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Influence of Potassium Salt based Glyphosate on Weed Control Efficacy and Yield in Winter Irrigated Cotton

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A field investigation was carried out at Tamil Nadu Agricultural University, during winter 2011-12 to evaluate the new formulation of potassium salt based glyphosate (Roundup Crop Shield 460 SL) on weed control in winter irrigated cotton. Experimental results revealed that, post-emergence application of glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 days after sowing + Intercultural operation as earthing up at 45 and 55 days after sowing resulted in lower weed density, weed dry weight and higher weed control efficiency. With respect to the relative weed density, broad-leaved weeds were higher at initial stages and grassy weeds were predominant at later stages of cotton. Higher seed cotton yield was obtained with POE glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS with + Intercultural operation at 45 and 55 DAS (2930 kg ha^{-1}), which was comparable with PE pendimethalin at 750 g a.i. ha^{-1} + Intercultural operation at 45 and 55 DAS (2710 kg ha^{-1}). Compared treatments without intercultural operation, intercultural operation carried out treatments performed better and recorded more seed cotton yield.

Key words: Cotton, Glyphosate, Weed density, Weed control efficiency, Yield.

Cotton, regarded as ‘white gold’ or ‘money spinner’ is one of the important commercial crop grown throughout the world. In textile industry, cotton plays a vital role in supplying raw materials to the tune of 85 per cent of total requirement and provides employment to about 60 million people in India (COTAAP, 2008). Cotton seed contains 18 - 25 per cent oil depending up on quality of seed as well as species.

The weeds which germinate before or simultaneously with the crop are frequently capable of forming a leaf canopy over cotton. Late emerging weeds may interfere with cotton at harvest and may lower lint grade due to lint staining. Factors like inclement weather, non availability of labour for timely weeding cause delay in weeding resulting in yield losses. Weeds growing with cotton offer severe competition causing yield reduction to an extent of 74 per cent (Shelke and Bhosle, 1990). Early control of weeds could be achieved by the use of pre-emerging herbicides. Cotton with minimal weed competition during the initial phase would yield better.

Hand weeding requires more labour, consumes more time leading to higher cost of weeding. Availability of labour is also scarce. An estimate of 400-600 man hrs ha^{-1} (Tajuddin, 1996) is the normal labour requirement for hand weeding, which also depends upon weed infestation. Mechanical weeding was partially effective because most of the weeds growing in intra rows escape during weeding.

Chemical weed control is easy, time saving and effective. Pre-sowing and pre-emergence herbicides are not effective against all weeds, whereas; post-emergence herbicides can control weeds, but it needs proper time of application and skill. The combination of pre and post-emergence herbicides are required to be integrated for effective weed control and increased seed cotton yield (Shaikh *et al.,* 2006). Post-emergence control of broadleaf weeds has typically been achieved with directed herbicide applications. For effective weed control and adequate crop safety with post-emergence directed herbicides, a height differential between the crop and weeds is required (Culpepper and York, 1998). Hence, an integration of different weed management methods would be the option for the effective weed management and enhancement of productivity in cotton.

Weeds accumulated higher concentration of mineral nutrients than crops, thereby depleting soil nutrients quickly reducing the yield. Number of sympodial branches are significantly reduced due to weed infestation as reported by Balasubramanian and Sankaran (1976). Velayutham *et al* . (2002) reported that unweeded check reduced the boll number plant^{-1} and boll weight of cotton. Khan and Khan (2003) reported that grassy weeds cause 15 to 40 per cent and broad leaf weeds 15 to 30 per cent yield losses in cotton crop. Losses caused by weeds in cotton ranged from 45-75 per cent

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depending upon the nature and intensity of weeds (Sandhu *et al.*, 1996). Hence, the integration of different weed management practices would be a viable option for wide spectrum weed management and enhancement of cotton productivity.

