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# Influence of Post Emergence Application of Glyphosate on Weed Control and Nutrient Uptake of Transgenic Maize

KEYWORDS: Transgenic maize, Glyphosate, Weed control efficiency, Nutrient uptake

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**ABSTRACT** *The research experiment was conducted with herbicide resistant transgenic maize during kharif2009 and rabi 2009-10 at Tamil Nadu Agricultural University, Coimbatore, with the treatments consisted of two transgenic maize hybrids named Hishell and 900 M gold with application of glyphosate as post emergence @ 900, 1800 and 3600 g a.e ha$^{-1}$ these were compared with non-transgenic counterpart maize hybrids with application of atrazine as pre-emergence @ 0.5 kg ha$^{-1}$ followed by one hand weeding at 40 DAS and unweeded control. The total density of weeds were significantly reduced with post emergence application of glyphosate at 1800 g a.e ha$^{-1}$ in transgenic 900 M Gold and 3600 g a.e ha-1 in transgenic Hishell during kharif 2009 and rabi 2009-10 seasons, respectively. Similarly, higher nutrient uptake by maize and yield were achieved by post emergence application of glyphosate at different level of doses.*

**Introduction**

Maize is a versatile crop having higher yield potential among cereals and cultivated over a wide range of agro climatic zones and hence it is popularly called as "*Queen of Cereals*". Maize is the third most important cereal food crop of India after rice and wheat and is cultivated in an area of 8.11 million ha with a production of 19.77 million tonnes.The major yield reducing factors for maize cultivation in India are weeds and insects. Weeds cause considerable yield loss due to competition for resources with maize crop. Initial slow growth particularly at early crop growth stages and wider plant spacing of maize crop encourages fast and vigorous growth of weeds. Modern technologies introduce the new approaches to weed management systems in maize that include the use of post emergence application of non-selective herbicides in hybrids for which resistance genes have been inserted. Two different glyphosate-resistant events, GA21 and NK603, are commercially available in maize. Both the events were released for commercial production in the United States in 1998 and 2001 respectively (Duke and Cerdeira, 2009).

Glyphosate is effective on numerous grassy and broadleaf weeds, and rates can be adjusted to improve control of difficult species. The efficacy of glyphosate can result in reduced usage of pre-emergence herbicides. Environmentally, this reduction may be significant since two of the most commonly used pre-emergence herbicides, atrazine and metolachlor, have both been detected in Missouri groundwater. (Donald et al., 1998). According to Johnson et al. (2000), two post emergence glyphosate applications on maize can provide better weed control and nutrient uptake, especially if interfering weeds are controlled at heights less than 15 cm.With these in view, the experiment was conducted with transgenic maize hybrids and non-transgenic maize hybrids with different weed control methods.Purba and Desmarwansyah (2008) reported that higher grain yield was found in the plots that received glyphosate treatment singly at the three leaf stage of maize growth or repeated either at the seventh or twelfth leaf stage

**Materials and Methods**

The Field experiments were conductedat Tamil Nadu Agricultural University, Coimbatore during kharif 2009 and rabi2009-10. The farm is situated in western agro-climatic zone of Tamil Nadu at 11° N longitude, 77° E latitude and at an altitude of 426.7 m above mean sea level. The experiments were laid in Randomized Block Design (RBD) with three replications. The maize hybrids were sown with the spacing of 60 x 25 cm and the treatment details are as follows.

$T_1$ - Transgenic Hishell with post emergence application of glyphosate @ 900 g a.e ha$^{-1}$
$T_2$ - Transgenic Hishell with post emergence application of glyphosate @ 1800 g a.e ha$^{-1}$
$T_3$ - Transgenic Hishell with post emergence application of glyphosate @ 3600 g a.e ha$^{-1}$
$T_4$ - Transgenic 900 M Gold with post emergence application of glyphosate @ 900 g a.e ha$^{-1}$
$T_5$ - Transgenic 900 M Gold with post emergence application of glyphosate @ 1800 g a.e ha$^{-1}$
$T_6$ - Transgenic 900 M Gold with post emergence application of glyphosate @ 3600 g a.e ha$^{-1}$
$T_7$ - Hishell (Non-transgenic) with pre-emergence application of atrazine @ 0.5 kg ha$^{-1}$ + Hand Weeding (HW) @ 40 DAS + insect control
$T_8$ - Hishell (Non-transgenic) with no weeding and no insect control
$T_9$ - 900 M Gold (Non-transgenic) with pre-emergence application of atrazine @ 0.5 kg ha$^{-1}$ + HW @ 40 DAS + insect control
$T_{10}$ -900 M Gold (Non-transgenic) with no weeding and no insect control

