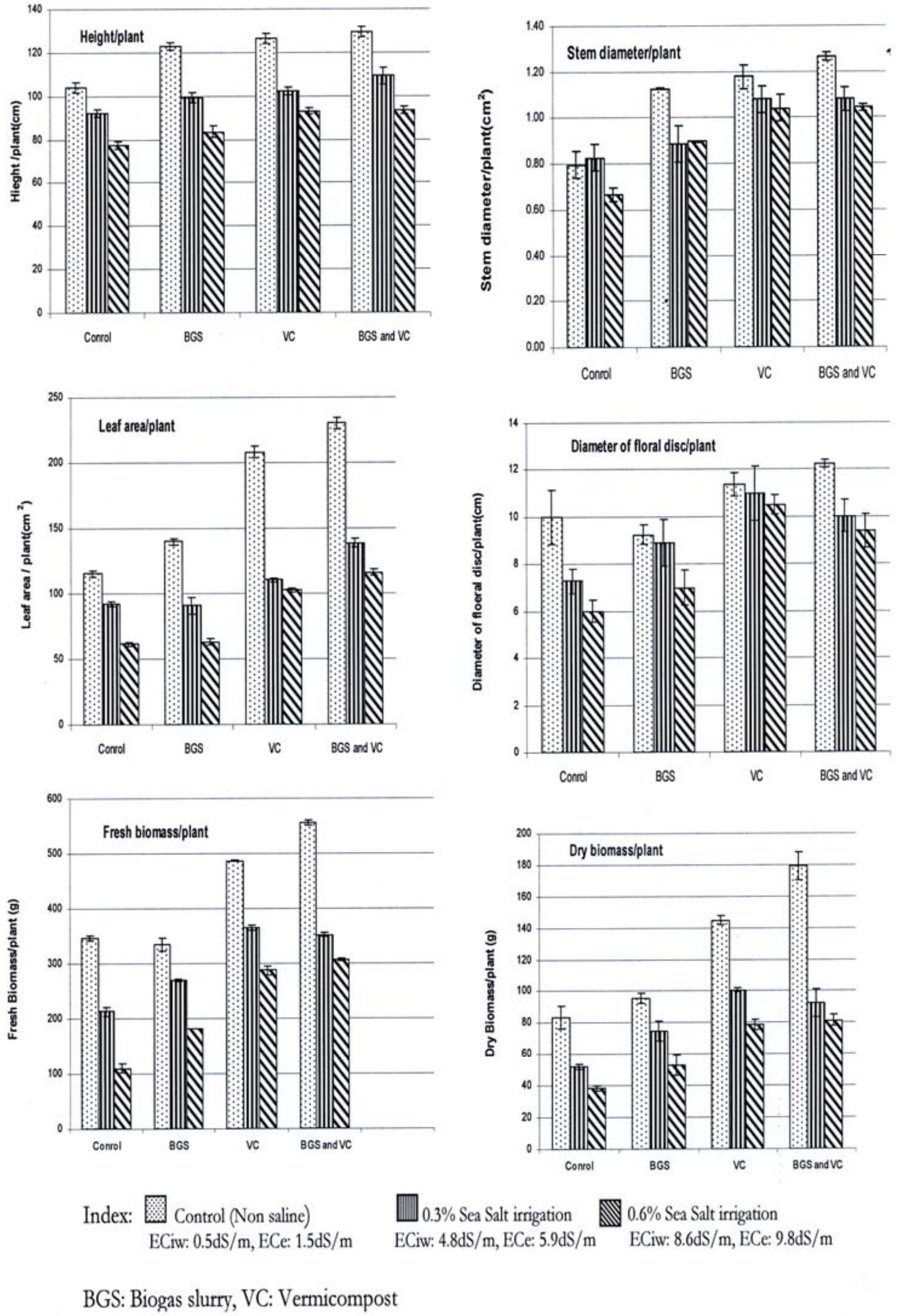

Fig. 1. Effect of organic manure on vegetative growth of sunflower under different salinity levels.