Materials and Methods

With a view to determine the influence of potassium salt based glyphosate on irrigated cotton, the present study was carried out during winter 2011-12 at Tamil Nadu Agricultural University. The soil was sandy clay loam in texture with low in available nitrogen (187.3 kg ha^{-1}), medium in available phosphorus (12.8 kg ha^{-1}) and high in available potassium (559.0 kg ha^{-1}) with pH of 8.44. The experiment was laid out in randomized block design with ten treatments replicated thrice. The treatments consisted of POE glyphosate (Roundup Crop Shield 460 SL) at 1350 (T_1), 1800 (T_2), 2250 (T_3) g a.e. ha^{-1}, 1800 g a.e. ha^{-1} + IC (T_4), PE pendimethalin at 750 g a.i. ha^{-1} + IC (T_5), HW at 35 and 70 DAS + IC (T_6), HWW at 35 and 70 DAS + IC (T_7), PWW at 35 and 70 DAS + IC (T_8), HW at 25 and 45 DAS (T_9) and Unweeded control (T_{10}). Good viable delinted seeds of MRC 7347 BG-II were dibbled on one side of the ridges with a spacing of 90 × 60 cm. The seed rate adopted was 2.5 kg of delinted seeds ha^{-1}. The experimental plots were applied with recommended dose of fertilizers (150:75:75 kg NPK ha^{-1}). Nitrogen, phosphorus and potassium were applied in the form of urea (46 per cent N), single super phosphate (16 per cent P_2O_5) and muriate of potash (60 per cent K_2O) respectively. Full dose of P and 50 per cent of N and K were applied as basal before sowing and the balance of 50 per cent of N and K were applied as top dressing at 45 and 60 DAS in two equal splits.

The pre-emergence herbicide was applied with pendimethalin (30 EC) at 750 g a.i. ha^{-1} at 3 DAS followed by earthing up at 45 and 55 DAS.

Calculated quantity of herbicide with a spray fluid of 500 l ha^{-1} was sprayed uniformly over the plots using hand operated sprayer fitted with fan type nozzle. Calculated quantity of potassium salt based glyphosate (Roundup Crop Shield 460 SL) at three different doses *viz.,* 1350, 1800, 2250 g a.e. ha^{-1} to the respective treatment plots (T_1, T_2 and T_3) was sprayed at 35 and 70 DAS using hand operated sprayer fitted with fan type and mist type nozzle, respectively under controlled application by using hood. Treatment T_4, was sprayed with potassium salt based glyphosate at 1800 g a.e. ha^{-1} under controlled application with hood at 35 and 70 DAS, followed by earthing up at 45 and 55 DAS. Two hand weeding were done in treatment T_6 at 35 and 70 DAS followed by earthing up at 45 and 55 DAS. Hand weeder and power weeder weeding were carried out in treatment T_7 and T_8, respectively at 35 and 70 DAS followed by earthing up at 45 and 55 DAS. In treatment T_9, hand weeding was carried out at 25 and 45 DAS. Number of bolls $plant^{-1}$ was counted at 90 DAS and the seed cotton *(Kapas*) was harvested in three pickings commencing on 125 DAS in all the treatment plots. During the experiment, observations on weed characters like weed flora, weed density, weed dry weight were recorded on regular intervals.

Results and Discussion

Weed flora

Weed flora of the experimental field predominantly consisted of seven species of broad-leaved weeds, four species of grasses and a sedge. Dominant among the grassy weeds were *Dactyloctenium aegyptium* and *Chloris barbata*. *Trianthema portulacastrum, Parthenium hysterophorus* and *Commelina benghalensis* were the major broad-leaved weeds and *Cyperus rotundus* was the only sedge present in the experimental field.

Table 1. Effect of different weed management methods on the density of total weeds in cotton

Treatment	Density of total weeds (No. m^{-2})		
	30 DAS	60 DAS	90 DAS
T_1 - POE glyphosate at1350 g a.e.ha^{-1} at 35 and 70 DAS	10.99 (119.3)	4.75 (20.67)	4.33 (17.33)
T_2 - POE glyphosate at1800 g a.e.ha^{-1} at 35 and 70 DAS	12.02 (142.6)	5.26 (26.00)	3.92 (14.00)
T_3 - POE glyphosate at 2250 g a.e.ha^{-1} at 35 and 70 DAS	11.76 (136.6)	4.40 (17.33)	2.91 (6.67)
T_4 - POE glyphosate at1800 g a.e.ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS	11.34 (126.6)	2.39 (4.00)	2.30 (3.33)
T_5 - Pendimethalin at 750 g a.i.ha^{-1} + IC at 45 and 55 DAS	4.00 (14.67)	2.57 (4.67)	5.53 (28.67)
T_6 - HW at 35 and 70 DAS + IC at 45 and 55 DAS	12.31 (150.0)	2.51 (4.33)	4.97 (23.00)
I_7 - HWW at 35 and 70 DAS + IC at 45 and 55 DAS	12.30 (149.3)	2.38 (3.67)	5.48 (28.33)
T_8 - PWW at 35 and 70 DAS + IC at 45 and 55 DAS	11.68 (134.6)	2.37 (3.67)	5.18 (25.33)
T_9 - HW at 25 and 45 DAS	2.79 (6.00)	3.62 (11.33)	6.38 (39.33)
T_{10} - Unweeded control	12.40 (152.0)	13.73 (186.6)	11.18 (124.3)

