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Effect of moisture stress management on growth and yield of soybean (*Glycine max* L.) under rainfed condition

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Abstract
An agronomical investigation was carried out held during the *kharif* season of 2022- 23, at the Agronomy Experimental Farm Department, Agriculture college, Latur. To investigate the effect of moisture stress management practices on growth and yield in soybean (*Glycine max* L.) under rainfed condition. The experiment was designed using Randomized Block Design (RBD). The eight treatments were tested three times. The treatments were T_1 - Control, T_2- Straw mulching @ 2.5 ton ha^{-1}, T_3- Straw mulching @ 5.0 ton ha^{-1}, T_4- Hydrogel @ 2.5 Kg ha^{-1}, T_5- Potassium nitrate @ 2% at pre flowering stage, T_6- Potassium nitrate @ 2% at pre flowering and pod development stage, T_7- Kaolin @ 5% at pre flowering stage, T_8- Hoeing at 20 days after sowing. According to the experiment's findings, the Hydrogel treatment, which applied 2.5 kg/ha, significantly outperformed the other treatments in terms of growth attributes such as plant height, number of functional leaves, leaf area, number of branches, and accumulation of dry matter. It also demonstrated yield attributes such as number of seeds pod^{-1}, number of seeds plant^{-1}, weight of pod plant^{-1}, weight of seeds plant^{-1}, seed yield, straw yield, and biological yield. These results were comparable to those obtained from applying 5.0 tons of straw mulching and 2% potassium nitrate at the pre-flowering and pod development stages.

Keywords: Soybean, straw mulching, hydrogel, potassium nitrate, kaolin, hoeing

Introduction
A wonder crop soybean (*Glycine max* (L.) Merill) is a leguminous crop and belongs to family Leguminoaceae with sub family Papilionaceae. Soybean was introduced in India probably as soon as it was domesticated in china (Dupare *et al*. 2008) [4] which contributes 25% of the global edible oil, about two-thirds of the world's protein concentrate for livestock feeding. India is also considered as a secondary centre of domestication for soybean (Khoshoo, 1995) [7]. Soybean contains about 40 percent protein, 23 percent carbohydrates and 20 percent oil. It is a water sensitive crop, requiring substantial water to grow and reproduce (Bhardwaj, 1986) [2].

Straw mulch improves the rate and ultimate count of seedling emergence by lowering the highest soil temperature, raising the lowest soil temperature, and keeping the soil moist in the seed zone (Kitoh and Yoshida, 1996) [6]. Potassium strengthens a plant's ability to withstand a variety of conditions, such as heat, frost, and diseases like mold and mildew in soybeans. According to Thalooth *et al*. (2002) [9], it controls how phosphorus and other elements are used. The white mineral kaolin is easily dissolved in water, non-abrasive, non-toxic, and chemically inert. When suspended in water and sprayed onto leaf surfaces, kaolin evaporates, leaving behind a layer of protective particles (Cantore *et al*., 2009) [3]. By raising antioxidant components including phenolics, flavonoids, and anthocyanins, kaolin may reduce the amount of reactive oxygen species and limit hydroxyl radicals (Dinis *et al*., 2016) [5].

Soybean generally cultivated during rainy season, and it is not generally irrigated. It requires 450 to 900 mm rainfall for better yield and seed quality, depending on growth conditions. It is extremely resilient and performs even under severe water stress conditions. Therefore, in view of the above facts attempts were made to be acquainted with the field experiment entitled "Moisture stress management practices in soybean (*Glycine max* L.) under rainfed condition."

Materials and Methods
The impact of moisture stress management strategies on soybean (*Glycine max* L.) development and yield under rainfed conditions was investigated agronomically at the

Experimental Farm of the Department of Agronomy, College of Agriculture, Latur, during the kharif season of 2022–2023. The experimental location had a texture akin to clay and was leveled. The experimental plot's soil had a clayey texture, was medium in available phosphorous (16.90 kg ha^{-1}), low in available nitrogen (231 kg ha^{-1}), and extremely high in available potassium (434 kg ha^{-1}). The soil was well-drained and had a sufficient ability to hold water.

Eight treatments were replicated three times in the randomized block design (RBD) experiment. The treatments were T_1 - Control, T_2- Straw mulching @ 2.5 ton ha^{-1}, T_3- Straw mulching @ 5.0 ton ha^{-1}, T_4- Hydrogel @ 2.5 Kg ha^{-1}, T_5- Potassium nitrate @ 2% at pre flowering stage, T_6- Potassium nitrate @ 2% at pre flowering and pod development stage, T_7- Kaolin @ 5% at pre flowering stage, T_8- Hoeing at 20 days after sowing. Each experimental unit's gross and net plot sizes were 5.4 m × 4.5 m and 4.5 m x 3.9 m, respectively. On July 09, 2022, seeds were sown using the dibbling method with a seed rate of 5 kg ha^{-1}. 30:60:30 kg NPK ha^{-1} was the RDF for soybean crop. Gross plot dimensions for each experimental unit in the study were 5.4 m x 4.5 m, while net plot dimensions were 4.5 m x 3.9 m. At the time of sowing, pure seed ofthe soybean variety MAUS-158 was sowed using the dibbling technique. The harvest took place on October 18, 2022. The data recorded were statistically analyzed by using technique of analysis of variance.

Results and Discussion

Growth Attributes

Different treatments had a substantial impact on the numerous growth characteristics of soybean, including plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area $plant^{-1}$ (dm^2), number of root nodules, dry matter accumulation $plant^{-1}$, and number of pods $plant^{-1}$ (Table 1). The application of Hydrogel @ 2.5 kg ha^{-1} (T_4) recorded significantly higher plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area $plant^{-1}$ (dm2), no. of root nodules, dry matter accumulation $plant^{-1}$ and number of pods $plant^{-1}$ at various growth stages, which was found to be at par with straw mulching @ 5.0 ton ha^{-1} and Potassium nitrate @ 2% at pre flowering and pod development stage and found significantly superior over rest of the treatments. The results of the present investigation are in accordance with the findings of Ali and Abdel-aal (2021) [1].