Under transgenic hybrids post emergence application of glyphosate was done at 2-4 leaf stage of weeds (approximately 25 DAS of transgenic maize hybrids). In non-transgenic maize hybrids, atrazine 0.5 kg ha$^{-1}$ was applies at 3 days after sowing (DAS)

The weeds falling within the frames of the quadrat (four randomly fixed places in each plot) were categorized into grasses, sedges and broad-leaved weeds and counted, finally the mean values were expressed in number m$^{-2}$. The weed counts were subjected to square root transformation ($\sqrt{x+2}$) to normalize the distribution. The weed control efficiency (WCE) of each treatment was calculated using the following formula (Mani et al., 1973) based on weed dry weight

$$WCE\ \% = \frac{WD_c - WD_t}{WD_c} \times 100$$

Where, WCE - weed control efficiency (per cent), $WD_c$ - weed biomass (g m$^{-2}$) in control plot and

$WD_t$- weed biomass (g m$^{-2}$) in treated plot. Nutrient uptake by

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maize was calculated by oven dried plant sample was powdered and analyzed for nutrient contents. Nitrogen, phosphorus and potassium uptake by crop was expressed in kg $ha^{-1}$. The data were analyzed according to randomized block design by standard ANOVA at $P \leq 0.05$ level of significance.

**Results and Discussion**

**Total weed density**

Significant variation in total weed density was observed among the weed control treatments during both the seasons of experiment. Significantly lesser and comparable density of total weeds was achieved with PE application of atrazine at 0.5 kg $ha^{-1}$+ HW under non-transgenic Hishell ($T_7$) at 20 DAS during both the seasons. Whereas, during kharif 2009, significantly lesser and comparable density of weeds were observed under transgenic 900 M Gold with POE application of glyphosate at 3600 g a.e $ha^{-1}$ ($T_6$) at 40 DAS and 65 DAS. At harvest stage, effective control of weeds was achieved by POE application of glyphosate at 1800 and 3600 g a.e $ha^{-1}$ under both the transgenic hybrids ($T_2$, $T_3$, $T_5$ and $T_6$), were closely followed by POE glyphosate at 900 g a.e $ha^{-1}$ under both the transgenic hybrids ($T_1$ and $T_4$). Invariably, unweeded checks recorded maximum weed density at all the stages of maize growth.During rabi 2009-10 POE application of glyphosate at 1800 and 3600 g a.e $ha^{-1}$ under transgenic Hishell and 900 M Gold ($T_2$, $T_3$, $T_5$ and $T_6$) registered significantly lesser density of weeds at 40 DAS. Total weed density was significantly reduced at 65 DAS with application of glyphosate as POE at 1800 and 3600 g a.e $ha^{-1}$ under transgenic Hishell and 900 M Gold. This was closely followed by POE glyphosate at 900 g a.e $ha^{-1}$ under the same hybrids and non-transgenic hybrids with PE application of atrazine at 0.5 kg $ha^{-1}$+ HW.Comparatively lesser number of weedswas observed under transgenic hybrids with 3600 g a.e $ha^{-1}$ of glyphosate at the time of harvest