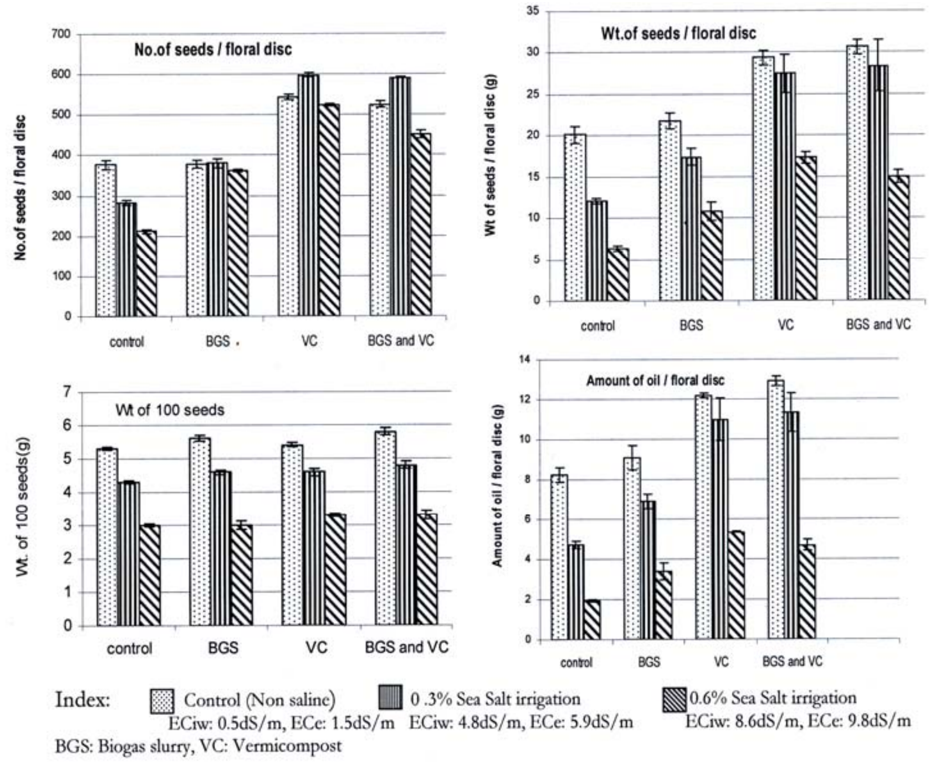

Fig. 2. Effect of organic manure on reproductive yield of sunflower under different salinity levels.

Significant increases in vegetative and yield were also reported by Abou El-Magd *et al*., (2008) on sweet fennel, irrigated with saline well water (5000 ppm) and fertilized with poultry manure.

Data in Table 2 show that Na^+ concentration in sunflower leave, bract and seed coat grown in salinity significantly increased with increasing concentration of salts in irrigation water as compared with plants grown in control (non saline). Where as K^+ concentration show the highest values in sunflower leaves, bract and seed coat, grown in control and it decreased with increasing salinity of irrigation water. Grattan & Grieve (1999) reported that under saline condition, high level of external Na^+ not only interfere with K^+ acquisition by the roots but also disrupt the integrity of root membranes and alter selectivity. The present results are also supported by the findings of Delgado & Sanchez (1997), Santos *et al.*, (1999) who stated that salinity decreases K^+ content in the whole sunflower. During salt stress the decrease in K^+ uptake and an increase in Na^+ influx has been reported by other workers as well (Serrano & Rodriguez-Navarro, 2001). Application of organic manure as fertilizer significantly decreased Na^+ content in plant parts under going saline water irrigation whereas K^+ content showed an increase accordingly in plant parts under saline conditions. Chamani, (2008), Abou El-Magd *et al*., (2008) confirmed that application of organic manure increased the availability of K^+ content, nitrogen and phosphorus to the whole plant.

Table 1. Effect of organic manure on water and osmotic potential of sunflower under different level of saline irrigation water.

