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Studies on the effect of osmoprotectants on microclimate of soybean (*Glycine max* L. Merrill)

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Abstract
The investigation was carried out on "Studies on the effect of Osmoprotectants on microclimate of soybean (*Glycine max.* L Merrill)" was designed and conducted at agricultural meteorological field in College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *Kharif.* season of 2016.
The yield components *viz.,* seed yield, stalk yield, biological yield, seed index were highest in treatment D_1 (27th June). Among the Osmoprotectant spray S_3 (Potassium Nitrate @ 2 %) produced higher yield and whereas lower yield was recorded in S_1 (Control). It may be due to water stress condition created in the field, dry spell at the time of sowing. Osmoprotectants spray S_3 (Potassium Nitrate @ 2 %) at 45 and 60 Days after sowing were significantly improved all growth parameters, yield attributes over rest of treatments except S_4 (Potassium Schoenite @ 2 %). The Osmoprotectant spray S_3 (Potassium Nitrate @ 2%) recorded highest yield (1341 kg/ha) as compared to other Osmoprotectants spray.
The total Growing Degree Days (GDD) recorded during total crop growth period was highest in D_1 (27th June) i.e. 57.9 ^{0}C as compare to remaining treatments. In case of Osmoprotectants spray S_1 (Control) recorded highest total GDD i.e. 57.71 ^{0}C as compare to remaining Osmoprotectants spray. Whereas lowest total GDD was recorded in D_3 (25th July) i.e. 56.82 ^{0}C. It may be due to different dates of sowing.

Keywords: Soybean, yield, osmoprotectant, water spray, potassium nitrate, potassium schoenite, GDD

Introduction
Soybean (*Glycine max*. L.) is the 'golden bean' or 'miracle bean'. Soybean has been recognized as one of the premier agricultural crops today for various reasons. Soybean plays a major role in the world food trade. Soybean is an important part of the human diet in many developing as well developed countries. In brief, soybean is a major source of vegetable oil, protein and animal feed. It contains about 40 % of good quality protein, 20 % fat, 23 % carbohydrates, 5 % minerals, 8 % moisture, 4 % fibre and reasonable amounts of vitamins. It is one of the most economical protein sources in the world (Ali, 2003) [1]. The climatic condition in Marathwada region of Maharashtra is suitable for cultivation of soybean and the crop is being preferred over others by farmers. Moreover the low cost of cultivation, short duration nature and good market prices are other reasons for area expansion of the soybean crop. However during the last 4-5 years, it was observed that erratic rainfall, gradual increase in temperature during its reproductive cycle and occurrence of dry spell or excess rainfall during its critical growth stages (Flowering, pod formation, and pod filling) caused water stress which hampered both crop growth and agronomic or intercultural operations in the field and reduced the soybean yield to a greater extent.
Weather parameters play an important role in deciding the success or failure of the crop, because these strongly influence the physiological expression, genetic potential of the crop. It is well known that yield from any given crop or variety depends on the availability of certain optimum conditions of solar radiation, temperature, heat units etc. during different stages of soybean crop growth.
Osmoprotectants or compatible solutes are small molecules that act as osmolytes and help plants to survive in extreme osmotic stress. In plants, their accumulation can increase survival under stress e.g. drought. Examples of compatible solutes include betaines, amino acids, and the sugar trehalose. Their specific action is unknown but is thought that they are preferentially excluded from the proteins interface due to their propensity to form water structures. Stress-tolerant plants accumulate specialized polyols (cyclitols) which may provide better stress protection than that of mannitol or sorbitol accumulation.

Also Potassium Nitrate and Potassium Schoenite which is having similar properties that of Osmoprotectants as it overcomes the effects caused by moisture stress during the dry spell period and also increases crop yield, quality, grain fill, weight etc. Goudarz Ahmadvand (2012) [4] studied the effect of seed priming with potassium nitrate on germination and emergence traits of two soybean cultivars under salinity stress. Seed priming with KNO_3 significantly increased germination, emergence percentages, radical and plumule length, seedling dry weight, plant height, leaf area and plant dry weight. Positive effects of priming with potassium nitrate on seeds were greater than other seeds.

