Weed suppression in cotton through phosphite fertilization

Shilpa Singh*, Devendra Pandeya, Keerti Rathore, Kater Hake† and Muthukumar Bagavathiannan

Department of Soil and Crop Sciences, Texas A&M University, College Station, TX

†Cotton Incorporated, Cary, NC

***Contact: shilpa.singh@tamu.edu**

Introduction

- Herbicide-resistant weeds have emerged as a serious problem in different cropping systems, specifically cotton-based systems.
- Phosphorus (P) is an essential macronutrient required by the plants for normal growth and development (Schachtman et al. 1998). Plants can only metabolize P in its orthophosphate (Pi) form, but unable to utilize the phosphite (Phi) form.
- A transgenic variety of cotton with the bacterial phosphite dehydrogenase (*ptxD*) gene has the ability to convert phosphite (Phi) into orthophosphate (Pi), whereas weeds lack this ability and hence can be negatively impacted by Phi application (López-Arredondo et al. 2012; Pandeya et al. 2018).

Hypothesis

- The *ptxD*-phosphite system will effectively suppress different weed species

Objectives

A) To evaluate the response of Palmer amaranth, johnsongrass, and *ptxD*- and wild-type (WT) cotton to foliar applications of phosphite.

i) evaluate the efficacy of foliar phosphite on plants grown in two soil types: low P [25 parts per million (ppm)] and normal P (50 ppm).

ii) evaluate the effect of Liberty (glufosinate) herbicide when tank-mixed with phosphite.

B) To evaluate the response of Palmer amaranth, johnsongrass and, *ptxD*- and wild-type cotton to soil applications of phosphite in four soil types (10, 15, and 25 ppm).

Materials & Methods

A. Foliar Application

Location: Research farm, Texas A&M University, College Station, TX.

1) Efficacy of foliar phosphite application

Plant establishment: In Summer 2020, seeds of Palmer amaranth, johnsongrass were planted in 1 m^2 areas per soil type with three replications. Foliar applications made at 5 to 7 cm seedling height.

Fertilizer doses: Five treatments: (1) Nutrient dose (adjusted for soil P status), (2) 2 gallon (g)/A, (3) 2 g/A (2 sequential applications), (4) 6 g/A, (5) Non-Treated check.

2) Efficacy of glufosinate and phosphite tank-mix

Plant establishment and application: Palmer amaranth and johnsongrass were sprayed at 7 to 10 cm height in 20 feet plots with four replications per treatment.

Doses: Twelve treatments:

1. Glufosinate 0.25X (1X = 29 Oz/A) alone
2. Glufosinate 0.25X + Phosphite 1 gallon/A
3. Glufosinate 0.25X + Phosphite 2 g/A
4. Glufosinate 0.25X + Phosphite 2 g/A followed by one sequential application of Phi 2 g/A a week later
5. Glufosinate 0.25X + Phosphite 4 g/A
6. Glufosinate 0.25X + Phosphite 2 g/A followed by two sequential applications of Phi 2 g/A
7. Glufosinate 0.25X + Phosphite 6 g/A
8. Glufosinate 0.5X alone
9. Glufosinate 0.5X + Phosphite 6 g/A
10. Phosphite 2 g/A Fb 2 sequential application of Phi
11. Phosphite 6 g/A
12. Non-treated check

Materials & Methods

B. Soil Application

Plant establishment: Seeds of Palmer amaranth, johnsongrass and, *ptxD*- and wild-type cotton were planted in small trays in the greenhouse in three soil types (10, 15, and 25 ppm). Phosphite applications were made to the soil as a pre-emergence (PRE) treatment.

Dose: Adjusted for soil P status as per soil test recommendations.

Experimental design: Randomized Complete Block Design (RCBD), 3 replications, 4 plants per replication.

Treatment Application: Backpack sprayer at 4.8 km h^{-1} speed, 140 L ha^{-1} spray volume, and 276 kPa pressure.

Variables evaluated: Visual injury on a scale of 0 (no injury/control) to 100 (complete desiccation), plant height, biomass at 21 days after treatment (DAT). All data were analyzed using (JMP Pro v. 14).

