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# Effect of establishment methods and 4HPPD inhibitors on weeds, productivity and economics of *Kharif* maize under bael based agri-horti system

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**ABSTRACT:** *The application of optimal establishment methods and proper weed control measures is of great significance to controlling weeds in a field and boosting productivity of crops. This study was conducted during the Kharif season of 2022 at the Agricultural Research Farm, Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur, Uttar Pradesh. The objective was to evaluate the effects of different crop establishment methods and herbicidal treatments on weed dynamics, crop growth, yield, and the economics of maize cultivation under a bael (Aegle marmelos)-based agroforestry system. The experiment was conducted in a randomized complete block design with two factors, establishment methods and herbicidal treatments. The ridge and furrow method of establishment was efficient in controlling weeds and improved maize productivity over the use of conventional method of establishment. Also, the application of atrazine 1.0 kg/ha PE fb topramezone 25.2 g/ha at 25 DAS for weed control was found to be superior over other herbicidal treatments. The treatment atrazine 1.0 kg/ha PE fb topramezone 25.2 g/ha at 25 DAS recorded significantly higher grain yield and stover yield 48.42 q/ha and 58.33 q/ha as compared to the other herbicidal treatment of atrazine 1.0 kg/ha PE fb halosulfuron 67.5 g/ha at 25 DAS of 37.65 q/ha and 46.56 q/ha, respectively. Consequently, the application of ridge and furrow establishment method along with atrazine 1.0 kg/ha PE fb topramezone 25.2 g/ha at 25 DAS as a weed control measure was observed to bring in significantly superior combined economics of maize along with bael in the system with a B:C ratio of 3.49.*

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## 1. INTRODUCTION

Agroforestry has emerged as a highly attractive form of sustainable agriculture in recent times, which is crucial for adequate nourishment and food security for a population that is constantly expanding. This is particularly true for a densely populated nation like India, which has 142.8 crore people living in it. Consequently, agroforestry has been more and more popular, encompassing 43.3 million hectares at this time, an increase of more than 4.21 million hectares (9.69%) between 1990 and 2020 (FAO, 2020). An estimated 25.31 million hectares, or 8.2 percent, of India's total reported geographical area is currently covered by agroforestry. Because of this, agroforestry makes up, on average, 14.2% of all farmed land. Agri-horticulture-based land use systems (LUSs) present a viable alternative strategy for reducing and mitigating carbon emissions through $CO_2$ sequestration under the agro-climatic conditions of Mirzapur. These systems offer multiple benefits for enhancing livelihoods in the region, including higher yields of staple food crops, increased fodder production, improved soil health, reduced soil erosion, and a significant contribution to mitigating anthropogenic warming via carbon sequestration. (Gupta *et al.*, 2024). In places like Uttar Pradesh, agroforestry covers 1.86 million hectares of land (Dhyani *et al.,* 2013). Hence agroforestry combined with a high-value commercial crop such that of maize, has a considerably greater positive effect on farmers' total economic welfare and providing food security than the more widely used monoculture cropping method (Ranum *et al.,* 2014, Murdia *et al.,* 2016). Maize (*Zea mays* L.) is believed to be endemic to Central Americas and Mexico has attained the status of a commercial crop and is globally established as the third most important cereal crop after wheat and rice, acquiring it name "Queen of cereals" (Yadesa and Diro, 2023). With 4.87 percent of the world's land under cultivation and the potential to significantly increase cultivation in the near future, India is the world's fifth-largest producer of maize, accounting for roughly 2.5 percent of production worldwide.In India, 9.40 million hectares of maize are planted, yielding a total yield of 27.78 million tonnes during the