Material and Methods

Details of materials to be used and methods to be adopted during the "Studies on the effect of Osmoprotectants on microclimate of soybean (*Glycine max.* L.)". The study will be carried at Agro Meteorological Observatory farm, for Soybean crop and variety MAUS-158 used during *kharif*. season of 2016.

The experiment was laid out in split plot design in which three replications and two factors *viz.*, Date of sowing D_1 (27th June), D_2 (13th July) and D_3 (25th July) and Osmoprotectants spray S_1 (Control), S_2 (Water spray), S_3 (Potassium Nitrate @ 2%), S_4 (Potassium Schoenite @ 2%) and to study the Osmoprotectants spray under different dates of sowing of soybean.

The growing degree days (GDD) were worked out by considering the base temperature of 10 ^{0}C. The total growing degree days (GDD) for different phenophases were determined as per Nuttonson (1955) [5].

Five plants were selected randomly from each treatment. During harvest stage number of branches emerged from main stem was counted per plant and recorded. Pods per plant were counted and recorded at harvest.

The weight of dry matter is an index of productive capacity of the plant. Hence, one representative plant from gross plot was randomly uprooted at each observation i.e. at 30, 45, 60, 75, 90 days and finally at harvest. The roots of plant uprooted for dry matter study from each gross plot were removed. This separated plant was sun dried in the first instance and oven dried at 65 $\pm$ 2 °C temperature till constant weight obtained. The constant weight was recorded as total dry matter weight (g) plant^{-1} for each treatment.

Seed index (gm) was calculated by 100 seeds weight from each net plot were counted and recorded at harvest. Seed yield plot^{-1} was calculated by the plants from each net plot were threshed and grains were cleaned. The cleaned grains obtained from each net plot were weighted in kg which was then converted in to seed yield (kg ha^{-1}) by multiplying with hectare factor. Straw yield plot^{-1}was estimated by fallowing procedure After separation of grains from biological yield, remaining material (Stem + Bhoosa) was considered as straw yield and its final weights were recorded in kg net plot^{-1}, which was then converted in to straw yield (kg ha^{-1}) by multiplying with hectare factor. The biological yield was recorded by the following formula. Biological yield= Seed yield + Straw yield. The data will be statistically analyzed by standard analysis of variance method suggested by Panse and Sukhatme (1985). The variance due to treatment was compared against variance due to error to test the null hypotheses by 'F' test at 5% level of significance.

Date of sowing

The data presented in Table 2 revealed that mean seed yield was influenced significantly by different dates of sowing.

Results and Discussion

In this chapter the data collected during the experiments has been analyzed by using appropriate statistical methods and the results are discussed under the following heads.

Growing degree days (GDD)

The data presented in Table 1 revealed that the mean heat unit requirement from the life cycle and is graphically depicted in Fig. 1.1 i.e. emergence to maturity stage (P_1 to P_{10}) in all dates of sowing and Osmoprotectanst spray total mean was 400.8 ^{0}C day. The mean heat load reported during D_1 (27th June) was 57.9 ^{0}C day and it was followed by D_2 (13th July), D_3 (25th July) and i.e. 57.54 ^{0}C day and 56.82 ^{0}C day. It indicated that the mean heat load was decreased from D_2 to D_3 it may be due to delayed sowing during crop growing season.

It is cleared that, when temperature of air was maximum then it will definitely affect GDD of soybean crop. Date of sowing D_1 (27th June) indicated more heat load (i.e. 57.9 ^{0}C day) than rest of the treatments; it may be due to maximum air temperature prevailed at sowing time. The lowest (i.e. 56.82 ^{0}C day) heat unit required for attaining various phenophases in D_3 (25th July) date of sowing due to effect of temperature and delayed sowing during the crop growing season.

