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Effect of glyphosate on weed management and grain yield in *Kharif* maize of transgenic stacked and conventional maize hybrids for higher productivity

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A field experiment was carried out at Tamil Nadu Agricultural University, Coimbatore during *kharif* seasons of 2010 and 2011 to study the effect of Glyphosate on weed management and grain yield in *kharif* maize of transgenic stacked and conventional maize hybrid. This investigation was conducted with the following objectives to evaluate the weed control efficiency and crop productivity with K salt of glyphosate formulations under field conditions. Treatments consisted of two transgenic stacked hybrids named 30V92 and 30B11 applied with glyphosate as early post emergence at 900 and 1800 g a.e ha^{-1} during *kharif* season of 2010 and conventional maize hybrids named 30V92 and 30B11 applied with glyphosate by controlled droplet application method at 900, 1350 and 1800 g a.e ha^{-1} during *kharif* season of 2011 compared with non-transgenic counterpart maize hybrids applied with pre emergence atrazine at 0.5 kg ha^{-1} followed by one hand weeding on 40 days after sowing (DAS) with and without insect management. Among the treatments, early POE application of glyphosate at 1800 g a.e ha^{-1} registered lower weed density and higher weed control efficiency in transgenic and non-transgenic maize hybrids at all the intervals. Higher grain yield was registered with post emergence application of glyphosate at 1800 g a.e ha^{-1} in transgenic and non transgenic maize hybrid of 30V92 during both the *kharif* seasons

Key words: Glyphosate, transgenic maize, weed control efficiency, weed index, yield.

INTRODUCTION

Herbicide tolerance has been introduced through genetic modification into a number of crops including maize. The development of crop cultivars with resistance to selected herbicides has the positive impact on agricultural production systems and food safety. Roundup Ready® crop varieties that can be safely treated with glyphosate herbicide to control weeds were first commercialized for soybeans in 1996, for cotton in 1997, and for corn in 1998 (Green et al., 2008). Herbicide tolerance has been introduced through genetic modification into a number of crops including corn. Glyphosate, the active ingredient in the Roundup family (ROUNDUP, ROUNDUP ULTRA AND ROUNDUP READY) were registered trademarks of Monsanto Technology of agricultural herbicides is one of the most widely used herbicides in the world. Glyphosate is highly effective against the majority of annual, perennial grasses, and broad-leaf weeds and has superior environmental and toxicological characteristics such as rapid soil binding and biodegradation as well as extremely low toxicity to mammals, birds, and fish. Glyphosate is a foliar applied, broad spectrum, post emergence herbicide capable of controlling annual,

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perennial grasses and dicotyledonous weeds.

The introduction of glyphosate resistant crops has created new opportunities for the use of effective, non selective herbicides like glyphosate as selective weed control in crop production. Now, it can be used as post emergence herbicide in glyphosate resistant crops (Norsworthy et al., 2001). Roundup Ready corn event NK603 was produced by the stable insertion of two gene cassettes that express 5-enolpyruvylshikimate-3-phosphate synthases from *Agrobacterium* sp. strain CP4 (*CP4 EPSPS*). Corn event NK603 differs from Roundup Ready corn event GA21 that expresses a modified corn EPSPS. While TC1507 maize expresses a Bt insecticidal protein (Cry1F) for control of certain lepidopteron (stem borers) pests and NK603 corn expresses a modified maize 5-enolpyruvylshikimate-3-phosphate synthase enzyme (*CP4 EPSPS*) that confers tolerance to herbicide products containing glyphosate. Post emergence herbicides have been achieved in adequate weed control programmes, due to its broad spectrum of activity, excellent crop safety, convenience and flexibility was reported by Ferrel and Witt (2002).

Post emergence application of glyphosate at 1800 g a.e ha^{-1} in transgenic maize and post emergence control droplet application method of glyphosate at 1800 g a.e ha^{-1} in conventional maize hybrid (30V92) recorded high productivity and profitability. In view of the above facts, an experiment on ''Effect of Glyphosate on weed management and grain yield in *kharif* maize of transgenic Stacked and conventional maize Hybrids'' taken up during *kharif* season of 2010 and 2011 (Tables 1 and 2). Target pests viz., stem borer and cob borer were effectively controlled in transgenic maize hybrids during both the *kharif* seasons.