**Table 1. Effect of different weed management practices on the total weed density (no. $m^{-2}$)in maize**

| Treatments | kharif, 2009 | | | Rabi, 2009-10 | | |
|---|---|---|---|---|---|---|
| | 20 DAS | 40 DAS | 65 DAS | 20 DAS | 40 DAS | 65 DAS |
| $T_1$ - Transgenic Hishell with POE glyphosate @ 900 g $ha^{-1}$ | 15.81 (248.0) | 3.61 (11.0) | 3.83 (12.7) | 12.10 (144.3) | 4.24 (16.0) | 3.96 (13.7) |
| $T_2$ - Transgenic Hishell with POE glyphosate @ 1800 g $ha^{-1}$ | 15.45 (236.7) | 2.65 (5.0) | 3.32 (9.0) | 12.65 (158.0) | 3.16 (8.0) | 2.52 (4.3) |
| $T_3$ - Transgenic Hishell with POE glyphosate @ 3600 g $ha^{-1}$ | 15.39 (235.0) | 2.00 (2.0) | 2.45 (4.0) | 12.03 (142.7) | 2.08 (2.3) | 2.00 (2.0) |
| $T_4$ - Transgenic 900 M Gold with POE glyphosate @ 900 g $ha^{-1}$ | 15.70 (244.4) | 3.79 (12.3) | 4.47 (18.0) | 11.82 (137.7) | 4.40 (17.3) | 3.87 (13.0) |
| $T_5$ - Transgenic 900 M Gold with POE glyphosate @ 1800 g $ha^{-1}$ | 14.38 (204.7) | 1.73 (1.0) | 3.31 (9.0) | 12.83 (162.7) | 3.00 (7.0) | 2.71 (5.3) |
| $T_6$ - Transgenic 900 M Gold with POE glyphosate @ 3600 g $ha^{-1}$ | 14.10 (196.7) | 1.73 (1.0) | 2.38 (3.7) | 12.46 (153.3) | 2.16 (2.7) | 1.73 (1.0) |
| $T_7$- Hishell PE atrazine @ 0.5 kg $ha^{-1}$ + HW+ IC | 7.26 (50.7) | 8.02 (62.3) | 5.03 (23.4) | 5.17 (24.7) | 7.30 (51.3) | 5.10 (24.0) |
| $T_8$ – Hishell with unweeded control | 16.14 (258.4) | 13.04 (168.0) | 12.42 (152.3) | 12.96 (166.0) | 11.39 (127.7) | 10.94 (117.7) |
| $T_9$ - 900 M Gold PE atrazine @ 0.5 kg $ha^{-1}$+ HW+ IC | 7.02 (47.3) | 7.66 (56.7) | 5.10 (24.0) | 5.39 (27.0) | 7.28 (51.0) | 5.26 (25.7) |
| $T_{10}$ - 900 M Gold with unweeded control | 14.86 (219.0) | 13.29 (174.7) | 12.40 (151.7) | 12.64 (157.7) | 11.82 (137.7) | 10.68 (112.0) |
| SEd | 1.38 | 1.01 | 0.79 | 1.07 | 0.77 | 0.69 |
| CD (P=0.05) | 2.82 | 2.12 | 2.14 | 2.18 | 1.58 | 1.41 |

Wilcut et al. (1996) also found that, glyphosate effectively controlled a broad spectrum of annual and perennial grasses, sedges and broad leaved weeds and might be a viable alternative to other commonly used herbicides. Whereas, post emergence weed control in transgenic maize was found better than pre-emergence weed management in non-transgenic hybrids. Similarly, 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 and weed dry weight.

**Nutrient uptake by maize**

Significant variation was observed in the nutrient uptake by maize due to weed management methods at both the seasons. Both 1800 and 3600 g a.e $ha^{-1}$of glyphosate applied in transgenic maize hybrids ($T_2$, $T_3$, $T_5$ and $T_6$) recorded higher uptake of nitrogen and was followed by glyphosate at 900 g a.e $ha^{-1}$ in both the transgenic hybrids ($T_1$ and $T_4$) and PE application of atrazine 0.5 kg $ha^{-1}$ + HW in all non-transgenic hybrids during both the seasons. All weedmanagement practices under both the transgenic and non-transgenic hybrids recorded significantly higher amount of phosphorus uptake by maize compared to unweeded checks during both the seasons. Significantly higher uptake of potassium was observed with application of POE glyphosate at 1800 and 3600 g a.e $ha^{-1}$ in both the transgenic hybrids ($T_2$, $T_3$, $T_5$ and $T_6$), which was on par with PE application of atrazine 0.5 kg $ha^{-1}$ + HW in non-transgenic Hishell ($T_7$) and 900 M Gold ($T_{10}$). This was closely followed by POE application of glyphosate at 900 g a.e $ha^{-1}$ under both the hybrids ($T_1$ and $T_4$) during kharif 2009. Whereas, during rabi 2009-10, transgenic hybrids with all doses of glyphosate ($T_1$, $T_2$, $T_3$, $T_4$, $T_5$ and $T_6$) recorded higher potassium uptake compared to non-transgenic hybrids with weed management practices ($T_7$ and $T_{10}$). Unweeded control recorded lower uptake of potassium at both the seasons