Salinity Conc.	Treatment organic manure	Water potential (MPa)	Osmotic potential (MPa)	Turgor potential (MPa)
ECiw: 0.5 dS/m	Control	-0.420 ± 0.049	-1.500 ±0.017	1.080 ± 0.042
EC (soil): 1.5 dS/m	Control + VC+ BGS	-0.120 ± 0.006	-0.900 ± 0.012	0.780 ± 0.006
ECiw: 4.8 dS/m	0.3% Conc. (sea salt)	-1.060 ± 0.006	-2.510 ± 0.017	1.450 ± 0.012
EC (soil): 5.9 dS/m	0.3% + VC+ BGS	-0.690 ± 0.017	-1.710 ± 0.012	1.020 ± 0.006
ECIW: 8.6 dS/m	0.6% Conc. (sea salt)	-1.340 ± 0.006	-3.240 ± 0.012	1.900 ± 0.006
EC (soil): 9.8 dS/m	0.6% + VC + BGS	-0.970 ± 0.012	-2.200 ± 0.017	1.230 ± 0.006
LSD at level 0.05	Salt	0.048	0.032	0.039
	Organic manure	0.039	0.026	0.032
	Interaction	ns	***	***

LSD: Least significant difference, ns: not-significant, BGS: Biogas slurry, VC: Vermicompost

Table 2. Effect of organic manure on Na^+, K^+ content of leaf, bracts and seed coat of sunflower under different level of saline irrigation water.

Salinity Conc.	Treatment organic manure	Na^+ Leaf	Na^+ (mg/g dry wt) Bracts	Na^+ Seed coat	K^+ Leaf	K^+ (mg/g dry wt) Bracts	K^+ Seed coat
Control	Control	0.080 ± 0.012	0.028 ± 0.002	0.018 ± 0.001	0.947 ± 0.009	0.054 ± 0.002	0.064 ± 0.001
ECiw: 0.5d S/m	BGS	0.018 ± 0.003	0.020 ± 0.001	0.014 ± 0.001	0.960 ± 0.046	0.057 ± 0.001	0.066 ± 0.001
EC (soil): 1.5 dS/m	VC	0.018 ± 0.002	0.019 ± 0.002	0.012 ± 0.001	0.966 ± 0.017	0.055 ± 0.002	0.065 ± 0.002
	BGS and VC	0.016 ± 0.003	0.020 ± 0.002	0.012 ± 0.001	0.964 ± 0.012	0.055 ± 0.001	0.070 ± 0.001
0.3% Conc.	Control	0.260 ± 0.005	0.030 ± 0.001	0.020 ± 0.001	0.810 ± 0.017	0.045 ± 0.001	0.061 ± 0.001
(sea salt)	BGS	0.035 ± 0.003	0.023 ± 0.002	0.016 ± 0.001	0.821 ± 0.023	0.047 ± 0.002	0.063 ± 0.001
ECiw: 4.8d S/m	VC	0.036 ± 0.002	0.021 ± 0.001	0.015 ± 0.001	0.827 ± 0.012	0.048 ± 0.002	0.064 ± 0.001
EC (soil) 5.9 dS/m	BGS and VC	0.036 ± 0.001	0.022 ± 0.002	0.016 ± 0.001	0..823 ± 0.006	0.048 ± 0.001	0.064 ± 0.001
0.6% Conc.	Control	0.380 ± 0.007	0.057 ± 0.002	0.026 ± 0.001	0.700 ± 0.023	0.038 ± 0.002	0.054 ± 0.001
(sea salt)	BGS	0.048 ± 0.004	0.051 ± 0.001	0.018 ± 0.001	0.720 ± 0.023	0.040 ± 0.001	0.060 ± 0.001
ECiw: 8.6d S/m	VC	0.048 ± 0.002	0.053 ± 0.002	0.019 ± 0.002	0.740 ± 0.012	0.039 ± 0.002	0.059 ± 0.001
EC (soil): 9.8 dS/m	BGS and VC	0.047 ± 0.001	0.050 ± 0.002	0.017 ± 0.001	0.740 ± 0.012	0.039 ± 0.001	0.060 ± 0.001
LSD at level 0.05	Salt	0.0012	0.0013	0.0019	0.0021	0.0016	0.0014
	Organic manure	0.0014	0.0015	0.0017	0.0024	0.0018	0.0017
	Interaction	***	ns	ns	***	ns	ns

LSD: Least significant difference, BGS: Biogas slurry, VC: Vermicompost ns: not significant