MATERIALS AND METHODS

Experimental site

Field experiments were laid out during *kharif* seasons of 2010 and 2011 in Eastern bloc farm of Tamil Nadu Agricultural University, located at Coimbatore, India. The geographical location of the experimental site is situated in western agro climatic zone of Tamil Nadu at 11°N longitude and 77°E latitude with an altitude of 426.7 m above MSL and the farm receives the total annual rainfall of 674 mm in 45.8 rainy days. The soil of the experimental site was sandy clay loam in texture (32.48% clay, 18.50% silt and 28.96% coarse sand) with low available nitrogen, medium in available phosphorous and high in available potassium. The soil analysed 260, 11.90 and 490 Kg ha^{-1} of KMnO4-N, Olsen–P and NH_4OAC-K, respectively with EC of 0.16 dSm^{-1}, pH of 8.11 and organic carbon of 0.31%.

Selection of cultivar and sowing

The experiment was laid out in randomized complete block design (RBD) with sixteen treatments and replicated thrice. The gross plot size adopted was (5 × 3.6 m) 18 m^2. The adopted spacing between the rows and plants were 60 and 25 cm respectively. Herbicide tolerant transgenic maize test hybrids namely 30V92, 30B11, and conventional hybrids of 30V92, 30B11, BIO 9681, and COHM5 during the *kharif* season of 2010. Conventional maize hybrids 30V92, 30B11, BIO 9681 and COHM5 were raised during *kharif* season of 2011. After sowing the seed, immediate light irrigation was given to the crop for uniform germination

The herbicides as per the treatments schedule were applied as pre emergence at third day after sowing, glyphosate application at 2 to 4 leaf stage of weeds [20 to 25 days after sowing (DAS) of maize]. Hand operated knapsack sprayer fitted with a flat fan type nozzle (WFN 40) was used for spraying the herbicides adopting a spray volume of 250 L ha^{-1}. The recommended dose of 150:75:75 Kg of NPK ha^{-1} are in the form of urea, single super phosphate and muriate of potash.

RESULTS AND DISCUSSION

Predominant weed flora of the experimental field

Effect on weeds

Weed flora of the experimental field in maize predominantly consist of 12 species of broad leaved weeds, 5 species of grasses and a sedge weed. The dominant among broadleaved weeds were *Trianthema portulacastrum*, *Datura stramonium, Cleome gynandra, Digera arvensis*, *Physallis minima,* and *Corchorus olitorius.* The dominant grass weeds were *Setaria verticillata* and *Cynodon dactylon. C. rotundus* was the only sedge present in the experimental field. With respect to individual weed species during both the years, density of *T. portulacastrum* recorded about 162.80% $No.m^{-2}$ before spraying of glyphosate. Higher weed flora composition registered during both years might be due to adequate rainfall during cropping period which favoured a conducive field environment for weed growth: *T. portulacastrum, D. stramonium, C. gynandra, P. minima, D. arvensis, S. verticillata*, and *C. dactylon.* The results are in line with the findings of (Nadeem et al., 2008) who reported that *T. portulacastrum, D. arvensis* were the most common weeds which compete with maize and assimilate faster biomass than maize.

Weed control rating in maize

Weed control rating score was done at 7, 15, and 21 days after sowing (DAS) in transgenic maize hybrids with POE application of glyphosate at various rates of application. At 7 DAS, moderate control of broad leaved weeds and grass (score = 6) and poor to deficient control of sedges (score = 3) were observed with glyphosate at 900 g a.e ha^{-1}. Satisfactory control of broad leaved weeds and grass (score = 7), deficient control of sedges (score = 4) were observed under glyphosate at 1800 g a.e ha^{-1}. Glyphosate at 900 and 1800 g a.e ha^{-1} at 15 DAS resulted in good control of broad leaved and grass weeds (score = 8), moderate control of sedges (score = 6) (Table 2). Whereas at 21 DAS, complete control of broad leaved weeds and grass (score = 10), good control of sedges (score = 9) were noticed under glyphosate at 1800 g a.e ha^{-1}. Satisfactory control of sedges was observed

Table 1. Weed control rating in transgenic maize – *kharif* season of 2010.