The data presented in Table 1 revealed that the mean heat unit requirement of both the Osmoprotectants spray during crop life cycle was different S_1 (Control), S2 (Water Spray), S3 (Potassium Nitrate @ 2%), S4 (Potassium Schoenite @ 2%), (57.71 ^{0}C), (57.24 ^{0}C), (56.92 ^{0}C), (56.72 ^{0}C). It may be due to the different. Crop duration in above four Osmoprotectants sprays. The results are in confirmatory with the work done by Anil Kumar *et al.*, (2008) [2].

Interaction

The interaction effect between date of sowing and Osmoprotectants spray was found to be non-significant at all stages of the crop growth.

Post-harvest studies

The data on yield attributes viz. 100 seed weight (Seed index), seed yield, straw yield and biological yield were presented in Table 2.

Seed index (g)

From the Table 2 it was revealed that average seed index is 10.7 g.

Date of sowing

The effect of sowing dates on seed index was found non-significant. The data presented in Table 2 revealed that the mean seed index was found to be 10.7 g and the seed was not influenced by sowing dates, osmoprotectants spray and interaction effect of sowing dates x osmoprotectants spray.

Osmoprotectants spray

The effect of Osmoprotectants spray on seed index was found non-significant.

Seed yield (kg ha^{-1})

From the Table 2 it was revealed that seed yield was significantly influenced by treatments.

Sowing of crop on 27th June recorded highest seed yield at all stages of crop growth. Sowing dates of D_1 i.e. 27th June and D_3 i.e. 25th were July at par with each other and significantly superior over D_2 i.e. 13th July. However, the low distribution of rainfall was observed in D_2 (13th July).which might cause significant decrease in seed yield. These findings are in conformity with Anil Kumar *et al.* (2008) [2].

Osmoprotectants spray

The data presented in Table 2 showed that the mean seed yield was influenced significantly by different Osmoprotectants spray at all stages of crop growth. The Osmoprotectant spray S_3 (Potassium Nitrate @ 2%) recorded more seed yield than Osmoprotectants spray S_2 (Water Spray) and S_1 (Control) and it was at par with S_4 (Potassium Schoenite @ 2%). It was due to foliar application of Potassium Nitrate and minimum seed yield observed in S_1 (Control). This increasing seed yield might due to supply of N and K to soybean crop through foliar application of Potassium Nitrate.

Straw yield (kg ha^{-1})

From the Table 2 it was revealed that straw yield was significantly influenced by treatments.

Date of sowing

The data presented in Table 2 revealed that mean straw yield was influenced significantly by different dates of sowing. Sowing of crop on 27th June recorded highest straw yield at all stages of crop growth. Sowing dates of D_1 i.e. 27th June and D_3 i.e. 25th July were at par with each other and significantly superior over D_2 i.e. 13th July. However, the low distribution of rainfall was observed in D_2 (13th July).which might have cause decrease in straw yield. These findings are in conformity with Shinde and Jadhav *et al*. (1996).

Osmoprotectants spray

The data presented in Table 2 showed that the mean straw yield was influenced significantly by different Osmoprotectants spray at all stages of crop growth. The Osmoprotectant spray S_3 (Potassium Nitrate @ 2%) recorded more straw yield than Osmoprotectants spray S_2 (Water Spray) and S_1 (Control) and it was at par with S_4 (Potassium Schoenite @ 2%). It was due to foliar application of Potassium Nitrate and minimum straw yield observed in S_1 (Control) i.e. (897.8). This increasing straw yield might have been due to supply of N and K to soybean crop through foliar application of Potassium Nitrate.

Biological yield (kg ha^{-1})

From the Table 2 it was revealed that biological yield was significantly influenced by treatments.

