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Bioefficacy of potassium salt of glyphosate in Bt cotton and its residual effect on succeeding crops

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ABSTRACT

A field experiment was conducted to evaluate potassium salt of glyphosate (MON 76366) in Roundup Ready Bt cotton hybrid at PAU, Ludhiana during 2009 and 2010. Potassium salt of glyphosate 50 EC at 900, 1350, 1800, 2700, 3600 and 5400 g/ha was applied twice (after one and three months of sowing) as post-emergence. All the treatments except glyphosate 900 g/ha and weedy check gave effective control of weeds. Application of K salt of glyphosate at 1350 to 5400 g/ha recorded the weed control efficiency (WCE) ranging from 96.8 -99.8%, and produced higher seed cotton yield. The performance of succeeding crops of wheat, barley and raya sown after cotton was not affected, indicating no residual toxicity of K-salt of glyphosate.

Key words: Glyphosate, Roundup ready cotton, Seed cotton yield, Weeds, Weed management

Cotton is the third major crop after wheat and rice in semi-arid sub tropical region of India including Punjab, Haryana and Rajasthan states. Due to its long duration, early slow growth and wider spacing, there is heavy infestation by weeds (Rajeswari and Chayulu 1996). Being a rainy season and long-duration crop, weeds flourish in many flushes and compete with the crop for nutrients, moisture, light, space *etc*. and also harbour insects, pests and diseases (Anderson 1983). Herbicides available for use in cotton, control only narrow range of weeds and even sequential applications of herbicides fail to provide effective control of weeds.

Glyphosate resistant cotton has provided number of alternatives to the farmers to use glyphosate as and when required. Glyphosate-resistant (GR) cotton cultivars have proved to be a boon for the cotton farmers as the glyphosate (MON 76366), trade name Roundup Ready$^{(R)}$ gave excellent weed control in this crop (Webster and Sosnoskie 2010). This technology provides superior broad spectrum control of weeds, better control of hardy weeds in wide row configurations, direct applications on target weeds and controls many flushes of weeds. However, the herbicides, when applied to the field not only control targeted weeds, but may also leave unwanted residues in the soil, which are ecologically harmful (Riaz *et al*. 2007). Cotton being an important crop of Punjab and normally the succeeding crops like wheat, barley and raya are sown by the farmers during *Rabi* season after this crop. A field study was done to study the efficacy of potassium salt of glyphosate as post-emergence blanket application in transgenic stack cotton hybrid, and its residual effect on succeeding crops of wheat, barley and raya.

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MATERIALS AND METHODS

The experiment was carried out at Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana, India during *Kharif* 2009 and 2010 with eight treatments in randomized block design with test hybrid '*MRC 8017 BG II RRF*' (Bt) and '*MRC 7347 BG-II RRF*' (non Bt) which was sown on 25 June, 2009 and 3 May, 2010 after preparing fine seed bed. Crop was sown with row to row spacing of 67.5 cm and plant to plant spacing of 90 cm. 90 kg N and 30 kg P_2O_5/ha was applied to the crop.All phosphorus was drilled at the time of sowing. Half N was applied at thinning and the remaining at the appearance of the first flower. Potassium salt of glyphosate 50 EC at 900, 1350, 1800, 2700, 3600 and 5400 g/ha was applied twice as post-emergence (blanket application) at one and three months after sowing. The knap sack sprayer fitted with flat fan nozzle with discharge rate of 250 l/ha was used.

Succeeding crops of wheat, barley and raya were taken during *Rabi* 2009-10 and 2010-11 by dividing the plot to find out the residual effects of potassium salt of glyphosate. These studies were continued in fixed lay out without disturbing the soil. The weeds were removed manually in these crops.

Species wise weed count was done for the dominant weeds at 14 and 21 days after spray and dry weight of weeds at 130 DAS. Weeds were cut from the ground

level, dried in sun and then oven dried at 60 °C for three days and then weighed. The experimental data were subjected to analysis using CPCS1, software developed by Cheema and Singh (1991). All the comparisons were made at 5% level of significance.

RESULTS AND DISCUSSION

Effect on weeds

Weed flora included grass, broad-leaf weeds and sedges, *viz. Acrachne racemose, Eleusine indica, Dactyloctenium aegyptiacum, Echinochloa colona, Digitaria sanguinalis, Cynodon dactylon, Eragrostis tenella, Trianthema portulacastrum, Mollugo nudicaulis, Commelina benghalensis, Phyllanthus niruri, Euphorbia hirta, Euphorbia microphylla, Digera arvensis, Amaranthus viridis, Rhyncosia capitata, Cucumis trigonus* and *Cyperus rotundus.*

No significant injury on Bt cotton was observed in any herbicide treatment, which indicated that the herbicide was safe for Bt cotton. Post-emergence application of K salt of glyphosate at 900, 1350, 1800, 2700, 3600 and 5400 g/ha showed no phytotoxicity to cotton with both the sprays when observations were recorded after 4, 7 and 14 days after application. On the second day after herbicide application, the leaves of weeds started rolling, yellowing started after third day, and on the fourth day, complete kill of weeds was observed. Only *Cynodon dactylon* remained green where K salt of glyphosate at 900 g/ha was applied but yellowing of leaves started few days of application.

Visually complete kill of all grasses, broad-leaved, perennial weeds and sedges was observed 10-11 days after spray, except in lower dose of potassium salt (900 g/ha). No regeneration of weeds was noticed at 14 or 21 days after first application of K salt of glyphosate. Similar findings were recorded when K salt of glyphosate was re-sprayed after three months of sowing.

