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The Effectiveness of a Tank Mix of a Herbicide that Inhibits Hydroxylphenyl Pyruvate Dioxygenase (HPPD) for Controlling a Variety of Weed Flora in Maize in Tamil Nadu Western Zone

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Abstract

Weeds' competition with maize for nutrients, moisture, and light interference is very likely to result in maize being damaged. In order to control weeds in maize, atrazine was the main tool at hand. Although it is a pre-emergence herbicide, it effectively controls some annual grasses and broad-leaved weeds; however, maize crops require some post-emergence herbicides to control complex weed flora. There are few herbicide mixtures that are approved for use on maize. Therefore, details about the sensitivity to POST tembotrione herbicide and PRE emergence atrazine in rabi maize are required. The goals of this experiment were to assess tembotrione 420 SC (Laudis)'s compatibility with maize and the impact of that compound's leftovers on a subsequent crop. To determine the compatibility of tembotrione 420 SC at 120 g a.i.ha-1 as its combination with surfactant isoxadifen-ethyl, atrazine, and 2,4-D Dimethyl amine salt as tank mix on the grain yield of maize, a field experiment was conducted over two consecutive years in the rabi season of 2015–16 and 2016–17. As compared to the application of POE tembotrione 420 SC at 120 g a.i.ha-1 + surfactant at 1000 ml + atrazine 50% WP at 500 g a.i.ha-1, individual herbicides and unsprayed control, the combination significantly reduced weed density and biomass of grasses and broad-leaved weeds. The predominant grassy and broad-leaved weeds were greatly reduced by it: In comparison to the other herbicidal treatments, Dactyloctenium aegyptium (L.) Willd., Panicum repens (L.), Cyperus rotundus (L.), Trianthema portulacastrum (L.), and Cleome gynandra (L.) were all effective. Finally, the compatibility of tembotrione 420 SC at 120 g a.i.ha-1, surfactant at 1000 ml, and atrazine 50% WP at 500 g a.i.ha-1 at 20 and 40 DAHS can maintain the total weed density and dry weight reasonably at lower levels and increase the productivity of rabi maize without causing any phyto-toxicity to the primary crop as well as the succeeding sunflower.

Keywords: 2, 4-D, isoxadifen-ethyl, atrazine, phytotoxicity, HPPD inhibitor, grain yield

Introduction

Zea mays L., or maize, is known as the "miracle crop" or "queen of cereals" due to its great yield potential and tolerance to a variety of environments. The third-most significant food crop in India after rice and wheat, maize holds a proud position as both human food and animal feed. According to other reports, maize has the ability to promote livelihood security and diversification. Defending maize against weeds, pests, and diseases is crucial if one is to prevent the severe losses in production and quality that these threats can entail. Over the course of maize's whole life cycle, weeds compete for every resource, including nutrients, water, sunlight, and space. Weeds cause production losses of up to 68.9% [2] in maize, which is a crop with a wider row spacing and more frequent rains during the rabi season. These losses vary from 27 to 60% depending on the size and persistence of the weed population. [3, 4, 5, 6, 7] The first 1 to 8 weeks following sowing are crucial for crop weed competition in maize. Their relative density also significantly contributes to lowering the crop's yield. During this time, weed control is crucial if maize is to produce its optimum yield potential. Regarding the various weed control methods, manual eradication has demonstrated that it is superior to all other methods for managing weeds; however, farmers have not embraced the technique due to its time commitment, labor intensity, cost, and frequent impracticability during peak seasons. Agriculture's labor needs are growing costly, inconvenient, and scarce. [8] In this instance, post-emergence herbicides are not accessible for the control of weeds, and herbicides like atrazine, pendimethelin, and alachlor are advised for use in controlling weeds in maize. However, these herbicides only manage a certain weed flora for the first 3–4 weeks.

In 2007, Bayer Crop Science initially introduced tembotrione as a herbicide for maize. [14] Tembotrione 2-[2-Chloro-4-(Methylsulfonyl)-3-[(2,2,2 Trifluoromethyl) Methyl]]A novel maize herbicide called 1,3-cyclohexanedione works well as a POST-emergence treatment for a variety of broad-leaved and grassy weeds. It prevents the 4-hydroxyphenylpyruvate dioxygenase (HPPD) enzyme from catalyzing the conversion

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of 4-hydroxyphenylpyruvate to homogentisate, which results in the depletion of carotenoids and the absence of chloroplast formation in developing foliar tissue, giving the plant a bleached and stunted appearance. [15] There is a definite connection between light and the development of HPPD inhibitors' herbicidal activities since carotenoids play a crucial role in photosynthesis and photo-protection. In numerous conferences [16, 17, 18, 19] and foreign scientific papers [20], the effectiveness of tembotrione as a herbicide was discussed.