Weed density

The total weed density was significantly altered by different weed control treatments. Lesser weed density was observed with HW at 25 and 45 DAS (T_9) at 30 DAS followed by PE pendimethalin at 750 g a.i. ha^{-1}+ IC at 45 and 55 DAS (T_5). But at 60 DAS, POE glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS (T_4), PE pendimethalin at 750 g a.i. ha^{-1}+ IC at 45 and 55 DAS (T_5), HW at 35 and 70 DAS + IC at 45 and 55 DAS (T_6), HWW at 35 and 70 DAS + IC at 45 and 55 DAS (T_7) and PWW at 35 and 70 DAS + IC at 45 and 55 DAS (T_8) exhibited good control of total weeds. POE glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS (T_4) registered good control over total weeds density at 90 DAS. Unweeded control (T_{10}) resulted in higher weed density at all the stages of observation.

Table 2. Effect of different weed management methods on the dry weight of total weeds and weed control efficiency (%) in cotton

Treatment	Dry weight of total weeds (g m^{-2})			Weed control efficiency (%)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1 - POE glyphosate at 1350 g a.e.ha^{-1} at 35 and 70 DAS	8.59 (72.07)	5.21 (25.24)	5.37 (27.63)	5.83	76.25	88.98
T_2 - POE glyphosate at1800 g a.e.ha^{-1} at 35 and 70 DAS	8.73 (74.33)	4.74 (20.99)	4.74 (21.10)	2.87	80.25	91.59
I_3 - POE glyphosate at 2250 g a.e.ha^{-1} at 35 and 70 DAS	8.71 (74.00)	3.66 (11.67)	3.38 (9.70)	3.31	89.02	96.13
T_4 - POE glyphosate at1800 g a.e.ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS	8.67 (73.13)	2.26 (3.11)	2.28 (3.23)	4.44	97.08	98.71
T_5 - PE pendimethalin at 750 g a.i.ha^{-1}+ IC at 45 and 55 DAS	2.83 (6.13)	2.18 (2.79)	5.73 (31.30)	91.99	97.38	87.52
T_6 - HW at 35 and 70 DAS + IC at 45 and 55 DAS	8.76 (74.83)	2.36 (3.58)	7.05 (47.67)	2.22	96.63	80.99
T_7 - HWW at 35 and 70 DAS + IC at 45 and 55 DAS	8.73 (74.43)	2.58 (4.70)	7.83 (59.33)	2.74	95.58	76.34
T_8 - PWW at 35 and 70 DAS + IC at 45 and 55 DAS	8.69 (73.63)	2.22 (2.99)	7.45 (53.67)	3.79	97.19	78.60
T_9 - HW at 25 and 45 DAS	1.85 (1.45)	4.17 (15.48)	8.24 (66.00)	98.11	85.43	73.68
T_{10} - Unweeded control	8.86 (76.53)	10.40 (106.2)	15.88 (250.7)	0.00	0.00	0.00
SEd 0.32	0.36	0.52	-	-	-	
CD (P=0.05)	0.68	0.75	1.08	-	-	-

Weed dry weight

Weed management methods significantly influenced the total weed dry weight at all the growth stages. Hand weeding at 25 and 45 DAS (T_9) showed lower total weed dry weight and was followed by PE pendimethalin at 750 g a.i. ha^{-1} + IC at 45 and 55 DAS (T_5) at 30 DAS. PE pendimethalin at 750 g a.i. ha^{-1} + IC at 45 and 55 DAS (T_5), POE glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS (T_4), PWW at 35 and 70 DAS + IC at 45 and 55 DAS (T_8), HW at 35 and 70 DAS + IC at 45 and 55 DAS (T_6) and HWW at 35 and 70 DAS + IC at 45 and

Table 3. Effect of weed management methods on bolls plant^{-1}, seed cotton yield and weed index (%) of cotton

Treatment	Bolls plant^{-1}	Seed cotton yield (kg ha^{-1})	Weed index (%)
T_1 - POE glyphosate at1350 g a.e.ha^{-1} at 35 and 70 DAS	44.7	1940	33.6
T_2 - POE glyphosate at1800 g a.e.ha^{-1} at 35 and 70 DAS	49.2	2180	25.6
T_3 - POE glyphosate at 2250 g a.e.ha^{-1} at 35 and 70 DAS	54.8	2250	23.2
T_4 - POE glyphosate at1800 g a.e.ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS	58.4	2930	-
T_5 - PE pendimethalin at 750 g a.i.ha^{-1} + IC at 45 and 55 DAS	55.4	2710	7.4
I_6 - HW at 35 and 70 DAS + IC at 45 and 55 DAS	55.8	2420	17.4
I_7 - HWW at 35 and 70 DAS + IC at 45 and 55 DAS	51.3	2000	31.6
T_8 - PWW at 35 and 70 DAS + IC at 45 and 55 DAS	51.7	2240	23.7
T_9 - HW at 25 and 45 DAS	50.4	2290	21.7
T_{10} - Unweeded control	22.5	910	68.9
SEd	1.58	189.3	-
CD (P=0.05)	3.31	397.7	-