Date of sowing

The data presented in Table 2 revealed that mean biological yield was influenced significantly by different dates of sowing. Sowing of crop on 27th June recorded highest biological yield at all stages of crop growth. Sowing dates of D_1 i.e. 27th June and D_3 i.e. 25th were July at par with each other and significantly superior over D_2 i.e. 13th July. However, the low distribution of rainfall was observed in D_2 (13th July).which might have cause decrease in biological yield. These findings are in conformity with Shinde and Jadhav *et al*. (1996).

Osmoprotectants spray

The data presented in Table 2 showed that the mean biological yield was influenced significantly by different Osmoprotectants spray at all stages of crop growth. The Osmoprotectant spray S_3 (Potassium Nitrate @ 2%) recorded more biological yield than Osmoprotectants spray S_2 (Water Spray) and S_1 (Control) and it was at par with S_4 (Potassium Schoenite @ 2%). It was due to foliar application of Potassium Nitrate and minimum biological yield observed in S_1 (Control) i.e. (2088). This increasing biological yield might have been due to supply of N and K to soybean crop through foliar application of Potassium Nitrate.

Interaction

The interaction effect between date of sowing and Osmoprotectants spray was found to be non-significant at all stages of crop growth.

Table 1: Growing Degree Days (^{0}C Days) at different phenophases of soybean crop under different treatments

Phenophases	Treatments							
	Date of sowing			Osmoprotectants spray				
	D1: 27th June	D2 : 13th July	D3 : 25th July	S1 : Control	S2 : Water Spray	S3 : Potassium Nitrate @ 2%	S4 : Potassium Schoenite @ 2%	Mean
P1	51	51.3	49.3	50.8	51.3	49.3	44.6	49.65
P2	108.3	103.8	100.6	98.8	103.8	100.6	99.6	102.21
P3	44.5	43.1	45.0	44.5	44.0	45.0	41.5	43.94
P4	23.5	23.8	22.6	25.5	23.5	22.6	25.6	23.87
P5	43.6	45.0	45.7	43.6	45.0	45.7	41.7	44.32
P6	45.0	47.9	45.3	54.0	45.5	45.3	52.6	47.94
P7	45.7	43.2	46.3	43.6	45.3	46.3	44.0	44.91
P8	72.6	71.5	71.2	71.5	70.8	71.2	71.5	71.47
P9	74.0	73.9	72.0	72.8	71.2	72.0	71.8	72.88
P10	70.8	71.9	70.2	72.0	72.0	71.2	74.3	71.77
Total	579	575.4	568.2	577.1	572.4	569.2	567.2	4008.5
Mean	57.9	57.54	56.82	57.71	57.24	56.92	56.72	400.8