In light of their affordability and efficiency in maize, managing weeds with pre-and post-emergence herbicides will be the optimal method for controlling the weeds. These tactics are also a crucial tool for avoiding issues with herbicide resistance, but they need some background knowledge to help farmers choose the right herbicide and dosage for their particular scenario. The need for an alternate post-emergence herbicide with a suitable combination that may provide broad-spectrum weed control in rabi maize without impacting growth and yield was felt in light of the aforementioned information.

Materials and Methods

Choosing a cultivar, planting, and other agronomic procedures: Every year, maize (var. TNAU maize hybrid CO6 with a growing period of 110 days) was sown during the first week of September and harvested during the last week of December. Initially, the test field was dry plowed three times using a tractor-drawn disc plough and once with a cultivator. Plots were demarcated, and 60 cm-diameter ridges and furrows were created once the land was leveled. TNAU maize hybrid CO6 seeds were dispersed at a rate of two seeds per hill, with a row spacing of 60 cm and a row spacing of 30 cm. A 20 kg ha-1 seed rate was chosen. The initial irrigation was administered just after seeding. The fourth day following sowing was the day for life irrigation. The timing of subsequent irrigation was based on requirement and ranged from 8 to 12 days. The treatment plots' two border rows on each of their four sides were first harvested, and the net plots were collected separately. Dehusked, shelled, and cleaned separately, the harvested cobs were then dried. The grains were cleaned and then sun dried to achieve a moisture content of 14%. Each treatment's grain weight was noted and expressed in kg ha-1.

Design of the experiment, interventions, and herbicides: The treatments in each year were set up in a three-replication, randomized full block design. For weed control in rabi maize, seven weed control treatments were combined with various herbicide dosages. Tembotrione 420 SC, 2,4-Dimethyl amine salt, 58% SL, atrazine, 50% WP, and surfactant (isoxadifen-ethyl) were the herbicides used in the study.

Observation on weeds

i). **Weight of dry weed:** The weeds that fell within the quadrant's frames were gathered, divided into grasses, sedges, and broad-leaved weeds, shade dried, and then dried in a hot-air oven at 80°C for 72 hours. Broadleaved weeds, sedges, and grasses' dry weights were measured in g per m2 and recorded separately at 20 and 40 DAHS.

ii). **Grass flora in the test field:** In order to account for the overall weed flora of the experimental field, species-specific observations of weeds in the treatment plots were made between 20 and 40 DAHS, which is when they are most noticeable. The experimental site's weed flora was catalogued by species.

Observation on crop

- **Residual crop cultivation:** The next crop of sunflower (TNAU sunflower hybrid CO2) was cultivated in order to evaluate the residual effects of herbicides used on maize without changing the experiment's design. Sunflower was planted in corn stubbles as a follow-up crop after the maize crop was harvested.
- **Observation on succeeding crop (sunflower):** The percentage of seeds that germinated relative to the total seeds sowed was calculated by counting the number of seeds that did so at 10 DAS. Ten harvested plants for each treatment were counted to determine the average quantity of developed seeds per head. Harvested sunflower was separated into its individual seeds. At 14% moisture, the seed production was measured and expressed in kg ha-1.
- **Plant toxicity signs:** The effects of phytotoxicity on the plants were assessed after herbicide treatment. On 3, 5, 7 and 10 DAHS, visual rating for weed control was performed for both the experiments and phytotoxic symptoms (epinasty, hyponasty, necrosis, wilting, and vein clearing) in the maize crop. The severity of herbicide damage was graded on a scale of 0 to 10, with 0 denoting no damage and 10 denoting total annihilation.
- **Grain yield:** Grains from each net plot were cleaned, sun dried, weighed and adjusted to 14% moisture content and the grain yield was expressed in kg ha^{-1}.