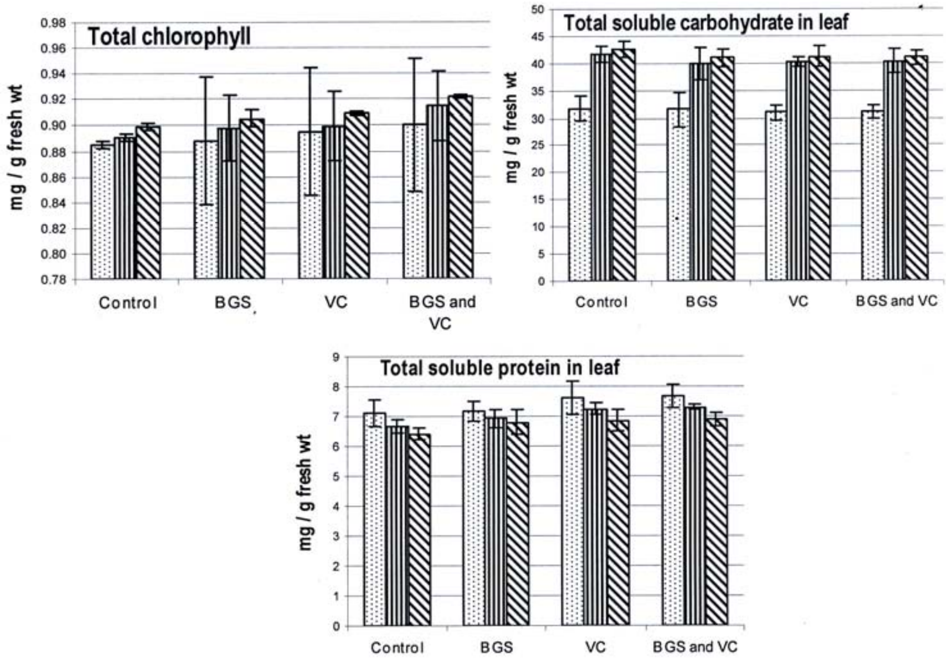

Fig. 3. Effect of organic manure on biochemical parameters of sunflower under different salinity level.

Index: Control (Non saline) ECiw: 0.5dS/m, ECe: 1.5dS/m

0 .3% Sea Salt ECiw: 4.8dS/m, ECe: 5.9dS/m

0.6% Sea Salt ECiw: 8.6dS/m, ECe: 9.8dS/m

BGS: Biogas slurry, VC: Vermicompost

The total chlorophyll and soluble carbohydrate of sunflower did not show any significant increase by the application of organic manure under non-saline condition but these values showed considerable increase in salinity (Fig. 3). Increase in chlorophyll may be due to the rate of quenching of chlorophyll fluorescence which was markedly increased in the salt stressed sunflower leaves and the steady state value of quenching was slightly greater than in control leave (Robert & Robyn 1982). Chlorophyll contents is reported to be reduced at high salinity concentration especially with aged plants (Ahmed *et al*., 1978). The amount of total chlorophyll reported in this paper is a bit low than that reported in sunflower leaves elsewhere (Mohamedin *et al*., 2006) but the trend of its increase under lower level of salinity is the same. Slight fluctuation in amount of chlorophyll in nature could also be a result of varietals differences.

Increase in total carbohydrate with increasing salinity level could be due to the accumulation of starch and soluble carbohydrate in plant under stressed condition. The accumulation of soluble carbohydrates in plants as a response to salinity has been widely reported by other workers (Parida *et al*., 2002; Murakeozy *et al*., 2003). This accumulation has also been attributed to impaired carbohydrate utilization (Munns & Termaat, 1986). It is apparent from the results that salinity significantly affects the content of total soluble carbohydrate and the application of vermicompost and biogas slurry lowered the salinity hazards and prevents the accumulation of starch and carbohydrate.

There appears a significant decrease in total soluble protein content with increased concentration of salts of rooting medium (Fig. 3). Strognov (1974) reported that balance between soluble amino acids and proteins are changed by salinity. Possibly the high salinity increases break down of protein due to proteolytic process. Decrease in soluble protein of leaves has been reported in many plants under salt stress irrespective of their salt tolerance (Ashraf & Waheed, 1993; Parida & Das, 2005). Application of organic manure showed slight increase of protein content under non-saline and insignificant difference under saline condition.