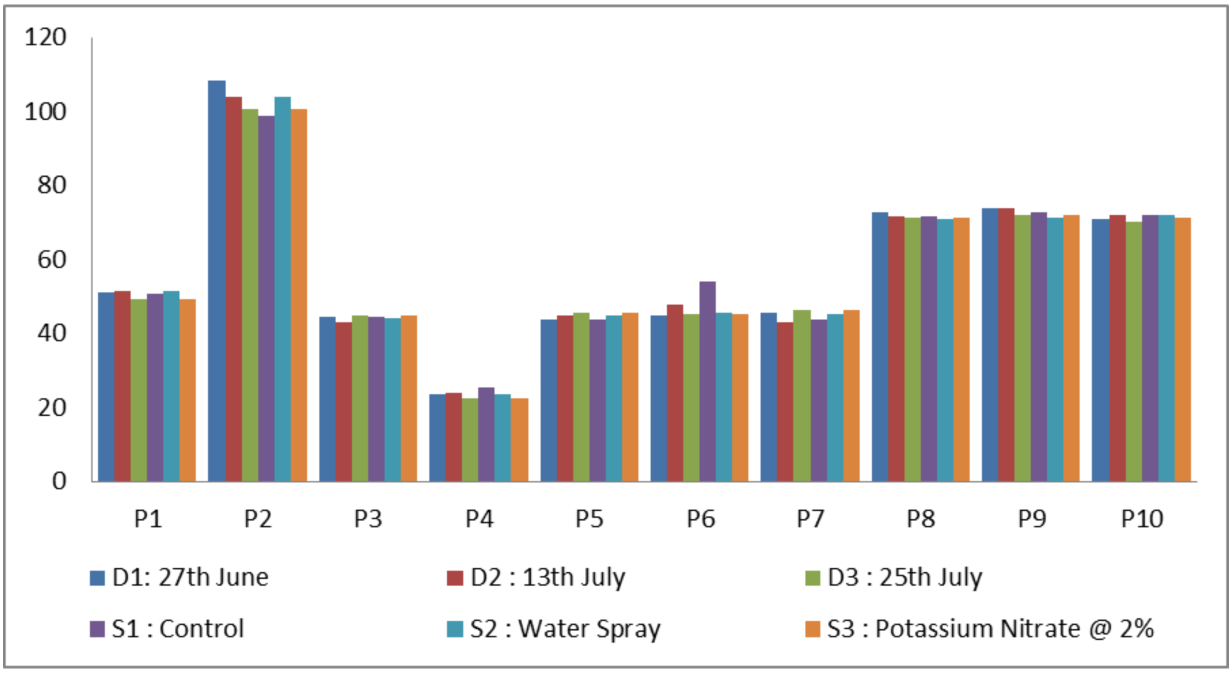

Fig 1: Growing degree days (^{0}C Days) at different phenophases of soybean crop under different treatments.

Table 2: Seed index (g), Seed, Straw and Biological yield (Kg ha-1) of soybean as influenced periodically by different treatments.

Treatment	Seed Index (g)	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)
Dates of sowing (D)				
D_1 : 27th June	10.7	1561	1088.3	2649.6
D_2 : 13th July	10.5	1057	826.05	1884.2
D_3 : 25th July	10.6	1207	934.4	2141.8
SE ±	0.01	630.2	23.23	73.42
CD at 5%	NS	247.4	91.24	288.3
Osmoprotectants Spray (S)				
S_1 : Control	10.5	1190	897.8	2088
S_2 : Water Spray	10.6	1264	920.6	2185
S_3 : Potassium Nitrate @ 2%	10.8	1341	1017	2358
S_4 : Potassium Schoenite @ 2%	10.7	1305	962.8	2267
SE ±	0.05	27.3	29.09	34.3
CD at 5%	NS	8.1	86.4	102.07
Interaction (D×S)				
SE ±	0.1	47.3	50.3	59.5
CD at 5%	NS	NS	NS	NS
G M	10.7	1275	949.6	2225.2

Conclusion

1) The ideal sowing date of soybean in *kharif* season was D_1 (i.e.27th June) and was significant over other dates of sowing.
2) In accordance with the readings of both the meteorological and biometric parameters, the Osmoprotectant spray S_3 (Potassium Nitrate @ 2 %) was found to be superior over the other osmoprotectants sprays. There was no significance difference among the interactions.
3) GDD was more pronounced with the date of sowing D_1 (27th June) then other date of sowing. GDD recorded during total crop growth period was highest in D_1 (27th June) i.e. 57.9 ^{0}C and lowest in D_3 (25th July) i.e. 56.82 ^{0}C. In case of Osmoprotectants spray S_1 (Control) recorded highest total GDD i.e. 57.71 ^{0}C and lowest in (Potassium Schoenite @ 2 %) i.e. 56.72 ^{0}C.
4) Osmoprotectants spray S_3 (Potassium Nitrate @ 2 %) at 45 and 60 Days after sowing significantly improved all growth parameters, yield attributes over rest of treatments.
5) Among the Osmoprotectants spray S_3 (Potassium Nitrate @ 2 %) recorded highest seed yield (1341 kg/ha), Straw yield (1017 kg/ha), Biological yield (2358 kg/ha) and seed index (10.8 g) as compared other Osmoprotectants spray.

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