Treatment	7 DAS			15 DAS			21 DAS		
	BLW	Grass	Sedge	BLW	Grass	Sedge	BLW	Grass	Sedge
T_1 - 30V92 HR Glyphosate at 900 g a.e ha^{-1}	6.0	6.0	3.0	8.0	7.0	6.0	10.0	8.0	8.0
T_2 - 30V92 HR Glyphosate at 1800 g a.e ha^{-1}	7.0	7.0	4.0	9.0	8.0	6.0	10.0	10.0	9.0
T_4 - 30B11HR Glyphosate at 900 g a.e ha^{-1}	6.0	6.0	3.0	7.0	7.0	6.0	9.0	9.0	8.0
T_5 - 30B11HR Glyphosate at 1800 g a.e ha^{-1}	7.0	7.0	4.0	9.0	8.0	6.0	10.0	10.0	9.0

Data not statistically analysed BLW: Broad leaved weeds.

Table 2. Weed control rating in non transgenic maize – *kharif* season of 2011.

Treatment	7 DAS			15 DAS			21 DAS		
	BLW	Grass	Sedge	BLW	Grass	Sedge	BLW	Grass	Sedge
T_1 - 30V92 POE Glyphosate at 900 g a.e ha^{-1}	6.0	6.0	3.0	7.0	7.0	5.0	9.0	9.0	8.0
T_2 - 30V92 POE Glyphosate at 1350 g a.e ha^{-1}	7.0	7.0	4.0	8.0	8.0	6.0	10.0	10.0	9.0
T_3 - 30B11 POE Glyphosate at 1800 g a.e ha	8.0	7.0	4.0	8.0	8.0	6.0	10.0	10.0	9.0
T_4 - 30B11 POE Glyphosate at 900 g a.e ha^{-1}	6.0	6.0	3.0	7.0	7.0	5.0	9.0	9.0	8.0
T_5 - 30B11 POE Glyphosate at 1350 g a.e ha^{-1}	7.0	7.0	4.0	8.0	8.0	6.0	10.0	10.0	9.0
T_6 - 30B11 POE Glyphosate at 1800 g a.eha^{-1}	8.0	7.0	4.0	8.0	8.0	6.0	10.0	10.0	9.0

Data not statistically analysed BLW: Broad leaved weeds.

with glyphosate at 900 g a.e ha^{-1}.In non-transgenic maize hybrids at 3 DAS, deficient to moderate control of broad leaved weeds, poor to deficit control of grass and poor control of sedge (scoring = 5, 3, and 2), respectively were observed with glyphosate application at 900 g a.e ha^{-1}. Whereas, POE application of glyphosate at 1350 and 1800 g a.e ha^{-1} was observed a deficient to moderate control of broad leaved weeds and grasses (score = 5), poor control of sedge (score = 2). Glyphosate at 1350 and 1800 g a.e ha^{-1} at 15 DAS resulted in good control of broad leaved and grass weeds (score = 8), moderate control of sedges (score = 6). Whereas, at 21 DAS, complete control of broad leaved weeds and grass (score = 10) good control of sedges (score = 9) were noticed under glyphosate at 1350 and 1800 g a.e ha^{-1} (Table 2).

Weed density

The weed control methods effectively controlled the density of all the weeds under both transgenic and non-transgenic maize hybrids at different stages of crop growth as compared to unweeded control. During *kharif* season of 2010, lower weed density was achieved under non transgenic maize hybrid BIO 9681 and 30B11 with pre emergence application of atrazine at 0.5 Kg ha^{-1} followed by hand weeding at 20 DAS. Relatively, a higher density was observed under unweeded checks and transgenic maize before imposing post emergence application of glyphosate. Atrazine effectively controlled majority of broad leaved and grassy weeds at earlier stages of maize growth. Mundra et al. (2003) reported that, application of atrazine at 0.5 kg ha^{-1} as pre-emergence fb inter cultivation at 35 DAS in maize significantly reduced the total weed density (Table 3).