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2021–2022 season. The yield of maize during the kharif season accounts for about 70% of the country's yearly yield of 19.47 million tonnes. (Unjia *et al.,* 2021 and Rakshit *et al*., 2023). Although maize can be grown all year round, there are a number of issues that can arise when it is grown in rainfed conditions during the kharif season (Chaurasia *et al.,* 2021). These include pests, diseases, soil degradation from improper management, erosion during heavy rainfall, and water stress from uneven rainfall distribution. However, the main cause of these issues is still weed infestation. The estimated global yield loss in maize attributed to weeds is approximately 37% (Mhlanga *et al*., 2016). The yield loss in maize attributed to weeds varies from 28-93% based on the kind of weed flora and the severity and length of crop weed competition, as well as the density and stage of emergence (Kumawat *et al.,* 2019 and Chaudhary *et al.,* 2021). To solve this problem the latest developments in chemical weed management techniques, applying herbicides to weeds is proving to be a more affordable, efficient, and effective way to control weeds in kharif maize since normal practice of manual weeding can become extremely difficult to either constant rainfall, the prevailing wet soil condition or the bright sun (Kumar *et al.,* 2017 and Maqsood *et al.,* 2020). The goal of the present study was to evaluate the effects of different establishment methods and herbicide treatments on weed dynamics, as well as the growth and productivity of maize. Additionally, the study aimed to assess the economic viability of the agroforestry system. .

## 2. MATERIALS AND METHODS

The field trail was carried out at the Agricultural Research Farm, Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur (25°05′N and 82°58′E and at an altitude of 143 m above mean sea level), Uttar Pradesh, India. An experiment was laid out during the kharif cropping season of 2022 in factorial randomized complete block design. The soil of the site was sandy clay loam with a pH 6.7 and organic carbon content of 0.37%. The experiment aimed to determine key components such as weed composition, crop yield and economic returns within the maize (*Zea mays*)–bael (*Aegle marmelos*) agri-horti system. It followed a factorial design comprising two factors:, *i.e*., establishment methods (at two levels: $M_1$: Conventional method and $M_2$: Ridge and furrow method) and herbicidal treatments (at four levels: $W_1$: Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha at 25 DAS, $W_2$: Atrazine 1.0 kg/ha PE *fb* halosulfuron 67.5 g/ha at 25 DAS, $W_3$: Hand weeding at 20 and 40 DAS and $W_4$: Weedy check). All herbicide were determined based on treatment plans and sprayed aqueously with a backpack sprayer equipped with a flat fan nozzle delivering 400 litres of water per hectare. Two days after the crop was sown, pre-emergence herbicide atrazine (1.0 kg/ha) was administered in accordance with the treatments in $W_1$ and $W_2$ and post-emergence herbicide applications were carried out at 25 DAS. Along with that manual weeding was also carried out in the $W_3$ treatment at 25 DAS with the aid of a khurpi. Maize variety Jaunpur local was sown at a spacing of 60 cm between rows and 20 cm between each plant in an inter spacing of 13-year-old bael orchard (with tree-to-tree distance of 7m x 7m). Recommended dose of fertilizer (RDF) is 150:75:75 @ NPK kg/ha and nitrogen was applied in three splits, basal dose at the time of sowing, knee high and tasselling stage while full dose of phosphorus and potash were applied as basal dose. Data on weed density (No./$m^2$) and dry weight (g/$m^2$) at 60 DAS were recorded randomly at four spots in each treatment plot using a quadrat of 0.5 m x 0.5 m. In every experimental plot, the crop qualitie parameters and yields were documented by following the established procedures. The cost of cultivation, gross returns, net returns, and benefit–cost ratio for both maize and bael were calculated using the prevailing market rates for inputs and the minimum labor wages as prescribed by the local government. Prior to statistical analysis weed data were subjected to square root transformation $\sqrt{X + 0.5}$ to normalize their distribution. All the data obtained in the study were statistically analysed using F-test and CD values at P=0.05. Which were used to determine the significance of difference between treatments. Based on total weed dry weight, weed control efficiency (WCE) was computed by using the formulae.

$$\text{Weed control efficiency} = \text{WDMc} - \text{WDMt} / \text{WDMc} \times 100$$

Where, WDMc = Weed dry weight (g/$m^2$) in control plot

WDMt = Weed dry weight (g/$m^2$) in treated plot

Weed index (WI) are expressed in percentage and was computed by using the formulae.

$$\text{Weed index} = X - Y / X \times 100$$

Where X = Yield from minimum weed competition plot

Y = Yield from the treatment plot

The gross returns were calculated on the basis of the local market price (Minimum support price, 2023).

