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EFFECT OF STRAW MULCH AND ANTI-TRANSPIRANTS ON YIELD AND QUALITY OF SOYBEAN (*GLYCINE MAX* L. MERRIL)

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ABSTRACT
A field experiment was conducted for three consecutive years during *kharif* season to assess the effect of straw mulch and anti-transpirants on growth, yield and quality of soybean. Straw mulch application @ 5 tons ha^{-1} resulted in significantly higher N, P and K content in grain, seed protein content, seed, stover and biological yield and harvest index. Foliar application of Glycerol 5% as anti-transpirant resulted in significantly higher seed yield and harvest index but for N, P and K content in seed, protein content and available N and K in soil anti-trans pirants did not show significant difference. All the treatments in which mulch was included proved to be superior. The highest seed yield (2347 kg ha^{-1}), stover yield (2736 kg ha^{-1}) and biological yield (5083.6 kg ha^{-1}) was recorded in M_1A_3 [mulch + Sodium carbonate (Na_2CO_3) 5%]. However, the highest harvest index was observed in M_1A_2 [mulch + Glycerol 5%] (47.51 %). M_1A_1 [mulch + Magnesium carbonate ($MgCO_3$) 5%] gave the highest N content and highest protein content in seeds. Available N and P in soil was recorded to be the highest in M_1A_2 [mulch + Glycerol 5%] with 283 kg $ha^{-1}$and M_1A_0 [mulch + control] 17.27 kg ha^{-1}.

INTRODUCTION

The wonder crop soybean (*Glycine max*, L. Merril) is a leguminous crop and belongs to family leguminoaceae with sub family papillionaceae. It is also called "Golden Bean" of the 20th century because of its nutritive value and regarded a substitute or compliment of protein. It is now the world's leading oilseed crop, cultivated in an estimated global area of 108.75 million ha with a production reaching 268 million tonnes and productivity of 2.5 tonnes ha^{-1} in 2012-13 (Anonymous, 2013). In India, it is grown in a projected area of 10.69 million ha with estimated production and productivity of 12.67 million tonnes and 1185 kg ha^{-1}(Anonymous, 2013). In Nagaland, the estimated area under soybean production is 24670 ha with total production of 30880 metric tonnes (Anonymous, 2013). It is a potential crop of the region and is grown primarily as a pulse crop as well as intercrop with maize, ragi, arhar etc.

The major factor for low yield of soybean is less plant population due to low germination rate. To obtain high yields there is a need to improve plant stand through higher emergence. Straw mulch lowers the maximum soil temperature (Singh and Kler, 1990), raises the minimum soil temperature (Kitoh and Yoshida, 1996) in the seed zone and keep the soil moist (Munn, 1992) resulting enhanced rate and final count of seedling emergence (Singh and Jolly, 2008). Apart from straw mulches, mulching with farm yard manure may also improve emergence in some crops (Chaudhari and Das, 1980).In soybean crop, the yield was recorded to be higher by 1.0 q $acre^{-1}$ by opting mulching as compared to normal sowing (Maan and Mandeep Singh, 2009) Climate change and erratic rainfall also affect the yield of soybean. Proper moisture control at flowering stage is the critical stage for soybean yield. At the time of flowering under moisture stress condition certain chemicals effectively reduces the water loss and improve the yield. Anti-transpirants affect stomatal movement influence the guard cells around the stomatal pores and reduces loss of water vapour but not intake of CO_2 (Sivadjian, 1967). The most efficient and desirable anti-trans pirants are those that especially close stomata to transpiration but produce no phytotoxic effects to plants (Gale and Hagan, 1966). Considering the beneficial effect of mulching and no information in regard to the effect of anti-trans pirants on yield and quality of soybean in North East region of India the present investigation was undertaken to study the effect of straw mulch and anti-tran spirants on growth, yield and quality of soybean (*Glycine max* L. Merril).