At 40 and 60 DAS, lower weed density (2.04 and 2.35) was observed under transgenic maize hybrid 30V92 with post emergence application of glyphosate at 1800 g a.e ha^{-1} resulted in effective control of broad leaved weeds, grasses and sedges due to its broad spectrum action (Wilcut et al., 1996). This may due to more impressive control of broadleaved weeds like *T. portulacastrum, D. stramonium, C. gynandra* and *P. minima*. Foliar application of glyphosate was readily and rapidly translocated throughout the actively growing aerial and underground portions at active growing stage of broadleaved weeds might have blocked the 5-Enulpyruvate shikimate-3-phosphate synthase enzyme and arrest the amino acid synthesis which led to complete control (Summons et al., 1995). During kharif season of 2011, post emergence controlled droplet application of glyphosate at conventional maize hybrid of 30V92 at 1800 g a.e ha^{-1} (1.84 Nos m^{-2}) observed lesser total weed density at 40 DAS. Thus, glyphosate effectively controlled a broad spectrum of annual and perennial grasses, sedges and broadleaved weeds could be due to increased translocation of glyphosate inside the plant tissues Suwunnamek and Parker (1975) (Table 4).

Effect on crop

High persistence nature of weeds was attributed to their ability of high seed production and seed viability. Post

Table 3. Effect of glyphosate application on total weed density in transgenic maize.

Treatment	Total weed density (No. m^{-2})		
	Kharif season of 2010		
	20 DAS	40 DAS	60 DAS
T_1 - T.30V92 HR Glyphosate at 900 g a.e ha^{-1}	15.43 (236.22)	2.78 (5.75)	3.41 (9.63)
T_2 - T.30V92HR Glyphosate at 1800 g a.e ha^{-1}	15.33 (233.08)	2.04 (2.15)	2.35 (3.52)
T_3 - T.30V92HR (Weedy check)	15.74 (245.60)	14.32 (202.93)	13.81 (188.75)
T_4 - T.30B11HR Glyphosate at 900 g a.e ha^{-1}	15.78 (246.89)	3.31 (8.98)	3.84 (12.74)
T_5 - T.30B11HR Glyphosate at 1800 g a.e ha^{-1}	16.06 (256.07)	2.55 (4.50)	3.06 (7.35)
T_6 - T.30B11HR (Weedy check)	15.81 (248.10)	14.54 (209.43)	14.42 (205.99)
T_7 - N.T.30V92 PE atrazine 0.5 kg ha^{-1} + HW+ IC	7.99 (61.85)	7.81 (59.00)	5.79 (31.48)
T_8 - N.T.30V92 No WC and only IC	15.45 (236.55)	13.64 (183.99	12.74 (160.36)
T_9 - N.T.30V92 No WC and no IC	16.05 (255.75)	14.37 (204.37)	14.38 (204.69)
T_{10} - N.T.30B11 PE atrazine 0.5 kg ha^{-1} + HW+ IC	7.55 (55.00)	8.14 (64.34)	5.87 (32.43)
T_{11} - N.T.30B11No WC and only IC	15.51 (238.44)	13.58 (182.38)	13.12 (170.11)
T_{12} - N.T.30B11 No WC and no IC	16.25 (262.00)	15.05 (224.47)	15.05 (224.57)
T_{13} - BIO9681 PE atrazine 0.5 kg ha^{-1}+ HW + IC	7.15 (49.14)	7.52 (54.58)	5.96 (33.49)
T_{14} - BIO9681No WC and no IC	14.69 (213.70)	13.85 (189.93)	14.52 (208.94)
T_{15} - CoHM5 PE atrazine 0.5 kg ha^{-1}+ HW + IC	7.83 (59.37)	8.32 (67.3)	6.20 (36.44)
T_{16} - CoHM5 No WC and no IC	16.38 (266.19)	15.24 (230.37)	15.79 (247.44)
SEd	1.34	1.11	1.06
CD(P = 0.05)	2.74	2.27	2.17

T.30V92-Transgenic stacked 30V92, N.T.30V92-Non transgenic 30V92, T.30B11– Transgenic30B11, N.T.30B11-non transgenic 30B11, HW-hand weeding, IC-insect control, WC-weed control.

Table 4. Effect of glyphosate application on total weed density in non transgenic maize.