Results

A. Foliar application

1) Response to foliar phosphite:

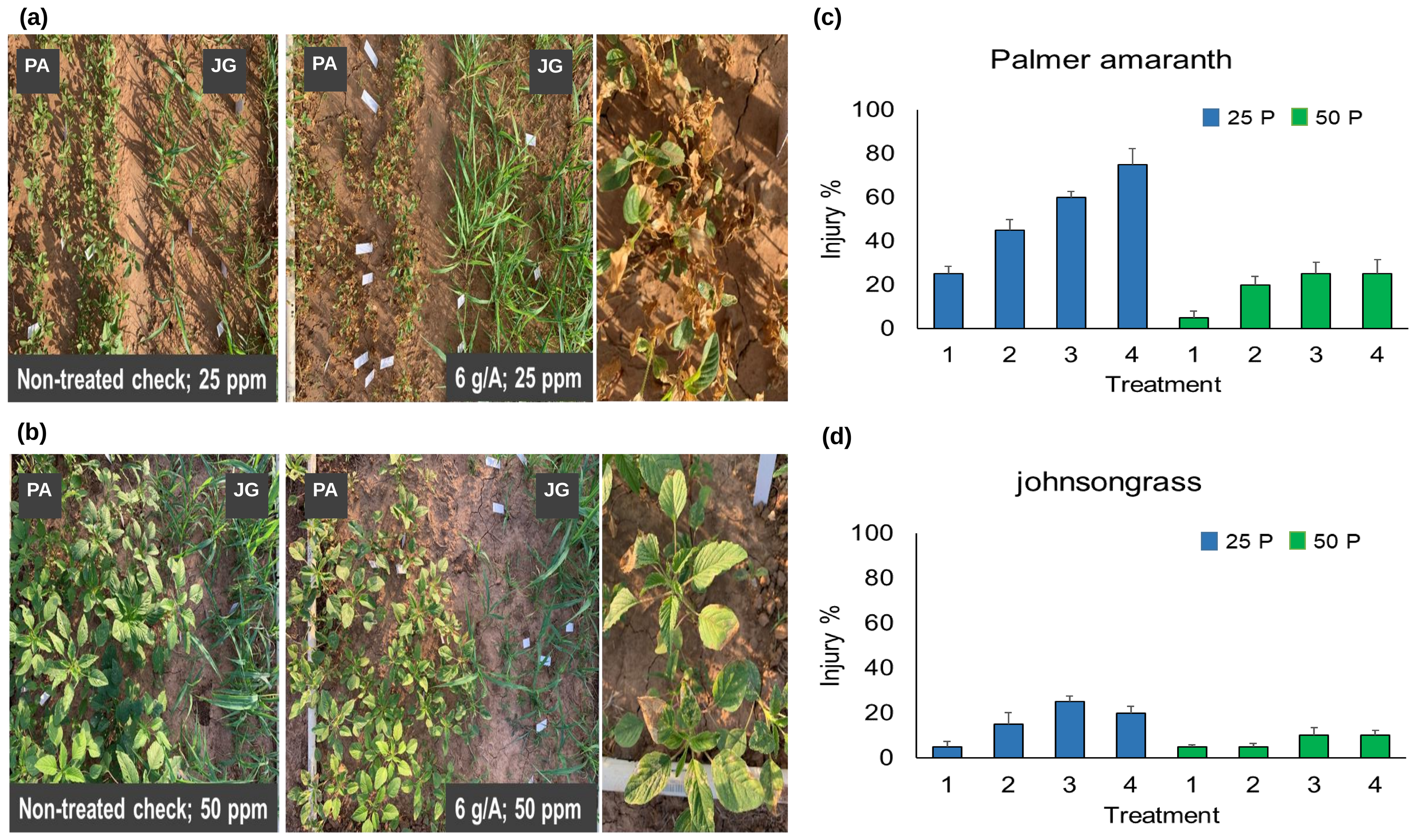

Fig.1. Response to foliar application of phosphite **(a)** 25 ppm, **(b)** 50 ppm; injury % **(c)** Palmer amaranth (PA), and **(d)** johnsongrass (JG) at 14 DAT.

2) Response of weeds to glufosinate and phosphite tank-mix at different growth stages in 50 ppm soil:

