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Mitigating Salt Injury in the Tobacco Float Transplant Production System in Zimbabwe

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***Abstract*— The tobacco float seedling production system occasionally exposes transplants to salt injury, especially when there is excessive evaporation due to winds or high temperatures. Evaporation causes salt accumulation on the Gromix® soilless media surface. These salts cause physiological damage to young transplants and more often, mortality. Three trials were conducted at Kutsaga Research Station to address this problem that affects mainly the late July, August and September sown float seedbeds. The first trial evaluated four hydroponic fertilizer formulations (Floatfert®, Hydrofert®, Peters® and Formula 1) for potential in reducing salt injury. While the fertilizers had different salt indices (SI), all the formulations exposed the transplants to salt injury. The second trial evaluated the effect of split fertilizer application and delayed application of Floatfert® fertilizer. Floatfert®is normally applied at 7, 21 and 35 days after sowing (d.a.s.). Further splitting or delayed Floatfert®application were tested to determine salt accumulation reduction potential. There were treatment differences in germination and survival at 21 and 28 d.a.s. when fertilizer was split-applied or when application was delayed. A third trial evaluated different mulch types (Vlei grass, [Eragrostis lehmanniana], perforated clear plastic, clear plastic tent and a floating-row cover) for reducing salt accumulation. Vlei grass mulch resulted in the highest germination and survival of transplants. The results from this work indicated that mitigation of salt injury during hot and windy periods requires a holistic approach that includes careful selection of fertilizers, appropriate application rates and timing and the use of suitable mulch.**

***Index Terms*— Salt injury, Germination, Transplant survival, Fertilizer, Mulching.**

I. INTRODUCTION

The tobacco float seedling production system occasionally exposes seedlings to salt injury in outdoor floatbeds, especially when environmental conditions promote excessive evaporation from the growing media surface. In Zimbabwe, salt injury is a common problem in late sown (late July to August) seedbeds when there is a lot of wind and hot temperatures prevail. Accumulated salts cause physiological damage and at times seedling mortality especially after germination and during early growth [1]; Murillo-Amador et al., [11]. Salt injury symptoms first appear as a mild chlorosis of the foliage and progresses to a necrosis (burn) of leaf tips and margins [9]. The roots may also be affected by the presence of soluble salts, predisposing them to a range of root diseases such as pythium. Extreme salt injury may interfere with water uptake resulting in wilting of the plant [9].

Irrigation water, fertilizers and growing media all contribute to soluble salts and need to be well managed with an integrated approach [5]. The electrical conductivity (EC) is a good measure of soluble salts in a solution [8], and the EC of the growing media and float water can be constantly monitored using small hand held devices and should be kept below 1 500 µS/cm.

The objectives of these trials were to evaluate the efficacy of four hydroponic fertilizers in mitigating salt injury, and the effectiveness of further splitting fertilizer applications and possible delay of fertilizer application in managing salt injury. The use of different mulching materials as evaporation retardants was also explored for the reduction of salt build up on the media surface.

II. MATERIALS AND METHODS

A. Description of Site

The study was done at Kutsaga Research Station during the 2010-2014 tobacco growing seasons. The site receives a mean annual temperature of 21°C with insignificant frost occurrence in the months of June and July. The experiment was carried out in an open outdoor seedbed site using the float seedling production system.

B. Floatbed Construction, Tray Filling and Sowing

A rectangular float bed was constructed from common farm brick and mortar, and float trays measuring 67 cm in length, 33.5 cm width and a 6 cm depth were used. The entire construction was lined with 250 µm black plastic sheeting and filled with water to a depth of 12 cm. Gromix® (pine bark based) was mixed with water in a volume ratio of 2:1 and uniformly packed into three 242-cell trays for each treatment. Media was dibbled and pelleted seed was sown using a hand held seeder.

C. Measurement of Electrical conductivity (EC)

A sample of the medium was collected from the upper 10 mm of the media from several trays. Distilled water was added to the growing media in a 2:1 (water: media) ratio. The sample was agitated for 2 to 3 minutes before measuring the EC.

D. Data recorded and Analysis

Specific treatments applied in each of the three experiments are detailed in the results tables. Germination and spiral root counts commenced at 14 DAS and weekly thereafter. At 12 weeks after sowing (WAS), seedlings from 50 centre cells of the middle tray were sampled for stem

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length and diameter, root and shoot dry mass assessments and; the number of transplantable seedlings for each treatment. Veneer callipers were used to determine seedling stem diameter at the root crown. Analysis of Variance (ANOVA) was used to test the treatment differences and the LSD was used to discriminate treatment differences.

III. RESULTS AND DISCUSSION

A. Splitting and delaying fertilizer application

Germination and survival were high at 14 DAS, however, seedling count declined for all treatments and; it declined most in the treatment with a split application at 14 and 28 days (table 1). Survival percentage at 12 weeks after sowing (WAS) was highest for the treatment in which the fertilizer was split applied at 14 and 35 days. This was due to reduced fertilizer concentration in the float water at a time when the foliage cover was low, and when the second application was effected, seedling foliage cover was high thereby lowering evaporation from the media surface and less salt accumulation and damage.