Treatment	Total weed density (No. m^{-2})		
	Kharif season of 2011		
	20 DAS	40 DAS	60 DAS
T_1 - N.T.30V92 POE Glyphosate at 900 g a.e ha^{-1}	16.61 (273.97)	4.11 (14.89)	4.61 (19.29)
T_2 - N.T.30V92 POE Glyphosate at 1350 g a.e ha^{-1}	16.25 (262.05)	2.91 (6.45)	3.69 (11.62)
T_3 - N.T.30V92 POE Glyphosate at 1800 g a.e ha^{-1}	16.52 (271.05)	1.84 (1.4)	2.85 (6.10)
T_4 - N.T.30B11 POE Glyphosate at 900 g a.e ha^{-1}	16.41 (267.29)	4.32 (16.65)	4.84 (21.41)
T_5 - N.T.30B11 POE Glyphosate at 1350 g a.e ha^{-1}	16.60 (273.46)	3.16 (8.01)	4.16 (15.27)
T_6 - N.T.30B11 POE Glyphosate at 1800 g a.e ha^{-1}	16.93 (284.57)	2.23 (2.99)	3.36 (9.32)
T_7 - 30V92 PE atrazine 0.5 kg ha^{-1} + HW+ IC	7.37 (52.27)	8.78 (75.16)	6.81 (44.43)
T_8 - 30V92 No WC and only IC	16.35 (265.46)	14.83 (217.99)	14.58 (210.68)
T_9 - 30V92 No WC and no IC	17.03 (287.95	15.49 (238.01)	15.35 (233.48)
T_{10} - 30B11 PE atrazine 0.5 kg ha^{-1} + HW+ IC	8.10 (63.62)	9.36 (85.67)	7.47 (53.85)
T_{11} - 30B11No WC and only IC	15.74 (245.85)	15.13 (226.78)	14.97 (222.00)
T_{12} - 30B11 No WC and no IC	17.12 (291.03)	15.91 (251.15)	16.06 (255.96)
T_{13} - BIO9681 PE atrazine 0.5 kg ha^{-1} + HW+ IC	7.95 (61.21)	8.84 (76.16)	6.86 (45.02)
T_{14} - BIO9681No WC and no IC	16.56 (272.3)	15.53 (239.32)	15.32 (232.73)
T_{15} - CoHM5 PE atrazine 0.5 kg ha^{-1} + HW+ IC	8.49 (70.03)	9.82 (94.53)	7.20 (49.79)
T_{16} - CoHM5 No WC and no IC	17.21 (294.18)	17.10 (290.48)	16.98 (286.30)
SEd	1.41	1.10	1.05
CD(P = 0.05)	2.89	2.26	2.14

T_1-T_{16}- Non Transgenic maize hybrids ; HW-Hand weeding; IC-Insect control; WC-Weed control.

emergence herbicides have been achieved adequate weed control programmes. During both years of study, among

Table 5. Effect of glyphosate application on weed control efficiency, weed index and grain yield of transgenic maize.

Treatment	*Kharif* season of 2010			
	WCE (%), weed index (%), yield (kg ha^{-1})			
	20 DAS	40 DAS	90 DAS	90 DAS
T_1 - T.30V92 HR Glyphosate at 900 g a.e ha^{-1}	0.00	98.56	9.09	11.10
T_2 - T.30V92HR Glyphosate at 1800 g a.e ha^{-1}	0.00	99.53	0.00	12.21
T_3 - T.30V92HR (Weedy check)	0.00	0.00	27.60	8.84
T_4 - T.30B11HR Glyphosate at 900 g a.e ha^{-1}	0.00	97.72	10.15	10.97
T_5 - T.30B11HR Glyphosate at 1800 g a.e ha^{-1}	0.00	98.97	1.88	11.98
T_6 - T.30B11HR (Weedy check)	0.00	0.00	25.30	9.12
T_7 - N.T.30V92 PE atrazine 0.5 kg ha^{-1} + HW+ IC	80.28	72.57	16.21	10.23
T_8 - N.T.30V92 No WC and only IC	0.00	14.66	31.77	8.33
T_9 - N.T.30V92 No WC and no IC	0.00	0.00	38.41	7.52
T_{10} - N.T.30B11 PE atrazine 0.5 kg ha^{-1} + HW+ IC	79.66	70.33	20.06	9.76
T_{11} - N.T.30B11No WC and only IC	0.00	11.92	32.84	8.20
T_{12} - N.T.30B11 No WC and no IC	0.00	0.00	39.80	7.35
T_{13} - BIO9681 PE atrazine 0.5 kg ha^{-1}+HW+ IC	77.27	68.73	34.47	8.00
T_{14} - BIO9681No WC and no IC	0.00	0.00	49.87	6.12
T_{15} - CoHM5 PE atrazine 0.5 kg ha^{-1}+HW+ IC	79.28	68.56	39.96	7.33
T_{16} - CoHM5 No WC and no IC	0.00	0.00	58.39	5.08
SEd	-	-	-	0.41
CD(P = 0.05)	-	-	-	0.84

