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Growth, nodulation and productivity of rainfed soybean (*Glycine max*) as influenced by mulching and anti-transpirants

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ABSTRACT

The research farm of the Punjab Agricultural University in Ludhiana, Punjab, was the site of a field experiment that examined the effects of straw mulching and anti- transpirants on the growth, nodulation, and productivity of soybeans (Glycine max (L.) Merr) during the kharif seasons of 2012, 2013, and 2014. A factorial randomized full block design with three replications was used to lay up the experiment. Over the course of the three years, participants in the study were randomly assigned to one of two mulching levels (wheat straw mulch @ 5 t/ha after sowing or control, no mulch) and one of five anti-transpirants (5% magnesium carbonate, 5% glycerol, 5% sodium carbonate in 2012, 2% sodium carbonate in 2013 and 2014, 1% potassium nitrate, and control). The maximum dry matter/plant, nodulation, plant height, pods/plant, straw yield, and seed production of soybean were reported after applying straw mulch at a rate of 5 t/ha after planting. Compared to not using mulch, seed output was 17.6% higher and rainfall usage efficiency was 22.6% better when straw mulch was used. The net returns (3,037) and gross returns (8,037) from straw mulching were much greater than those from the control group (no mulch). There was no discernible change in soy bean nodulation or seed output after using anti-transpirants. Compared to other anti- transpirants, potassium nitrate had better gross returns, net returns, and benefit-to-cost ratios when applied. By contrast, the control group did not save money by using anti-perspirants. The results show that compared to not mulching at all, applying straw mulch at a rate of 5 t/ha after planting increases soybean seed production.

***Key words*: Anti-transpirants, Economics, Mulch, Nodulation, Soybean**

INTRODUCTION:

One of the most significant oilseed crops, soybeans are typically planted during the kharif season. By incorporating nitrogen into the soil via crop rotation, it serves a crucial purpose in agricultural diversification (Singh and Shivakumar, 2010). According to FAO (2019), in 2017, it was cultivated on 10.60 million hectares of land in India, yielding 10.98 million tons at a productivity of 1,036 kg/ha. Soybean output and area in India are dominated by the states of Maharashtra and Madhya Pradesh, with the most of the land being rainfed. One of the most important variables limiting crop production is soil moisture. Evaporation from soil and transpiration from plants both contribute to its loss. To keep plants' water balance

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possible to utilize this excess agricultural waste as mulch. Soybean cultivation in the hot summer months is made possible by mulching the soil, which controls soil temperature and conserves moisture, creating an ideal soil microclimate. Insufficient soil moisture during the planting and blooming to pod filling stages of soybean agriculture is a major limitation. A high soybean seed yield can only be achieved with soil that is at an ideal moisture level (Singh,2010). Reduced agricultural yields of up to half may be used by water stress in plants in certain parts of the globe (Lisar et al., 2012). Stomatal closure, leaf rolling, osmotic adjustments, reductions and consequent decreases in cellular expansion, and alterations of various essential physiological and biochemical processes can all help plants maintain a favorable water balance when they are under water stress

Poljakoff-Mayber and Gale (2012) found that in semi-arid conditions, losses may boost crop output and mitigate the negative impacts of water deficit. Also, according to Dass and Bhattacharyya (2017), soybean seed output is improved and plants are protected from moisture stress when anti-transpirants are applied topically. This study aimed to examine the effects of straw mulch and anti-transpirants on soybean growth, nodulation, and productivity in light of the benefits of mulching and the lack of data on the effects of anti-transpirantsonthesetraits.

MATERIALS AND METHODS

During the kharif (rainy season) of 2012–2014, researchers at the Punjab Agricultural University's research farm in Ludhiana, India (at 30° 54' N, 75° 48' E, a height of 247 m mean sea-level), ran an experiment. Organic carbon was low at 0.29%, available nitrogen was low at 145.1 kg/ha, available phosphorus was high at 28.5 kg/ha, available potassium was medium at 153.5 kg/ha, and the pH was 7.9. It rained 382.5 mm (26 wet days) in 2012, 732.4 mm (26 rainy days) in 2013, and 418.7 mm (23 rainy days) in 2014 during the kharif season, while crops were growing, accordingly.

After planting, 5 t/ha of wheat straw mulch was spread, and 15 days after flower initiation, anti-transpirant spray was administered. The crop was given a baseline dosage of nutrients, namely 30 kg nitrogen and 60 kg P_2O_5/ha. Rows of the crop variety 'SL 744' were sowed 45 cm apart on June 7th, 2013, and 2014, at a seed rate of 75 kg/ha. In 2012, the dimensions of each subplot were 5.0 m × 3.6 m, whereas in 2013 and 2014, they were 6.0 m × 3.6 m.