Floatfert is normally applied at 7, 21 and 35 days after sowing (d.a.s.) without any detrimental effects for June/July (early) sowings but sometimes with limited success for the August/September (late) sowings due to salt injury. The standard fertilizer program caused some salt injury and was second in performance; Saffan [12] also reported that salt injury can occur even when recommended fertilization programs are followed.

Apparent treatment differences in stem height and diameter, root and shoot dry weight are due to treatments with less seedling survival having more fertilizer available to the fewer surviving seedlings (table 2).

Table 1:Germination and Survival

Treatment	Germination/survival (%)			
	14 DAS	21 DAS	28 DAS	Survival counts (%, 12 WAS)
Floatfert at 7, 21 and 35 DAS*	74.90	59.61	56.61	37.00
Floatfert at 7 and 28 DAS	61.88	28.41	23.86	19.50
Floatfert at 14 and 35 DAS	75.10	73.55	65.08	58.50
Floatfert at 21 and 35 DAS	80.17	64.36	55.79	41.50
Floatfert at 7, 14, 21, 28 and 35 DAS	78.20	37.50	31.41	16.00
F-PROBABILITY	0.06	0.002	0.01	0.03
L.S.D	12.41	19.85	24.23	26.37

*Standard

Table 2. Seedling Quality Parameters

Treatment	Stem diameter (mm)	Stem height (mm)	Shoot dry mass (g)	Root dry mass (g)
Floatfert at 7, 21 and 35 DAS*	4.92	182.47	1.71	0.23
Floatfert at 7 and 28 DAS	6.45	210.97	3.37	0.51
Floatfert at 14 and 35 DAS	4.27	166.95	1.08	0.17
Floatfert at 21 and 35 DAS	5.00	157.75	2.47	0.22
Floatfert at 7, 14, 21, 28 and 35 DAS	5.37	189.24	2.64	0.36
F-PROBABILITY	0.006	0.44	0.17	0.007
L.S.D	0.96	63.87	1.97	0.17

*Standard

Table 3. Germination and Survival

Treatment	Germination/survival counts (per 242-cell tray)			Transplantable %
	14 DAS	21 DAS	28 DAS	
Floatfert®	183	150	143	35.60
Hydrofert®	200	187	179	50.00
Peters®	195	182	176	42.80
Formula 1	182	157	152	38.80
F-PROBABILITY	0.371	0.078	0.048	0.24
L.S.D	25.36	33.19	28.83	15.12

Table 4. Seedling Quality Parameters

Treatment	Diameter (mm)	Height (mm)	Shoot dry weight (g)	Root dry weight (g)
Floatfert®	5.29	211.81	1.87	0.27
Hydrofert®	4.51	178.54	1.27	0.21
Peters®	4.44	210.67	1.34	0.21
Formula 1	4.90	240.41	1.56	0.22
F-PROBABILITY	0.001	0.002	0.12	0.50
L.S.D	0.35	26.46	0.54	0.10

B. *Effect of different mulching materials*

The vlei grass mulch had significantly high germination/survival at all assessment times and the least was when there was no mulch. Seedling height for the different mulching materials was comparable and, lower seedling diameter in treatments with higher survival were due to competition as explained previously. Vlei grass mulch also had the highest number of transplantable seedlings which was significantly higher than all treatments including the standard (clear plastic). Management practices which reduce air movements and direct sun light on the media surface are effective in mitigating salt injury [3].

Table 5. Germination and seedling quality parameters

Treatment	**Germination/survival (%)**			**Seedling quality**		
	14 DAS	**21 DAS**	**28 DAS**	**Height (mm)**	**Diameter (mm)**	**% transplantable**
No mulch	37.40	67.98	54.34	203.81	6.35	28.00
Perforated plastic	56.61	72.83	70.87	195.03	5.08	38.00
Vlei grass	70.87	83.26	88.02	183.25	3.92	67.50
Float row cover	64.15	75.10	77.17	182.64	4.49	46.50
Clear plastic*	58.26	72.52	56.51	194.66	5.78	27.50
F-PROBABILITY	0.004	0.04	0.003	0.48	<.001	0.002
L.S.D	14.81	9.23	15.90	28.52	0.45	17.58

IV. RECOMMENDATIONS

Splitting and delaying Floatfert application to 14 and 35 DAS can be adopted in late sown seedbeds to minimize salt injury. The two new formulations (Peters® and Formula 1) can also be used in the tobacco float seedling production system as a means to mitigate salt damage since these were comparable to the two standards (Floatfert and Hydrofert). Vlei grass mulch produced the best results for germination, survival and the percentage of transplantable seedlings and can be recommended to reduce salt injury mortalities. Results from these studies indicated that mitigation of salt injury during hot and windy periods requires a holistic approach that includes appropriate fertilizer application rates and timing, careful selection of fertilizers and, the use of a suitable mulching material.

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