$$\text{Net return} = \text{Gross return - Cost of cultivation}$$

$$\text{Benefit:Cost} = \frac{\text{Gross returns}}{\text{Cost of Ciltivation}}$$

## 3. RESULTS AND DISCUSSION

### Weed density

In establishment methods, the weed density of $M_2$: Ridge and furrow method was recorded to be significantly lesser in comparison to $M_1$: Conventional method, this might be due to the early weed supersession in ridge and furrow which corroborated with the findings of Choudhary (2016), except for *Amaranthus viridis* and *Commelina benghalensis* where it was found to at par. While, in herbicidal treatment application the weed density was lowest with $W_3$: Hand weeding at 20 and 40 DAS and highest with $W_4$: Weedy check. This might be due to the precise and complete removal of weeds manually, which results in extensive suppression of weed at the critical growth stage in maize. Whereas, maximum weed density and dry weight were observed in the weedy check plots since weeds were allowed to grow without interference. This result was similar to the findings of Nayak *et al.* (2022). However, the weed density of *Brachiaria reptans, Commelina benghalensis* and *Euphorbia species* was found to be significantly lesser in $W_1$: Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha at 25 DAS than in $W_2$: Atrazine 1.0 kg/ha PE *fb* halosulfuron 67.5 g/ha at 25 DAS. Except for *Cyperus rotundus* where $W_2$: Atrazine 1.0 kg/ha PE *fb* halosulfuron 67.5 g/ha at 25 DAS recorded significantly lesser weed density than in $W_1$: Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha at 25 DAS. This might be due to the greater effectiveness of the post emergence herbicide halosulfuron against sedge weed species. Similar findings were reported by Kumar *et al.* (2013) and Verma *et al.* (2018). While, with *Cynodon dactylon* and *Amaranthus viridis* the weed density was more in $W_1$: Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha at 25 DAS in comparison to $W_2$: Atrazine 1.0 kg/ha PE *fb* halosulfuron 67.5 g/ha at 25 DAS but was significantly at par to each other (Table 1).

### Weed dry weight

The weed dry weight in establishment method used was found to be significantly lesser in *Brachiaria reptans* in $M_2$: Ridge and furrow method than in $M_1$: Conventional method. This might be due to reduced stress caused by weeds caused by the increased grain yield of maize. These results corroborate the findings of Kumar *et al.* (2023); while in for other weed species it was found to be significantly at par. The lowest and highest weed dry weight was observed in $W_4$: Weedy

**Table 1. Effects of establishment methods and herbicidal treatments on weed density (No./m$^2$) at 60 DAS in *kharif* maize.**

| Treatments | Weed density (No./m$^2$) | | | | | |
|---|---|---|---|---|---|---|
| | ***Brachiaria reptans*** | ***Cynodon dactylon*** | ***Cyperus rotundus*** | ***Amaranthus viridis*** | ***Commelina benghalensis*** | **Euphorbia species** |
| **Establishment methods** | | | | | | |
| M1 | 3.73 (18.80) | 3.89 (20.63) | 4.83 (33.36) | 2.18 (6.15) | 2.33 (7.32) | 2.27 (7.42) |
| M2 | 3.45 (16.30) | 3.70 (18.36) | 4.61 (30.78) | 2.14 (5.99) | 2.28 (7.08) | 2.22 (7.17) |
| SEm ± | 0.05 | 0.06 | 0.06 | 0.04 | 0.03 | 0.04 |
| CD (p=0.05) | 0.16 | 0.16 | 0.18 | 0.12 | 0.09 | 0.11 |
| **Herbicidal treatments** | | | | | | |
| W1 | 2.92 (8.06) | 3.36 (10.88) | 6.58 (42.93) | 1.54 (1.88) | 1.63 (2.15) | 1.46 (1.64) |
| W2 | 3.51 (11.96) | 3.59 (12.43) | 2.26 (4.66) | 1.73 (2.48) | 1.83 (2.85) | 1.66 (2.29) |
| W3 | 0.85 (0.22) | 0.82 (0.17) | 1.06 (0.62) | 0.91 (0.33) | 0.87 (0.27) | 0.80 (0.14) |
| W4 | 7.10 (49.98) | 7.41 (54.50) | 8.97 (80.08) | 4.47 (19.58) | 4.90 (23.52) | 5.06 (25.11) |
| SEm ± | 0.08 | 0.09 | 0.10 | 0.06 | 0.05 | 0.06 |
| CD (p=0.05) | 0.25 | 0.26 | 0.28 | 0.19 | 0.15 | 0.17 |