MATERIALS AND METHODS

A field experiment was carried out during *kharif* season of 2012, 2013 and 2014 in the experimental farm of Department of Agricultural Chemistry and Soil Science, SASRD, Medziphema to study the "Effect of anti-tran spirants and mulches on the yield and quality of soybean (*Glycine max*, L. Merril)".The soil samples were collected from experimental site, processed and physic-chemical properties of soil were measured with prescribed standard procedure (Jackson,

1973). The soil of experimental field was sandy loam and well drained, having low available N (227.21 kg ha^{-1}), medium available P (17.8 kg ha^{-1}), and low available K (175.6 kg ha^{-1}). Soil organic carbon content was also low (0.72%) with soil pH of 4.6.The treatments consisted of two mulches treatments *viz.,* M_0 [control (no mulch)] and M_1 (straw mulch @ 5 tons ha^{-1} after sowing) and four anti-transpirants *viz.*, Magnesium carbonate ($MgCO_3$) 5%, Glycerol 5%, Sodium carbonate (Na_2CO_3) 5% and KNO_3 1%, with a control (water supply). The experiment was conducted in Factorial Randomized Block Design with three equal blocks and each block was divided into ten equal plots of 2.5m × 2.5m size, consisting of 30 plots in total. Soybean variety RKS-18 @ 65 kg ha^{-1} were treated with Malathion powder @ 12 g $plot^{-1}$ for controlling termites, ants and worms and sown on 23rd June, 2012, 26th June 2013 and 2nd July 2014. Straw mulch @ 5 tons $ha^{-1}$was applied to the plots randomly at the time of sowing and spraying of anti-trans pirants was done 15 days after flowering. Crop was harvested at physiological maturity, threshed and plot-wise seed and stover yields in kg ha^{-1}were recorded. Final seed samples were taken from each plot for analysis of N, P, K by modified kjeldhal method as described by Black (1965), vanado-molybdate yellow colour method as outlined by Jackson (1973)and flame photometry as described by Chapman and Pratt (1961) respectively. Seed protein content (%) was estimated by multiplying per cent N content in seed with the factor 6.25. Composite soil samples were collected plot wise after harvesting and available N, P, K were analysed as per the method described by Jackson (1973). The experiment data recorded during the course of investigation for each parameter were analysed statistically as per standard method prescribed by Cochran and Cox, 1957

RESULTS AND DISCUSSION

Effect of straw mulch, anti-transpirants and their interaction on yield and harvest index

Two mulch treatments *viz.*, M_0 [control (no mulch)] and M_1 (straw mulch @ 5 tons ha^{-1} after sowing) were tested in the experimental plot. Significant increase in seed yield (2139.46 kg ha^{-1}), biological yield (4730.53kg ha^{-1}) and harvest index (45.27%) attributes was observed with mulch application as compared to no mulch (1791.93 kg ha^{-1}, 4227.93 kg $ha^{-1}$and 42.38% respectively), while for stover yield (2591.06kg ha^{-1}) there was no significant increase although the mulch treatment recorded higher value. Higher value of growth, yield attributes and pod yield was observed with slash grass mulch by Sah *et al.* (2015) in cowpea while Kumar *et al.* (2015) summarized that use of bio- fertilizer along with mulching proved useful in increasing growth and yield attributes of potato crop significantly compared to control.

Significant variations inseed yield and harvest index were observed with different anti-transpirant applications *viz.,*Magnesium carbonate ($MgCO_3$) 5%, Glycerol 5%, Sodium carbonate (Na_2CO_3) 5% and KNO_3 1%, and control (water supply). Stover yield and biological yield did not vary significantly although an increase over control was observed on anti-transpirant application. The maximum seed yield (2100.33) and harvest index (45.28%) was recorded on application of A_2 [Glycerol 5%], whereas, maximum stover yield (2588.00) and maximum biological yield (4636.83) was recorded on application of A_1 [Magnesium carbonate ($MgCO_3$) 5%]. These findings are in conformity with Dalvi *et al.*, (1991) who reported significant differences on seed yield and harvest index due to anti-transpirants.

The interaction effects of mulches and anti-transpirantswith respect to seed yield,biological yield and harvest index were found to be significant. However, interaction effect for stover yield was not significant. The highest seed yield(2347kg ha^{-1}), stover yield (2736kg ha^{-1}) and biological yield (5083.6kg ha^{-1})was associated with treatment combination M_1A_3[mulch + Sodium carbonate (Na_2CO_3) 5%]. Treatment combination M_1A_2 [mulch + Glycerol 5%] recorded the highest harvest index (47.51 %). This finding is in agreement with Brahma *et al.* (2007) who reported that growth and yield attributing characters differed significantly due to the application of straw mulch and anti-transpirants.