T.30V92-Transgenic stacked 30V92 , N.T.30V92- non transgenic 30V92,T.30B11 – transgenic30B11, N.T.30B11-non transgenic 30B11, HW-hand weeding, IC-insect control; WC-weed control.

the weed control treatments, post emergence application of glyphosate at 1800 g a.e ha^{-1} in transgenic corn hybrid recorded higher grain yield of 12.21 t ha^{-1} this was 36.64 % higher than the unweeded check plot of transgenic 30V92 during *kharif* season of 2010 (Table 5). Whereas during *kharif* season of 2011, post emergence controlled droplet application of glyphosate at 1800 g a.e ha^{-1} in conventional maize hybrid of 30V92 resulted in higher grain yield of 11.23 t ha^{-1} (Table 6). This was 44.79% higher than the unweeded check plot of conventional maize hybrid. This could be the achieved control of weeds with non selective, translocated herbicide, provided the favourable crop growth environment at the establishment stage of the crop itself by minimizing the perennial and annual weeds and increased the seed and stalk yields (Tharp et al., 1999). This might be due to the fact that, the perennial weeds like *Cyperus rotundus*, *C. dactylon*, troublesome broadleaved weeds like *T. portulacastrum* weeds were effectively controlled and might increase the maize yield may be due to better light utilization of narrow row zone and faster canopy closure (Murphy et al., 1996). This might be also improved yield components viz., higher number of grains per cob, grain weight per plant and test weight. This improvement in turn was due to improved growth attributes such as higher total dry matter production and distribution in different parts, higher leaf area index. Thus, the improvement in crop growth and yield components was the consequence of lower crop weed competition, which shifted the balance in favour of crop in the utilization of nutrients, moisture, light and space. These results are in conformity with the findings of Kamble et al. (2005).

Maize grain yield of POE application of glyphosate at 1800 g a.e ha^{-1} in transgenic 30V92 (T_2) was taken as basis to work out the weed index (WI) during *kharif* season of 2010. In transgenic maize hybrids, among the different rates of glyphosate, 900 g a.e ha^{-1} recorded lesser weed index of (9.09 and 10.15 per cent) in transgenic 30V92 (T_1) and 30B11 (T_4) respectively. In non-transgenic maize hybrids, PE application of atrazine 0.5 kg ha^{-1} + HW in 30V92 recorded lesser weed index (16.21%) compared all other non-transgenic hybrids with same treatment. During *kharif* of the 2011 among the different rates of glyphosate by controlled droplet application method of glyphosate at 1350 g a.e ha^{-1} recorded lower weed index of 7.75 and 15.23% in non transgenic maize hybrids of 30V92 (T_2) and 30B11(T_5). It was followed by POE application of glyphosate at 900 g a.e ha^{-1} in both non transgenic maize hybrids *viz*., 30V92 and 30B11. However, in PE application of atrazine at 0.5 kg ha^{-1} *fb* HW in 30V92 (T_7) maize hybrid recorded least weed index compared all other non-transgenic hybrids with same treatment. Unweeded check plots resulted in higher weed index and performed poorly during both the years.

Weed control efficiency which indicates the comparative magnitude of reduction in weed dry matter, was highly influenced by different weed control treatments. Pre emergence application of atrazine at 0.5 Kg ha^{-1} followed

Table 6. Effect of glyphosate application on weed control efficiency, weed index and grain yield of transgenic maize.