55 DAS (T_7) recorded lower and comparable dry weight at 60 DAS. Post-emergence glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS (T_4) exhibited lower weed dry weight at 90 DAS.

Weed control efficiency

Higher weed control efficiency of 98.11 per cent was recorded in HW at 25 and 45 DAS (T_9) at 30 DAS. At 60 DAS, higher weed control efficiency (97.38 %) was observed with PE pendimethalin at 750 g a.i. ha^{-1} + IC at 45 and 55 DAS (T_5) and was closely followed by POE glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS (T_4) with 97.08 per cent of weed control efficiency. Higher weed control efficiency of 98.71 per cent were recorded with POE glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS (T_4) at 90 DAS. Lower density of 73.68 per cent with HW at 25 and 45 DAS (T_9) was observed at 90 DAS.

Number of bolls plant^{-1}

Application of POE glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS (T_4) produced more number of bolls plant^{-1} (58.4), which was on par with PE pendimethalin at 750 g a.i. ha^{-1} + IC at 45 and 55 DAS (T_5) and HW at 35 and 70 DAS + IC at 45 and 55 DAS (T_6) at 90 DAS. Unweeded control (T_{10}) registered lesser number of bolls (22.5) plant^{-1}.

Seed cotton yield

Among the treatments tried, POE glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS (T_4) recorded higher seed cotton yield of 2926 kg ha^{-1} and was on par with PE pendimethalin at 750 g a.i. ha^{-1} + IC at 45 and 55 DAS (T_5) of 2709 kg ha^{-1} followed by HW at 35 and 70 DAS + IC at 45 and 55 DAS (T_6), which recorded seed cotton yield of 2418 kg ha^{-1} , HW at 25 and 45 DAS (T_9), POE glyphosate at 2250 g a.e. ha^{-1} at 35 and 70 DAS (T_3), PWW at 35 and 70 DAS + IC (T_8) and POE glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS (T_2) with 2290, 2246, 2232 and 2178 kg ha^{-1} of seed cotton yield, respectively and these were comparable with each other.

Unweeded control (T_{10}) recorded lower seed cotton yield of 911 kg ha^{-1}. Compared to non-intercultural operation treatments, intercultural operation carried out treatments registered more seed cotton yield. POE glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS (T_4), PE pendimethalin at 750 g a.i. ha^{-1} + IC at 45 and 55 DAS (T_5) and HW at 35 and 70 DAS + IC at 45 and 55 DAS (T_6) recorded higher seed cotton yield than non-intercultural operation treatments.

Weed index

Seed cotton yield of POE glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 DAS + IC at 45 and 55 DAS (T_4) was taken as basis to work out the weed index (WI). PE pendimethalin at 750 g a.i. ha^{-1} + IC at 45 and 55 DAS (T_5), followed by HW at 35 and 70 DAS + IC at 45 and 55 DAS (T_6) performed better and recorded lower weed index. POE glyphosate at 1350 g a.e. ha^{-1} at 35 and 70 DAS (T_1) and HWW at 35 and 70 DAS + IC at 45 and 55 DAS (T_7) were found to record higher weed index. Unweeded control (T_{10}) resulted in higher weed index and performed poorly.

Conclusion

Experimental results revealed that, post-emergence application of glyphosate at 1800 g a.e. ha^{-1} at 35 and 70 days after sowing + Intercultural operation as earthing up at 45 and 55 days after sowing resulted in lower weed density, weed dry weight and higher weed control efficiency. With respect to the relative weed density, broad-leaved weeds were higher at initial stages and grassy weeds were predominant at later stages of cotton. Highest seed cotton yield was obtained with post-emergence application of glyphosate at 1800 g a.e. ha^{-1} applied at 35 and 70 DAS with intercultural operation of earthing up at 45 and 55 DAS which was comparable with pre- emergence application of pendimethalin at 750 g a.i. ha^{-1} + intercultural operation at 45 and 55 DAS. The treatments with intercultural operation performed better in yield attributes and higher yield compared to treatments without intercultural operation.

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