Effect of straw mulch, anti-transpirants and their interaction on N, P, K and protein content of seed

The N, P and K content estimated in seeds of soybean were significantly influenced by mulching treatment. M_1 (straw mulch @ 5 tons ha^{-1}) recorded higher N, P and K content in seeds as compared to control(no mulch). Shah *et al.* (2015) also reported higher NPK content in wheat grains that were given mulch treatment @ 5 t ha^{-1} combined with 20 kg ha^{-1}N and 20 kg ha^{-1} P 30 days before sowing.

Protein content due to mulching was also found to be

Table 1: Effect of straw mulch and anti-transpirants on biological yield (kg ha^{-1}), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) of soybean. (Pooled)

Treatment	Biological yield (kg/ha)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
Mulches (M)M_0	4227.93	1791.93	2436.00	42.38
M_1	4730.52	2139.46	2591.06	45.22
SEm ±	101.97	30.63	74.69	0.43
CD (P = 0.05)	366.28	110.02	NS	1.55
Anti-transpirants (A)A_0	4111.83	1703.83	2408.00	41.43
A_1	4636.83	2048.83	2588.00	44.18
A_2	4628.33	2100.33	2528.00	45.37
A_3	4589.66	2026.50	2563.16	44.15
A_4	4429.50	1949.00	2480.50	44.00
SEm ±	161.22	48.43	118.09	0.68
CD (p = 0.05)	NS	173.97	NS	2.45

Table 2: Interaction effect of straw mulch and anti-transpirants on biological yield (kg ha^{-1}), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%). (Pooled)

Treatment	Biological yield (kg/ha)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
M_1A_1	4916.00	2261.00	2655.00	45.91
M_1A_2	4679.00	2223.00	2456.00	47.51
M_1A_3	5083.66	2347.00	2736.00	46.16
M_1A_4	4455.66	1960.66	2495.00	44.01
M_1A_0	4518.33	1905.66	2612.66	42.17
M_0A_1	4357.66	1836.66	2521.00	42.14
M_0A_2	4577.66	1977.66	2600.00	43.20
M_0A_3	4095.66	1706.00	2389.66	41.65
M_0A_4	4403.33	1937.33	2466.00	44.00
M_0A_0	3705.33	1502.00	2203.33	40.53
SEm ±	228.01	68.49	167.01	0.96
CD (p = 0.05)	819.04	246.03	NS	3.47

Table 3: Effect of straw mulch and anti-transpirants on N, P and K content (mg g^{-1} seed) and protein content (%) of soybean. (Pooled)

Treatment	N	P	K	Protein content (%)
Mulches (M)M_0	5.52	0.34	1.22	34.54
M_1	6.36	0.42	1.30	39.76
SEm ±	0.07	0.01	0.01	0.46
CD (P = 0.05)	0.26	0.03	0.04	1.67
Anti-transpirants (A)A_0	5.78	0.35	1.25	36.16
A_1	5.95	0.41	1.31	37.22
A_2	5.97	0.39	1.29	37.34
A_3	6.03	0.39	1.27	37.73
A_4	5.96	0.38	1.21	37.30
SEm ±	0.11	0.01	0.02	0.73
CD (p = 0.05)	NS	NS	NS	NS

Table 4: Interaction effect of straw mulch and anti-transpirants on N, P and K content (mg g^{-1} seed) and protein content (%) in soybean.(Pooled)

Treatment	N	P	K	Protein content (%)
M_1A_1	6.49	0.45	1.35	40.56
M_1A_2	6.25	0.45	1.34	39.06
M_1A_3	6.35	0.41	1.30	39.70
M_1A_4	6.35	0.41	1.22	39.70
M_1A_0	6.36	0.39	1.32	39.77
M_0A_1	5.42	0.37	1.26	33.89
M_0A_2	5.70	0.33	1.24	35.62
M_0A_3	5.72	0.36	1.24	35.76
M_0A_4	5.58	0.35	1.20	34.89
M_0A_0	5.21	0.32	1.18	32.56
SEm ±	0.16	0.02	0.02	1.04
CD (p = 0.05)	0.59	NS	NS	3.73