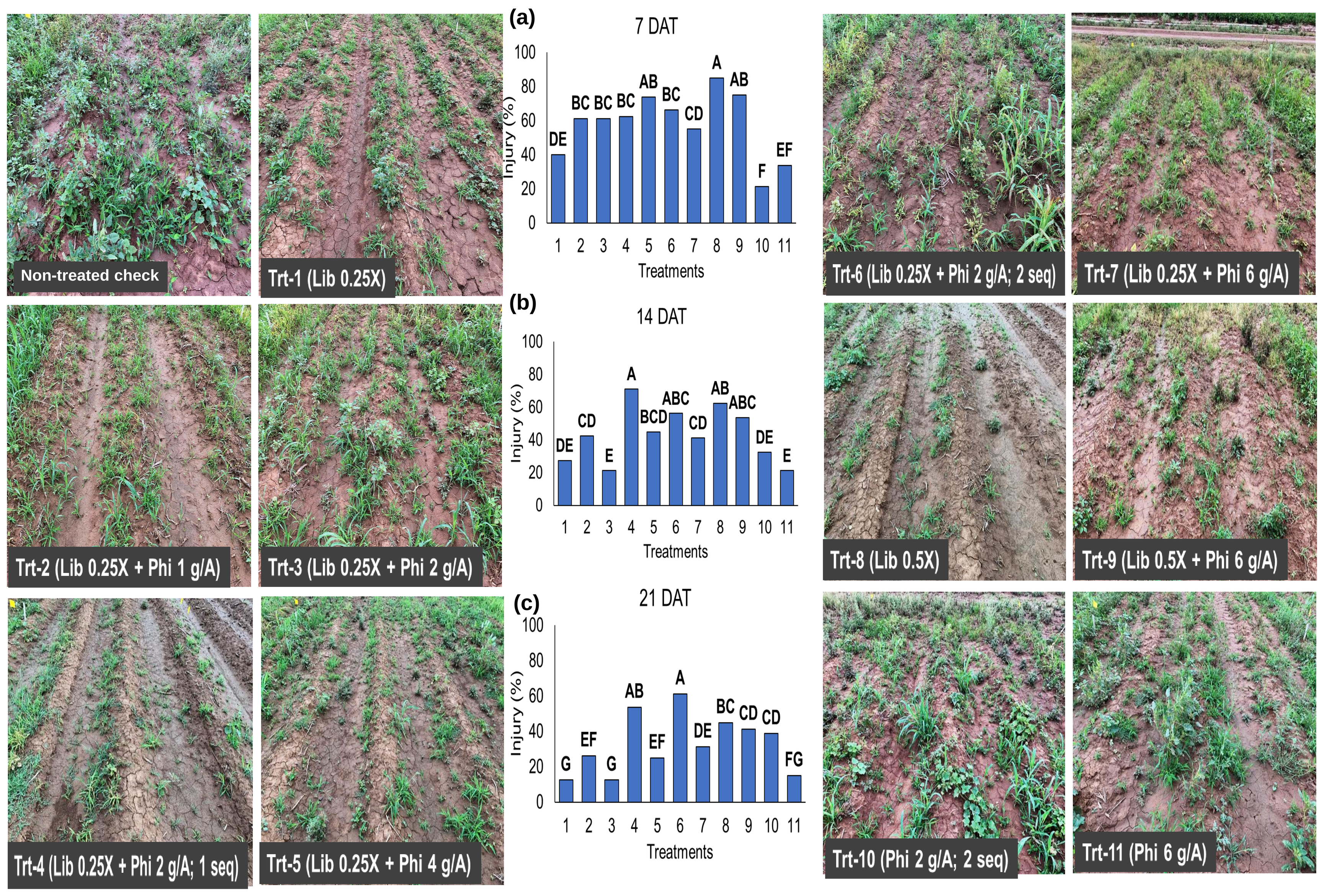

Fig.2. Response of weeds (Palmer amaranth and johnsongrass) to foliar application of glufosinate and phosphite tank-mix at at 7 DAT; Injury % at **(a)** 7 DAT, **(b)** 14 DAT and **(c)** 21 DAT.