All the herbicidal treatments controlled the weeds effectively as the population of different weeds and their dry matter of weeds recorded was significantly less as compared to unweeded check. All the herbicidal treatments at 1350, 1800, 2700, 3600 and 5400 g/ha were at par with respect to the control of weed species. Similar results were reported by Chinnusamy *et al.* (2013). Higher weed control efficiency of 99.8% was recorded with glyphosate at 2700 and 5400 g/ha, followed by 3600 g/ha (99.6%) (Table 1).

Effect on yield

Seed yield of cotton was significantly higher at all the doses of K salt of glyphosate than manual weeding and unweeded check (Table 1). The difference in seed yield in two years was due to late sowing in 2009. The increase in yield was 36.1, 77.8, 69.4, 66.6, 63.9 and 55.5% where K salt of glyphosate was applied at 900, 1350, 1800, 2700, 3600 and 5400 g/ha, and 16.7, 52.4, 45.2, 42.9, 40.5, 33.3% over two manual weedings. However, the seed yield differed significantly (0.49 t/ha) where herbicide was applied at 900 g/ha with the manual weeding but it was higher than unweeded plot. Similar results were obtained in the second year. Chinnusamy *et al.* (2013) also registered high seed cotton yield with glyphosate at 2700 g/ha.

Higher seed cotton yield with 1350, 1800, 2700, 3600 and 5400 g/ha of potassium salt of glyphosate was mainly due to effective control of wide weed flora. Untreated control resulted in poor growth and ultimately reduced the seed cotton yield. The seed cotton yield was at par when potassium salt of glyphosate was applied at 1350, 1800, 2700, 3600 and 5400 g/ha, and all these treatments produced significantly higher seed cotton yield than 900 g/ha. The performance of all the doses of K salt of glyphosate was at par and significantly better than manual weeding and unweeded check.

Table 1. Effect of different treatments on weed dry matter and seed cotton yield

Treatment	Dose (g/ha)	Weed dry matter (14 days after 1st spray) (g/m^2)	Weed dry matter (14 days after 2nd spray) (g/m^2)	Weed dry matter at 130 DAS (g/m^2)		WCE at 130 DAS (%)		Boll weight (g)		Seed cotton yield (t/ha)	
				2009	2010	2009	2010	2009	2010	2009	2010
K-salt of glyphosate	900	1.0 (0)	1.0 (0)	2.8 (7)	2.8 (7)	94.4	93.6	6.23	14.4	0.49	1.75
K-salt of glyphosate	1350	1.0 (0)	1.0 (0)	2.2 (4)	2.1 (3)	96.8	97.3	6.80	18.3	0.64	2.22
K-salt of glyphosate	1800	1.0 (0)	1.0 (0)	1.4 (1)	1.3 (0.7)	99.2	99.4	5.80	16.9	0.61	2.08
K-salt of glyphosate	2700	1.0 (0)	1.0 (0)	1.1 (0.3)	1.1 (0.2)	99.8	99.8	5.68	16.1	0.60	2.00
K-salt of glyphosate	3600	1.0 (0)	1.0 (0)	1.2 (0.5)	1.1 (0.2)	99.6	99.8	5.52	15.4	0.59	2.11
K-salt of glyphosate	5400	1.0 (0)	1.0 (0)	1.1 (0.3)	1.1 (0.3)	99.8	99.7	5.48	14.5	0.56	2.03
Manual weeding	-	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	64.3	41.5	6.67	19.0	0.42	1.59
Unweeded	-	8.7 (74)	9.5 (90)	11.2 (124)	10.6 (111)	-	-	4.33	10.9	0.36	1.42
LSD (P=0.05)		0.15	0.17	0.46	0.28	-	-	0.30	1.9	0.1	0.25

Table 2. Residual effect of K salt of glyphosate on growth (30 DAS) and yield of following rabi crops (pooled data of two years)

Treatment	Dose (g/ha)	Wheat			Barley			Raya		
		Plant height (cm)	Dry matter (g/m^2)	Grain yield (t/ha)	Plant height (cm)	Dry matter (g/m^2)	Grain yield (t/ha)	Plant height (cm)	Dry matter (g/m^2)	Seed yield (t/ha)
K-salt of glyphosate	900	13.9	94.7	4.34	19.2	123.4	3.62	11.8	75.0	1.35
K-salt of glyphosate	1350	12.9	85.3	4.07	19.9	151.4	3.67	11.2	74.2	1.26
K-salt of glyphosate	1800	12.8	93.1	3.91	20.7	149.0	3.52	12.6	88.6	1.28
K-salt of glyphosate	2700	12.9	90.6	3.90	17.8	144.9	3.89	10.1	68.7	1.37
K-salt of glyphosate	3600	12.6	86.2	3.64	20.0	131.7	3.64	12.7	84.5	1.25
K-salt of glyphosate	5400	12.5	77.2	3.77	17.8	136.8	3.30	10.1	69.7	1.23
Manual weeding		12.5	87.8	4.12	17.7	136.0	3.48	12.0	79.7	1.33
Unweeded	-	13.4	80.4	3.58	18.2	136.3	3.33	10.2	66.4	1.37
LSD (P=0.05)	-	NS	9.5	NS	NS	NS	NS	2.1	NS	NS

Residual effect

No phytotoxicity due to residues of K salt of glyphosate was recorded on wheat, barley and raya. The plant height at 30 days after sowing was not affected but dry matter accumulation of crops at 30 DAS was comparatively less in unweeded control as compared to glyphosate (Table 2). This indicated no residual carryover of K salt of glyphosate in the soil. In fact, the yield of succeeding crops was found to be marginally higher in glyphosate treatments as compared to unweeded control.

It was concluded that the transgenic stack of Bt cotton hybrid was tolerant to K salt of glyphosate, which also did not affect growth and yield of succeeding crops of wheat, barley and raya.

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