The values of parenthesis were the original values that had been changed to $\sqrt{X + 0.5}$;

check and $W_3$: Hand weeding at 20 and 40 DAS, respectively from the establishment methods. However, in herbicidal application of $W_1$: Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha at 25 DAS recorded significantly lesser weed dry weight than $W_2$: Atrazine 1.0 kg/ha PE *fb* halosulfuron 67.5 g/ha at 25 DAS with the exception of sedge *Cyperus rotundus* where $W_2$: Atrazine 1.0 kg/ha PE *fb* halosulfuron 67.5 g/ha at 25 DAS recorded lesser weed dry weight (Table 2).

**Yield attributes and crop yield**

The number of cobs per plant, number of rows per cob, number of grains per row and seed index (%) was all found to significantly higher with $M_2$: Ridge and furrow method than in $M_1$: Conventional method. While in herbicidal treatments the highest yield attributes was recorded with $W_3$: Hand weeding at 20 and 40 DAS followed by $W_1$: Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha at 25 DAS, $W_2$: Atrazine 1.0 kg/ha PE *fb* halosulfuron 67.5 g/ha at 25 DAS and finally $W_4$: Weedy check, and they differed significantly from each other. The overall higher yield attributed could be due to greater LAI and the dry matter accumulation in absence of crop-weed also reported by Walia *et al.* (2007). The stover, grain and biological yields of maize was recorded to be significantly higher in $M_2$: Ridge and furrow method in comparison to $M_1$: Conventional method amongst establishment methods used. Also, in herbicidal treatments the crop yield was recorded to be higher in $W_3$: Hand weeding at 20 and 40 DAS. The crop yield was higher in $W_1$: Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha at 25 DAS than $W_2$: Atrazine 1.0 kg/ha PE *fb* halosulfuron 67.5 g/ha at 25 DAS and finally $W_4$: Weedy check, and they differed significantly from each other. This might be due to the greater efficacy of the topramezone herbicide over halosulfuron in reducing crop weed competition, promoting better crop growth and nutrient availability for maize crop development, and improved yield. Similar results were observed by Negalur *et al*. (2020) (Table 3).

**Weed control efficiency and weed index**

The weed control efficiency of the establishment method was higher in $M_2$: Ridge and furrow method in comparison to $M_1$: Conventional method since ridges provides narrower spacing causing weed supersession and superior growth of maize crop at the early stage of ridge plantation (Choudhary *et al.* 2022). Whilst in herbicidal treatments applied the highest weed control

**Table 2. Effects of establishment methods and herbicidal treatments on dry weight ($g/m^2$) of weeds at 60 DAS in *kharif* maize.**