Yield attributes

The various yield parameters of soybean *viz*., number of seeds pod^{-1}, number of seeds $plant^{-1}$, weight of pod $plant^{-1}$, weight of seeds $plant^{-1}$, seed yield, straw yield and biological yield were significantly influenced due to different treatments (Table 2). The maximum number of seeds pod^{-1}, number of seeds $plant^{-1}$, weight of pod $plant^{-1}$, weight of seeds $plant^{-1}$, seed yield, straw yield and biological yield were obtained with the application of Hydrogel @ 2.5 kg ha^{-1}, which was at par with the application of straw mulching @ 5.0 ton ha^{-1} and Potassium nitrate @ 2% at pre flowering and pod development stage and found significantly superior over rest of the treatments. The application of Hydrogel @ 2.5 kg ha^{-1} recorded maximum harvest index, which was followed by the application of straw mulching @ 5.0 ton ha^{-1} and Potassium nitrate @ 2% at pre flowering and pod development stage. Similar kind of result was reported by Fidelis *et al*. (2018) [10], Ali and Abdel-aal (2021) [1] and Rajanna *et al*. (2022) [8].

Table 1: Effect of different treatments on growth attributing characters of soybean

Treatments	Plant height at harvest (cm)	No. of branches $plant^{-1}$ at harvest	No. of leaves of $plant^{-1}$ at 60 DAS	Leaf area $plant^{-1}$ (dm2) at 60 DAS	No. of root nodules $plant^{-1}$ at 60 DAS	Dry matter $plant^{-1}$ (g) at harvest	No. of pods $plant^{-1}$ at harvest
T_1: Control	35.37	6.43	15.15	7.49	44.67	15.00	32.33
T_2: Straw mulching @2.5 ton ha^{-1}	41.77	8.20	18.27	7.84	49.33	17.90	35.93
T_3: Straw mulching @5.0 ton ha^{-1}	45.63	9.20	26.91	8.69	55.67	20.13	38.67
T_4: Hydrogel @2.5 kg ha^{-1}	46.77	9.43	28.73	10.03	58.67	21.17	40.00
T_5: Potassium nitrate @ 2% at pre flowering stage	41.57	7.97	22.78	8.47	51.00	18.60	35.00
T_6: Potassium nitrate @ 2% at pre flowering stage and pod development stage	44.70	8.17	24.89	9.19	53.33	19.10	38.33
T_7: Kaolin @ 5% at pre flowering stage	40.53	7.17	17.13	8.96	46.67	15.50	34.62
T_8: Hoeing at 20 days after sowing	42.77	8.73	19.88	9.73	50.33	18.20	35.93
S.E. (m) ±	1.63	0.42	1.19	0.40	2.14	0.77	1.21
C.D. at 5%	4.76	1.23	3.47	1.17	6.27	2.24	3.62
General Mean	42.39	8.16	21.72	8.80	51.21	18.20	36.40

Table 2: Effect of different treatments on yield and yield attributing characters of soybean

Treatments	No. of seeds $plant^{-1}$	Pod yield $plant^{-1}$ (g)	Seed yield $plant^{-1}$ (g)	Seed yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})	Biological yield (Kg ha^{-1})	Harvest index (%)
T_1: Control	72.82	9.84	6.20	1752	2841	4593	38.15
T_2: Straw mulching @2.5 ton ha^{-1}	74.00	11.41	6.63	2350	3202	5590	42.04
T_3: Straw mulching @5.0 ton ha^{-1}	79.76	11.78	8.01	2663	3375	6038	42.54
T_4: Hydrogel @2.5 kg ha^{-1}	81.76	12.21	9.20	2805	3381	6186	45.35
T_5: Potassium nitrate @ 2% at pre flowering stage	75.81	11.56	7.12	2433	3279	5712	42.59
T_6: Potassium nitrate @ 2% at pre flowering stage and pod development stage	77.08	7.33	24.89	2568	3334	5902	45.12

T_7: Kaolin @ 5% at pre flowering stage	73.47	6.44	17.13	2280	3200	5480	41.61
T_8: Hoeing at 20 days after sowing	74.94	6.94	19.88	2400	3255	5655	42.44
S.E. (m) ±	1.72	0.67	1.19	115	120	195	-
C.D. at 5%	5.02	1.97	3.47	337	353	594	-
General Mean	76.20	7.23	21.72	2410	3233	5780	42.48

Conclusion

The application of Hydrogel @ 2.5 kg ha^{-1} (T_4) was proved to be effective for obtaining higher growth attributes *viz*., plant height, number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1} (dm2), no. of root nodules, dry matter accumulation plant^{-1} and number of pods plant^{-1}, which was at par with the application of Straw mulching @ 5.0 ton ha- 1 (T_3) and Potassium nitrate @ 2% at pre flowering stage and pod development stage (T_6) and found significantly superior over rest of the treatments.

The various yield parameters of soybean *viz*., number of seeds pod^{-1}, number of seeds plant^{-1}, weight of pod plant^{-1}, weight of seeds plant^{-1}, seed yield, straw yield and biological yield were recorded maximum with the application of Hydrogel @ 2.5 kg ha^{-1} (T_4), which was followed with the application of Straw mulching @ 5.0 ton ha^{-1} (T_3) and Potassium nitrate @ 2% at pre flowering stage and pod development stage (T_6). The application of Hydrogel @ 2.5 kg ha^{-1} recorded maximum harvest index.

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