The weeds were suppressed by using 500 liters of water with 0.45 kg/ha of pendimethalin (Stomp 30 EC) as a pre-emergence spray. Every step of the way, with the exception of irrigation, the crop was grown according to the guidelines laid downbythePAU (2012). In 2013 and 2014, data on plant dry matter was collected from three randomly chosen plants per plot at 30 and 45 days after seeding (DAS). We sun-dried the whole plant, even its tops. Eighty days after seeding, we counted and documented the dry weight of the nodules. We removed five plants at random from each plot, ensuring that the root systems remained intact. Nodules were delicately removed using forceps after the roots were rinsed in flowing tap water. The nodules were weighed after being oven-dried at 60°C for 2 days after their count. We expressed the data on the quantity and dry weight of nodules per plant.

Data on plant height and pods per plant were recorded at harvesting from randomly selected 5 plants from each plot. Biological yield and seed yield were recorded on the plot basis and then converted into kg/ha. Straw yield was obtained by subtracting seed yield from biological yield. The data on 100-seed weight were recorded after taking 100 randomly selected seeds. Harvest index was calculated by dividing seed yield by biological yield and multiplied by 100. Gross returns, net returns as well as benefit : cost (B : C) ratio were also worked out. Rainfall-use efficiency (RUE) was calculated by using the following formula:

$$\text{Rainfall-use efficiency (kg/ha-mm)} = \frac{\text{Grain yield (kg/ha)}}{\text{Rainfall received during crop growing period (mm)}}$$

Data were subjected to analysis of variance (ANOVA) in a factorial randomized complete block design (RBD) as

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Treatment	Dry matte r/plant (g)*		Nodule number/plant	Nodule dry weight (mg/plant)
	30 DAS	45 DAS		
Mulch				
Mulch @ 5 t/ha	4.58	7.82	36.3	96.7
Without mulch (Control)	3.60	5.42	31.0	87.5
SEm±	0.11	0.23	1.1	1.6
CD (*P*=0.05)	0.32	0.70	3.4	4.7
Anti-transpirant				
Magnesium carbonate @ 5%	4.05	6.59	35.3	94.4
Glycerol @ 5%	4.20	6.60	34.2	91.7
Sodium carbonate	4.36	6.34	32.6	90.2
Potassium nitrate @ 1%	3.99	7.01	33.6	92.6
Control (Water spray)	3.85	6.55	32.3	91.5
SEm±	0.14	0.28	1.9	2.6
CD (*P*=0.05)	NS	NS	NS	NS

Table 1. Dry-matter and nodulation of soybean as influenced by mulch and anti-transpirants (pooled mean of 3 years)

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RESULTS AND DISCUSSION

DevelopmentalmetricsApplying 5 t/ha of straw mulch after planting resulted in considerably greater dry matter/plant at 30 and 45 DAS compared to the control group that did not receive mulch (Table 1). It is possible that the increased soil moisture that resulted from using straw mulching led to a higher dry matter/plant compared to not using mulch (control). Higher moisture regimes in mulched plots may have enhanced crop growth, according to Dass and Bhattacharyya (2017). According to Aulakh et al. (2012) and Kumar et al. (2013), surface mulch may change the hydrothermal regimes of soil by lowering its temperature. Consistent with expectations, the dry matter/plant at 30 and 45 DAS under various anti- transpirants was comparable (Table 1), perhaps because the anti- transpirants were administered later in the process.

Formation of nodules Applying 5 t/ha of straw mulch after planting had a far greater impact on nodulation than not applying mulch at all (Table 1). Both the number of nodules per plant and their dry weight were much greater when straw mulch was applied compared to when mulch was not used. Reduced soil temperature and water loss due to evaporation are two benefits of straw mulching (Aulakh et al., 2012). This leads to an improved microclimate beneath the mulch, which in turn encourages more nodulation (Siczek and Lipiec, 2011). There was no statistically significant difference in the quantityordryweightof nod- as seen in Table 1. No effect of anti-transpirants on nodulation was found by Dass and Bhattacharyya (2017) as well.