Results and Discussion

Effect on weeds

The quantity and type of weeds

Setaria verticillata: Setaria verticillata density in the unsprayed control recorded larger populations of S. verticillata at 20 and 40 DAHS (Table 2), with values of 22.56 and 28.62 No. m-2 in 2015 and 18.62 and 23.46 No. m-2 in 2016, respectively. By applying tembotrione 420 SC at 120 g a.i.ha-1, surfactant at 1000 ml, and atrazine 50% WP at 500 g a.i.ha-1 via POE during the 2015 rabi, the decreased density of S. verticillata was detected, and this was comparable to hand weeding twice on 20 and 40 DAS (1.23 and 4.62 No. m-2). With the tank mix application of the HPPD-inhibiting herbicide tembotrione and the atrazine, weed control of 95% was observed. In this study, POE tembotrione 420 SC at 120 g a.i.ha-1 + surfactant at 1000 ml + 2,4-Dimethyl amine salt 58% SL at 500 g a.i.ha-1 (4.08 and 6.42 No. m-2) was recorded poor control weed of Setaria verticillata than that of herbicides alone like atrazine 50% WP at 500 g a.i.ha-1 (2.84 and 5.88 No. m-2) and 2,4-Dimethyl amine salt 58% SL at 500 g a.i.ha-1 (8.68 and 10.22 No. m-2). The density of Setaria verticillata was dramatically impacted by weed management measures during rabi in 2016. The post-emergence tank mix treatment of tembotrione and atrazine in maize produced effective control of grassy weeds. Our findings demonstrated that due to the crop's vigorous growth, which prevented S. verticillata from later flushing, the POE application of the new herbicide combination of tembotrione 420 SC at 120 g a.i.ha-1 + surfactant at 1000 ml + atrazine 50% WP at 500 g a.i.ha-1 achieved higher weed control during both years. The rabi maize was able to develop vigorously at first thanks to this treatment's effectiveness against S. verticillata, which in turn had a smothering impact on the crop later on.

Panicum repens: At 20 and 40 DAHS, P. repens had a higher population density in the unsprayed control (5.66 and 6.55 No. m-2 in 2015 and 3.21 and 6.26 No. m-2 in 2016 respectively). In contrast to tembotrione 420 SC at 120 g a.i.ha-1 + surfactant at 1000 ml + 2,4-Dimethyl amine salt 58% SL at 500 g a.i.ha-1 (0.33 and 0.46 No. m-2 in 2015 and 0.00 and 0.42 No. m-2 in 2016, respectively), POE application of these treatments resulted in higher weed density of P. repens. Individual applications of atrazine 50% WP at 500 g a.i.ha-1 during both years revealed a lower density of P. repens at both phases of observation than tembotrione 420 SC at 120 g a.i.ha-1 + surfactant at 1000 ml. A almost weed-free maize crop was produced after applying the herbicide combination of tembotrione 420 SC at 120 g a.i. ha-1, surfactant at 1000 ml, and atrazine 50% WP at 500 g a.i. ha-1. The crop's strong growth prevented the latter flush of weed seedlings from emerging.

Effect on crop: According to the germination % and quantity of seeds per sunflower head, there were no appreciable differences between the treatments (Table 5). Due to varied herbicide combinations of tembotrione 420 SC POE application at 120 g a.i.ha-1 in rabi maize throughout both years, the yield of sunflower grown as the next crop exhibited no obvious difference. [28] There were no lingering phyto-toxicity symptoms in the wheat crop that followed the application of tembotrione to maize at 120 and 240 g ha-1 (with surfactant) at 15 and 30 DAHS.

Conclusion

According to the findings of the current experiment, individual applications of POE herbicides like tembotrione, 2,4-Dimethylamine salt, and atrazine resulted in lower WCE in the complex weed flora in maize. Tembotrione 420 SC at 120 g a.i. ha-1, surfactant at 1000 ml, and atrazine 50% WP applied at 2-4 leaf stage provided satisfactory control of all types of weeds (grassy weeds, broad-leaved weeds, and sedges) in rabi maize without causing any crop phyto-toxicity on maize, which led to a higher grain yield and greater profitability. The necessity of adding a surfactant was discovered in order to achieve good tembotrione efficiency against mixed weed flora in maize. On maize, tembotrione 420 SC (Laudis) with different herbicide combinations had no phytotoxicity. There was also no residual toxicity on the sunflower crop that followed.

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