Table 5: Effect of straw mulch and anti-transpirants on available N, P and K at harvest in soil.(Pooled)

Treatment	Available nutrient in soil at harvest (kg ha^{-1})		
	N	P	K
Mulches (M)M_0	251.29	11.61	175.27
M_1	271.54	15.52	176.34
SEm ±	3.60	0.46	4.26
CD (P = 0.05)	12.93	1.65	NS
Anti-transpirants (A)A_0	259.48	15.22	181.32
A_1	259.36	12.08	178.19
A_2	263.58	12.84	175.68
A_3	258.35	13.69	177.32
A_4	263.00	14.01	161.53
SEm ±	5.57	0.72	6.60
CD (p = 0.05)	NS	2.61	NS

Table 6: Interaction effect of straw mulch and anti-transpirants on available N, P and K at harvest in soil.(Pooled)

Treatment	Available nutrient in soil at harvest (kg ha^{-1})		
	N	P	K
M_1A_1	271.11	13.23	174.98
M_1A_2	283.00	15.83	175.90
M_1A_3	267.51	15.12	179.19
M_1A_4	274.14	16.17	170.54
M_1A_0	261.96	17.27	181.11
M_0A_1	247.61	10.94	181.40
M_0A_2	244.15	9.84	175.45
M_0A_3	249.19	12.27	175.45
M_0A_4	251.85	11.85	152.53
M_0A_0	257.00	13.18	181.54
SEm ±	7.88	1.02	9.33
CD (p = 0.05)	28.30	3.69	NS

significantly higher (39.76%) than control (34.54%). Non-significant variations in N, P and K content in seeds were observed with different anti-transpirant applications. Similarly, protein content also did not vary significantly due to anti-trans pirant treatment.The interaction effects of mulches and anti-trans pirants on protein content was found significant. The interaction M_1A_1[mulch + Magnesium carbonate ($MgCO_3$) 5%] gave the highest protein content (40.56%). Mulch and anti-transpirant interaction for seed nutrient content showed significant variation for N content in seeds whereas, P and K contents varied non significantly among treatment combinations. The highest N content was observed in M_1A_1[mulch + Magnesium carbonate ($MgCO_3$) 5%] treatment.

Effect of straw mulch, anti-transpirants and their interaction on available soil nutrient status

The highest available nitrogen (271.54 kg ha^{-1}) was recorded from M_1 (straw mulch @ 5 tons ha^{-1}). Results showed that higher amounts of nutrients were left in the soil following crop harvest in the case of application of mulches. This might have been due to the supply of nutrients by the microbial decomposition of plant residues placed on soil surface and also due to the multiplication of N_2-fixing bacteria and algae on the plant residues that act as a source of nitrogen supply. Similar results were observed by Harper and Lynch, (1984). Correspondingly, the highest available phosphorus (15.52 kg ha^{-1}) and potassium (176.34 kg ha^{-1}) was recorded from M_1 (straw mulch @ 5 tons ha^{-1}), although increase in potassium content as compared to control was non significant. These findings on phosphorus and potassium were in agreement with the findings of Sonsteby *et al*., (2004) who reported that application of straw mulch significantly increased the available phosphorus and potassium in the soil.

There were non significant differences for available nutrients in soil due to anti-transpirant application, except for phosphorus. The highest value for phosphorus (15.22 kg ha^{-1}) and potassium (181.32 kg ha^{-1}) was associated with control treatment A_0 (water supply). Results showed that application of anti-trans pirants did not prove to be superior over control for P and K.

The interaction effects of mulches and anti-transpirants on soil nutrient status was found to be significant for nitrogen and phosphorus and non-significant for potassium. The highest available N (283 kg ha^{-1}) and P (17.27 kg ha^{-1}) was associated with M_1A_2 [mulch + Glycerol 5%] and M_1A_0 [mulch + control (water supply)], respectively

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