| Treatments | Weed dry weight ($g/m^2$) | | | | | |
|---|---|---|---|---|---|---|
| | ***Brachiaria reptans*** | ***Cynodon dactylon*** | ***Cyperus rotundus*** | ***Amaranthus viridis*** | ***Commelina benghalensis*** | **Euphorbia species** |
| **Establishment methods** | | | | | | |
| M1 | 2.15 (5.11) | 1.95 (3.77) | 1.92 (4.47) | 1.63 (2.99) | 1.58 (2.64) | 1.69 (3.23) |
| M2 | 2.00 (4.40) | 1.86 (3.37) | 1.83 (4.06) | 1.60 (2.92) | 1.56 (2.58) | 1.67 (3.12) |
| SEm ± | 0.04 | 0.03 | 0.04 | 0.02 | 0.02 | 0.03 |
| CD (p=0.05) | 0.11 | 0.10 | 0.12 | 0.05 | 0.05 | 0.09 |
| **Herbicidal treatments** | | | | | | |
| W1 | 1.70 (2.39) | 1.90 (3.14) | 2.11 (3.98) | 1.15 (0.83) | 1.21 (0.96) | 1.23 (1.02) |
| W2 | 2.13 (4.09) | 2.12 (3.99) | 0.98 (0.47) | 1.30 (1.21) | 1.36 (1.34) | 1.40 (1.48) |
| W3 | 0.92 (0.36) | 0.89 (0.31) | 0.82 (0.18) | 0.81 (0.16) | 0.80 (0.14) | 0.86 (0.24) |
| W4 | 3.56 (12.17) | 2.71 (6.84) | 3.59 (12.45) | 3.18 (9.63) | 2.91 (8.00) | 3.23 (9.97) |
| SEm ± | 0.06 | 0.05 | 0.07 | 0.03 | 0.03 | 0.05 |
| CD (p=0.05) | 0.17 | 0.15 | 0.20 | 0.08 | 0.08 | 0.14 |

The values of parenthesis were the original values that had been changed to $\sqrt{X + 0.5}$;

**Table 3. Effects of establishment methods and herbicidal treatments on yield, weed control efficiency and weed index.**

| Treatments | No. of cobs per plant | No. of row per cob | No. of grains per row | Seed index (%) | Grain yield (q/ha) | Stover yield (q/ha) | Biological yield (q/ha) | Harvest index (%) | Weed control efficiency (%) | Weed Index (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Establishment methods** | | | | | | | | | | |
| M1 | 2.92 | 13.28 | 29.00 | 34.38 | 38.67 | 47.98 | 86.65 | 43.66 | 62.80 | 30.75 |
| M2 | 3.12 | 14.52 | 30.55 | 35.59 | 41.06 | 49.94 | 91.01 | 44.16 | 63.35 | 28.08 |
| SEm ± | 0.05 | 0.24 | 0.28 | 0.27 | 0.28 | 0.21 | 0.45 | 0.21 | - | - |
| CD (p=0.05) | 0.16 | 0.73 | 0.82 | 0.81 | 0.83 | 0.63 | 1.32 | 0.64 | - | - |
| **Herbicidal treatments** | | | | | | | | | | |
| W1 | 3.32 | 15.09 | 31.60 | 35.76 | 48.42 | 58.33 | 106.74 | 45.35 | 78.47 | 15.80 |
| W2 | 2.89 | 14.00 | 29.90 | 34.65 | 37.65 | 46.56 | 84.21 | 44.71 | 76.00 | 34.62 |
| W3 | 3.61 | 16.05 | 34.47 | 37.43 | 57.61 | 66.46 | 124.07 | 46.41 | 97.83 | 0.00 |
| W4 | 2.27 | 10.46 | 23.14 | 32.10 | 15.79 | 24.51 | 40.30 | 39.18 | 0.00 | 67.24 |
| SEm ± | 0.08 | 0.39 | 0.44 | 0.43 | 0.44 | 0.34 | 0.70 | 0.34 | - | - |
| CD (p=0.05) | 0.25 | 1.15 | 1.30 | 1.28 | 1.32 | 1.00 | 2.09 | 1.01 | - | - |

efficiency was found in $W_3$: Hand weeding at 20 and 40 DAS followed by $W_1$: Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha at 25 DAS and $W_2$: Atrazine 1.0 kg/ha PE *fb* halosulfuron 67.5 g/ha at 25 DAS (Table 3). Weed index is directly proportional to crop yield loss. Here the weed index (Table 3) with the application of establishment was recorded higher in $M_1$: Conventional method in comparison to $M_2$: Ridge and furrow method. Also, the weed index was higher in $W_4$: Weedy check (67.24) which caused greater yield loss due to uncontrolled weed growth. Among the herbicidal application the $W_2$: Atrazine 1.0 kg/ha PE *fb* halosulfuron 67.5 g/ha at 25 DAS recorded higher weed index then $W_1$: Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha at 25 DAS. Lowest weed index was observed with $W_3$: Hand weeding at 20 and 40 DAS. This might be due to the greater weed killing efficiency of the post emergence herbicide topramezone and early weed suppression with the application of atrazine. These results corroborate the findings of Hargilas (2020), Lavanya *et al.* (2021) and Sanodiya *et al.* (2013).