Results

B. Soil application

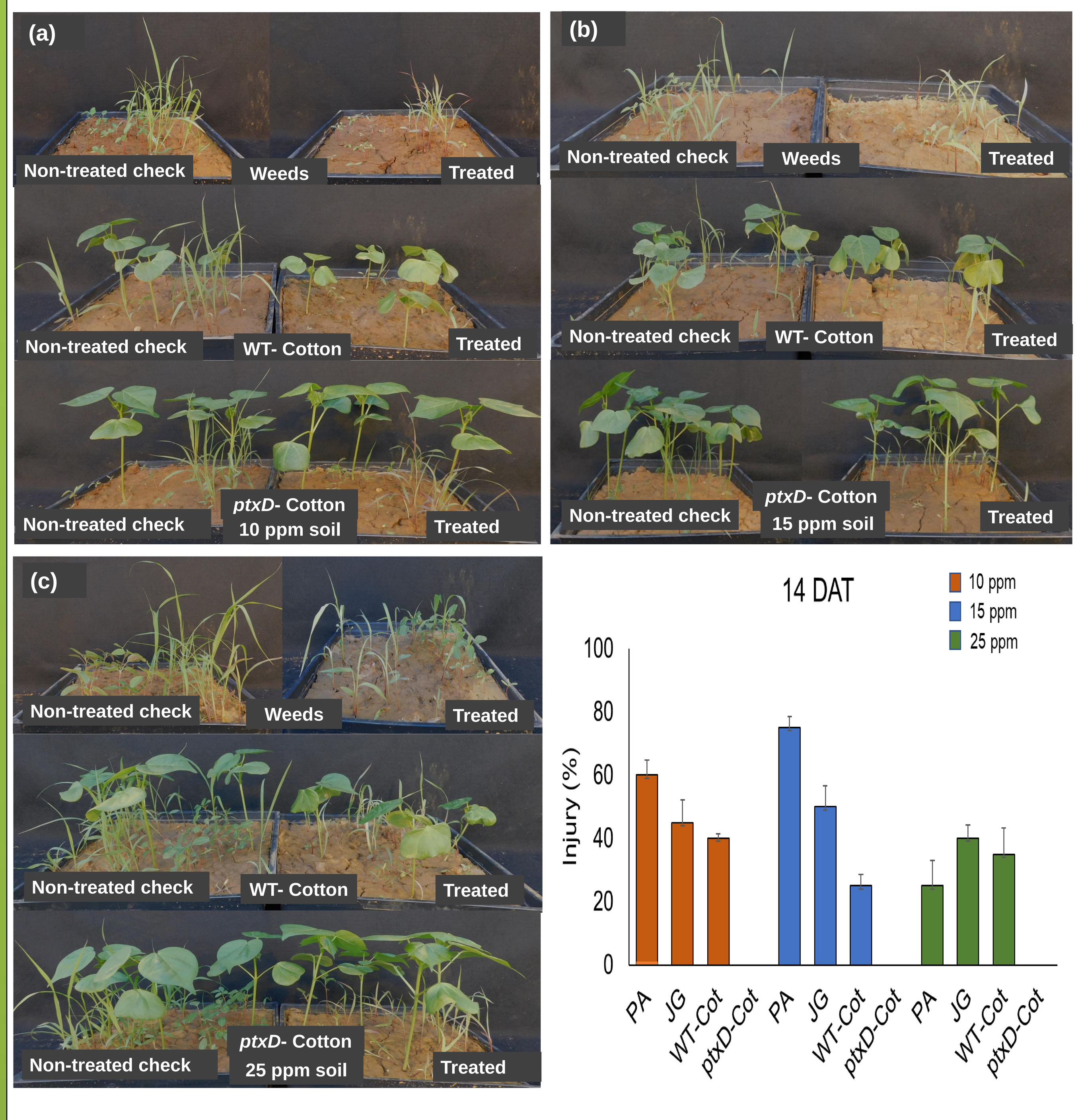

Fig.3. Impact of soil applications of phosphite (soil test recommendation) on Palmer amaranth, johnsongrass, wild type (WT) and *ptxD* cotton in 10 ppm **(a),** 15 ppm **(b),** and 25 ppm **(c)** soil at 14 DAT.

Results & Discussion

- High injury on Palmer amaranth was observed in low P (25 ppm) soil in all of the POST treatments, but no effect on johnsongrass was observed **(Fig. 1).**
- Tank-mix of liberty provided synergistic effect and sequential application of phosphite was more effective than single application of high rate (6 g/A) of phosphite **(Fig. 2).**
- Soil application provided >60% growth reduction for Palmer amaranth and 50% growth reduction for johnsongrass in low P soil types compared to normal P (50 ppm) soil type (data not shown) **(Fig. 3)**. Similar findings have been reported by Pandeya et al. (2018) for Palmer amaranth.

Conclusion

- *ptxD*-cotton technology is effective in suppressing weeds when applied as a foliar or soil treatment in low P soil

Future Research

- Evaluate the effectiveness of phosphite on a mutliple crop and weed species.
- Determine if there could be any combined effect of phosphite and cover crops for weed suppression.

References

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- Pandeya, et al. (2018) Selective fertilization with phosphite allows unhindered growth of cotton plants expressing the ptxD gene while suppressing weeds. Proc Natl Acad Sci. USA 115:E6946–E6955.
- Schachtman, et al. (1998) Phosphorus uptake by plants: from soil to cell. Plant Physiol. 116:447–453.

Acknowledgment

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