Treatment	*Kharif* season of 2011			
	WCE (%), weed index (%), yield (Kg ha^{-1})			
	20 DAS	40 DAS	90 DAS	90 DAS
T_1 - N.T.30V92 POE Glyphosate at 900 g a.e ha^{-1}	5.14	96.15	9.09	9.12
T_2 - N.T.30V92 POE Glyphosate at 1350 g a.e ha^{-1}	14.29	97.66	0.00	10.36
T_3 - N.T.30V92 POE Glyphosate at 1800 g a.e ha^{-1}	8.73	99.14	27.60	11.23
T_4 - N.T.30B11 POE Glyphosate at 900 g a.e ha^{-1}	21.41	95.86	10.15	8.25
T_5 - N.T.30B11 POE Glyphosate at 1350 g a.e ha^{-1}	14.16	97.17	1.88	9.52
T_6 - N.T.30B11 POE Glyphosate at 1800 g a.e ha^{-1}	11.15	98.87	25.30	10.39
T_7 - 30V92 PE atrazine 0.5 kg ha^{-1} + HW+ IC	82.26	68.96	16.21	8.72
T_8 - 30V92 No WC and only IC	13.97	10.25	31.77	7.40
T_9 - 30V92 No WC and no IC	0.00	0.00	38.41	6.20
T_{10} - 30B11 PE atrazine 0.5 kg ha^{-1} + HW+ IC	80.03	65.71	20.06	8.01
T_{11} - 30B11No WC and only IC	13.57	8.31	32.84	6.80
T_{12} - 30B11 No WC and no IC	0.00	0.00	39.80	6.22
T_{13} - BIO9681 PE atrazine 0.5 kg ha^{-1} + HW+ IC	78.97	63.82	34.47	7.10
T_{14} - BIO9681No WC and no IC	0.00	0.00	49.87	5.60
T_{15} - CoHM5 PE atrazine 0.5 kg ha^{-1} + HW+ IC	73.19	61.68	39.96	6.10
T_{16} - CoHM5 No WC and no IC	0.00	0.00	58.39	4.80
SEd	-	-	-	0.80
CD(P = 0.05)	-	-	-	1.64

T_1-T_{16}- Non Transgenic maize hybrids, HW-Hand weeding; IC-Insect control; WC-Weed control.

by hand weeding recorded higher weed control efficiency of 80.28% in non transgenic maize hybrid 30V92 at 20 DAS. Whereas at 40 DAS, after spraying of herbicide, higher weed control efficiency of 99.53% was recorded in glyphosate at 1800 g a.e ha^{-1} followed by 30B11 was observed 98.97% during *kharif* season of 2010 (Table 5). Whereas, during *kharif* season of 2011, higher weed control efficiency was observed with glyphosate at 1800 g a.e ha^{-1} in conventional maize hybrid of 30V92 registered maximum weed control efficiency of 99.14% owing to the fact that registered the lesser weed density (Table 6).

Different rates of glyphosate under transgenic maize hybrids recorded more than 90% control efficiency at 40 DAS. Whereas, at the same time PE application of atrazine in non transgenic hybrids recorded only 70 to 80. This might be due to the application of glyphosate which did not allow weeds to accumulate sufficient biomass and ultimately resulted in higher weed control efficiency. Properly timed sequential application of glyphosate was effective in season-long control of common waterhemp (*Amaranthus rudis*), giant foxtail (*Setaria faberi*), velvetleaf (*Abutilion theophrasti*), common cocklebur (*Xanthum strumarium*) and common lambsquarters (*Chenopodium album*) at levels more than 90 per cent through the season was reported by (Hellwig et al., 2002).

Conclusion

The results of this experiment revealed that, lesser weed dry weight and higher weed control efficiency were achieved with post emergence application of glyphosate at 1800 g a.e ha^{-1} in transgenic and post emergence controlled application of glyphosate at 1800 g a.e ha^{-1} in non transgenic hybrid of 30V92 during *kharif* season of 2010 and 2011 seasons, respectively. These enhanced the productivity of kharif maize resulting in higher economic returns.

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