**Economics of maize–bael based agroforestry system**

The highest cost of cultivation was observed in $M_2W_3$: Ridge and furrow method + Hand weedings at 20 and 40 DAS (₹86776.00/ha) as labour needed for ridge and furrow establishment in addition (Barua *et al.,* 2019), and least was with $M_1W_4$: Conventional method + Weedy check. The highest gross return was observed in $M_2W_3$: Ridge and furrow method + Hand weedings at 20 and 40 DAS followed by $M_1W_3$: Conventional method + Hand weedings at 20 and 40 DAS and $M_2W_1$: Ridge and furrow method + Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha 25 DAS, while the least was in $M_2W_4$: Ridge and furrow method + Weedy check. Also, the net return calculated to be the highest in $M_2W_3$: Ridge and furrow method + Hand weedings at 20 and 40 DAS followed by $M_2W_1$: Ridge and furrow method + Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha 25 DAS and $M_1W_3$: Conventional method + Hand weedings at 20 and 40 DAS. The highest gross and net might be due to better weed suppression in the system, leading to superior crop growth and yields for the plots. This was similar to the finding of Kakade *et al.* (2020). The benefit cost ratio of maize-bael based system was calculated to be found highest (3.49) in $M_2W_1$: Ridge and furrow method + Atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha 25 DAS. This might be due to early weed suppression by atrazine, followed by the greater efficacy of topramezone in controlling weed while also being more economical than halosulfuron; while, ridge and furrow method helped in reducing crop weed competition boosts yield

**Table 4. Effects of establishment methods and herbicidal treatments on combined economics of maize and bael.**

| Treatment | Cost of cultivation (₹/ha) | Gross return (₹/ha) | Net return (₹/ha) | Combined B:C ratio |
|---|---|---|---|---|
| $M_1W_1$: Conventional method + Atrazine 1.0 kg/ha PE fb topramezone 25.2 g/ha 25 DAS | 68543.83 | 305231.03 | 236687.20 | 3.45 |
| $M_1W_2$: Conventional method + Atrazine 1.0 kg/ha PE fb halosulfuron 67.5 g/ha 25 DAS | 75532.60 | 280533.95 | 205001.35 | 2.71 |
| $M_1W_3$: Conventional method + Hand weedings at 20 and 40 DAS | 85876.00 | 325856.09 | 239980.09 | 2.79 |
| $M_1W_4$: Conventional method + Weedy check | 67876.00 | 230796.90 | 162920.90 | 2.40 |
| $M_2W_1$: Ridge and furrow method + Atrazine 1.0 kg/ha PE fb topramezone 25.2 g/ha 25 DAS | 69443.83 | 311887.07 | 242443.24 | 3.49 |
| $M_2W_2$: Ridge and furrow method + Atrazine 1.0 kg/ha fb halosulfuron 67.5 g/ha 25 DAS | 76432.60 | 285722.35 | 209289.75 | 2.74 |
| $M_2W_3$: Ridge and furrow method + Hand weedings at 20 and 40 DAS | 86776.00 | 333745.38 | 246969.38 | 2.85 |
| $M_2W_4$: Ridge and furrow method + Weedy check | 68776.00 | 233021.97 | 164245.97 | 2.39 |

potential of the treatment plot (Jakhar *et al.,* 2017 and Sundari *et al.,* 2019). Whereas, the least was in $M_2W_4$: Ridge and furrow method + Weedy check (Table 4).

## 4. CONCLUSION

The utilization of ridge and furrow establishment method along with pre-emergence application of atrazine @ 1.0 kg/ha followed by post emergence application of topramezone 25.2 g/ha was found give superior yield attributes, crop yield, economics and overall better weed control from major weed during kharif season. Thus, adopting these treatments could prove to be viable and productive in a setting with of maize and bael in an agri-horti system.


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### Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could appear to have influenced the work reported in this paper.


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