Leaf water potential, osmotic potential and turgor potential are interrelated in plant cells and are markedly affected when plant are exposed to salt stress. In the present study salt stress also showed an adverse effect on water relation of sunflower. Leaf water potential and osmotic potential, significantly decreased with increasing salt concentration of rooting medium (Table 1).

During stress conditions plants alter values of internal water potential in comparison with soil and maintain turgor and water uptake for growth (Tester & Davenport, 2003). This requires an increase in osmotica, either by uptake of soil solutes or by synthesis of metabolic ingredients. To maintain favorable ionic balance in the vacuoles, cytoplasm accumulates low molecular weight compounds, which do not interfere with normal biochemical reactions (Zhifang & Loescher, 2003); and do not inhibit water regulation. Some compatible osmolyte are essential elemental ions and the majority are organic solutes (Yokoi *et al*., 2002), these osmotic solutes build osmotic balance, control water influx (reduce efflux) and enable maintenance of turgor. It is well known that plants under saline condition maintain their turgor by osmotic adjustment (Hernandez & Almansa, 2002; Chaperzadeh *et al*., 2003), as shown in Table 1, highest turgor is maintained at highest level of water stress i.e. 0.6% conc. of sea salt.

It appears from Table 1 that plant irrigated with 0.3% and 0.6% conc. of sea salt have lower water potential and osmotic potential as compared to that plant provided with vermicompost and biogas slurry as fertilizer under the same salinity treatment. Application of organic manures has shown improvement in leaf water potential and osmotic potential. They have reduced the tendency of lowering these parameters and ameliorate the negative effects of sea salt by enhancing the availability of some other essential cat ions and Phytoharmones. K^+ is reported to play predominantly osmotic role in plants (Marshall & Portar 1991).

The application of organic manures increase solute potential of adjoining somatic cells and turgor in leaves is maintained by solute regulation within the protoplast of guard cells. Accumulation of K^+ and some other organic ions increases osmotic activity, causing a reduction in water potential and an inward diffusion of water from the surrounding cells which results in expansion and maintenance of turgor of a cell. Phytoharmone and Ca have also been reported to play important signaling role on the regulation of stomata (Sage & Reid, 1994). Burstrom (1971) stated that turgor pressure of cell is merely the increasing volume of vacuolar sap. Cell expansion and turgor pressure are both caused by inward diffusion of water, resulting from a difference in water potential between the interior and exterior of the cell.

Correlation between productivity in term of seed numbers and seed weight with water potential developed in cells of plants irrigated with sea salt solution and those supplemented with organic fertilizers is presented in Fig. 4. It appears that cells of plants supplied with organic fertilizer show some increase in water potential, which has shown improvement in seed production and their weight.

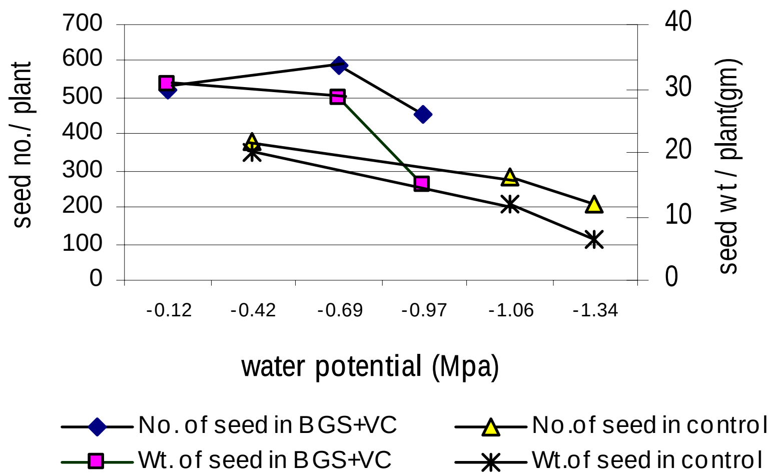

Fig. 4. Correlation between the values of water potential with seed number and seed weight/plant.

Conclusion

Results of present investigation provide evidences that application of vermicompost up to greater extent and biogas slurry up to lesser extent as fertilizers are capable of increasing the yield of sunflower at normal as well as medium saline soil up to profitable extent. These organic fertilizers are also capable of extending threshold values of salts in rooting medium.

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