**Table 2. Effect of different weed management methods on nutrient uptake (kg $ha^{-1}$) by maize at harvest**

| Treatments | Kharif, 2009 | | | Rabi, 2009-10 | | |
|---|---|---|---|---|---|---|
| | N | P | K | N | P | K |
| $T_1$ - Transgenic Hishell with POE glyphosate @ 900 g $ha^{-1}$ | 188.5 | 20.9 | 178.5 | 186.5 | 20.7 | 182.6 |
| $T_2$ - Transgenic Hishell with POE glyphosate @ 1800 g $ha^{-1}$ | 194.7 | 21.2 | 186.9 | 192.7 | 21.0 | 182.8 |
| $T_3$ - Transgenic Hishell with POE glyphosate @ 3600 g $ha^{-1}$ | 197.4 | 21.6 | 195.4 | 193.6 | 21.2 | 191.6 |
| $T_4$ - Transgenic 900 M Gold with POE glyphosate @ 900 g $ha^{-1}$ | 190.1 | 21.7 | 185.0 | 188.5 | 20.4 | 183.3 |
| $T_5$ - Transgenic 900 M Gold with POE glyphosate @ 1800 g $ha^{-1}$ | 203.6 | 22.1 | 193.0 | 199.2 | 21.7 | 188.9 |
| $T_6$ - Transgenic 900 M Gold with POE glyphosate @ 3600 g $ha^{-1}$ | 208.8 | 21.3 | 192.8 | 204.6 | 22.1 | 188.9 |
| $T_7$- Hishell PE atrazine @ 0.5 kg $ha^{-1}$ + HW+ IC | 186.0 | 20.0 | 187.2 | 185.8 | 21.0 | 181.8 |
| $T_8$ – Hishell with unweeded control | 132.3 | 15.6 | 130.8 | 130.1 | 15.4 | 128.7 |
| $T_9$ - 900 M Gold PE atrazine @ 0.5 kg $ha^{-1}$+ HW+ IC | 191.2 | 20.9 | 188.0 | 187.9 | 20.5 | 180.3 |
| $T_{10}$ - 900 M Gold with unweeded control | 142.6 | 17.3 | 140.3 | 138.0 | 16.8 | 135.8 |
| SEd | 7.07 | 1.40 | 5.17 | 5.96 | 1.09 | 4.77 |
| CD (P=0.05) | 14.13 | 2.82 | 10.36 | 11.92 | 2.17 | 9.53 |

Singh et al., (2009) concluded that the weeds emerging with the crop competing with them for nutrients especially nitro-

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gen, grow faster and utilize it in larger amounts than the crop, resulting in poor crop yield.

**Yield**

Weed management practices showed significant variation in grain yields in both transgenic and non-transgenic hybrids during both the seasons. Among the treatments evaluated, POE application of glyphosate at 1800 g a.e ha$^{-1}$ in transgenic 900 M Gold maize hybrid resulted 36.64 per cent higher grain than the unweeded check plots of counter part of non-transgenic 900 M Gold maize hybrid ($T_{10}$). During kharif, 2009. Whereas during rabi, 2009-10, POE application of glyphosate at 3600 g a.e ha$^{-1}$ in transgenic Hishell maize hybrid resulted in higher grain yield of 10.12 t ha$^{-1}$. This was 37.15 per cent higher than the unweeded check plots of counterpart non-transgenic Hishell maize hybrid ($T_8$)

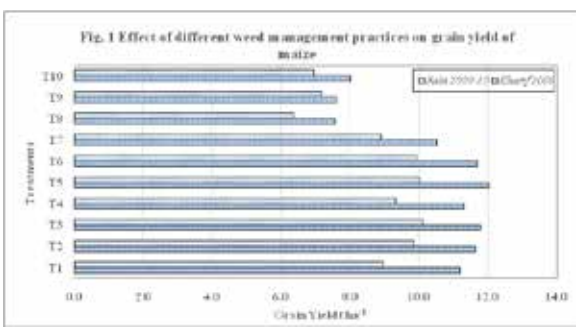

Fig. 1 Effect of different weed management practices on grain yield of maize

The findings are in accordance with observation of Tharp et al. (1999) who had earlier reported that maize yields of herbicide resistant hybrids were maximum with glyphosate at 0.84 kg ae ha$^{-1}$ of glyphosate when applied at fifth leaf stage of maize

**Conclusion**

The total density of weeds were significantly reduced with POE application of glyphosate at 1800 g a.e ha$^{-1}$ in transgenic 900 M Gold and 3600 g a.e ha$^{-1}$ in transgenic Hishell during kharif 2009 and rabi 2009-10 seasons, respectively. PE application of atrazine at 0.5 kg ha$^{-1}$+ HW in non-transgenic maize hybrids recorded lesser weed density and dry weight over unweeded control. Higher nutrient uptake and grain yield was recorded with POE application of glyphosate at 1800 g a.e ha$^{-1}$ in transgenic 900 M Gold and 3600 g a.e ha$^{-1}$ in transgenic Hishell during kharif, 2009 and rabi, 2009-10 seasons, respectively.

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