Efficacy in using rainfall, yield characteristics, and yield Soybean harvest height, pods/plant, 100-seed weight, biological yield, straw yield, and seed yield were all much greater when 5 t/ha of straw mulch was applied after planting compared to when no mulch was applied (Table 2). The seed output was 17.6% greater when straw mulch was treated compared to when mulch was not. The increased seed production in the mulching treatment may be attributable to the fact that the mulching of straw helps to maintain the hydro-thermal regime, which in turn improves growth and yield properties. Soybean emergence, growth characteristics, and seed production were all enhanced by straw mulching, according to earlier studies (Singh and Jolly, 2008; Singh, 2009; Paliwal et al., 2011; Jamir et al., 2016; Sanbagavalli et al., 2017). Table 2 shows that the harvest index was unaffected by straw mulching. It is possible that the higher rainfall-use efficiency was due to the conservation of soil moisture brought about by the application of straw mulch at a rate of 5 t/ha. Mulching with straw increased rainwater usage efficiency by 22.6% compared to the control group that did not utilize mulch. Plant height, pods/plant, 100-seed weight, biological yield, straw production, and seed yield of soy-bean were not significantly affected by the application of several anti- transpirants (Table 2). The harvest index was also unaffected by the use of anti-transpirants. Sodium bicarbonate, when applied at a rate of 5%, had a phytotoxic impact on soybean leaves and decreased the biological yield, as well as the production of straw and seeds. The efficiency of rainwater use was not significantly affected by the application of anti-transpirants. Non-

Table 2. Yield attributes, yield of soybean and rainfall-use efficiency as influenced by mulch and anti-transpirants (pooled mean of 3 years)

Treatment	Plant height at harvesting (cm)	Pods/ plant	100-seed weight (g)	Biological yield (t/ha)	Straw yield (t/ha)	Seed yield (t/ha)	Harvest index (%)	Rainfall-use efficiency (kg/ha-mm)
Mulch								
Mulch @ 5 t/ha	76.0	62.8	11.93	5.19	3.66	1.54	29.8	2.87
Without mulch (Control)	66.8	53.5	11.17	4.27	2.93	1.31	31.0	2.34
SEm±	0.9	1.2	0.07	0.08	0.07	0.02	0.5	0.05
CD (*P*=0.05)	2.7	3.5	0.21	0.22	0.21	0.06	NS	0.16
Anti-transpirant								
Magnesium carbonate @ 5%	72.0	59.5	11.58	4.69	3.27	1.41	30.4	2.64
Glycerol @ 5%	69.2	55.7	11.66	4.65	3.25	1.36	29.9	2.53
Sodium carbonate	71.6	56.5	11.59	4.54	3.17	1.38	30.6	2.47
Potassium nitrate @ 1%	70.3	59.4	11.22	4.80	3.29	1.47	31.4	2.72
Control (Water spray)	74.1	59.8	11.69	4.99	3.51	1.47	29.9	2.67
SEm±	1.5	1.9	0.12	0.12	0.11	0.03	0.8	0.06
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Economics of soybean as influenced by mulch and anti-transpirants (pooled mean of 3 years)

Treatment	Cost of cultivation (×10³ ₹/ha)	Gross returns (×10³ ₹/ha)	Net returns (×10³ ₹/ha)	Benefit: cost ratio
Mulch				
Mulch @ 5 t/ha	30.48	53.77	23.29	0.83
Without mulch (Control)	25.48	45.73	20.25	0.89
SEm±		0.71	0.71	0.04
CD (*P*=0.05)		2.13	2.13	NS
Anti-transpirant				
Magnesium carbonate @ 5%	41.25	50.94	8.33	0.20
Glycerol @ 5%	26.15	49.04	21.55	0.83
dium carbonate	25.17	49.82	23.28	0.93
Potassium nitrate @ 1%	24.35	53.05	27.23	1.12
Control (Water spray)	23.00	52.94	28.47	1.25
SEm±		1.12	1.12	0.05
CD (*P*=0.05)		NS	3.37	0.12

NS, Non-significant.

Table 2 shows that anti-transpirants had a substantial impact on yield characteristics and yield. This could be because the treatments were obscured by the heavy rains that fell throughout the crop season. In terms of yield characteristics and seed yield, the interaction between mulches and anti-transpirants did not reach statistical significance.

Businessandfinance Table 3 shows that compared to the control group (no mulch), the group that received straw mulch had much better gross and net returns. Nevertheless, straw mulching did not significantly affect the B:C ratio. Compared to a control treatment that did not use mulch, the application of straw mulch resulted in 3,037/ha greater net returns.

Potassium nitrate outperformed competing anti-transpirants in terms of both gross and net returns when applied. Nonetheless, compared to the control, the usage of anti-perspirants was shown to be cost-ineffective. The significant chemical cost of magnesium carbonate in this treatment resulted in very poor net returns. While using anti-transpirants was not cost-effective, applying straw mulch at a rate of 5 t/ha after planting increased soybean seed production compared to not mulching at all.

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