

## Effect of 2, 4-D sodium salt on weeds, growth and yields in *rabi* maize (*Zea mays* L.)

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Received: December 2022; Revised accepted: November 2023

### ABSTRACT

A field investigation was conducted during winter (*rabi*) season of 2021 at Agricultural Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, to study the efficacy of doses of 2, 4-D sodium salt 80% WP on weeds, productivity and economics of *rabi* maize (*Zea mays* L.). Application of 2, 4-D sodium salt 80% WP @ 1,250 g/ha at 25 days after sowing (DAS) resulted in to lesser weed density and weed dry weight of *Physalis minima* Roem. & Schult, *Chenopodium album* (L.), *Melilotus indicus* (L.) and *Cichorium intybus* (L.) as compared to 2, 4-D sodium salt 80% WP @ 1,000 g/ha and 2, 4-D sodium salt 80% WP @ 750 g/ha at 60 DAS, with higher weed control efficiency (77.3 %) and lesser weed index (34.9 %). At 60 DAS, 2, 4-D sodium salt 80% WP (applied @ 1250 g/ha at 25 DAS) produced higher plant height, number of leaves, chlorophyll content, leaf area index and plant dry-matter over other treatments except weed free and two hand weeding at 20 and 40 DAS. Application of 2, 4-D sodium salt 80% WP @ 1,250 g/ha at 25 DAS recorded higher number of cobs, number of kernels, number of kernels/row and seed index as compared to 2, 4-D sodium salt 80% WP @ 1,000 g/ha, and 2, 4-D sodium salt 80% WP @ 750 g/ha. Higher kernel (3.7 t/ha) and stover yield (4.7 t/ha) of maize was recorded due to application of 2, 4-D sodium salt 80% WP @ 1,250 g/ha at 25 DAS with higher harvest index (44.5%) and monetary returns ( $62.5 \times 10^3$  ₹/ha) as compared to 2, 4-D sodium salt 80% WP @ 1,000 g/ha, and 2, 4-D sodium salt 80% WP @ 750 g/ha.

**Key words:** 2, 4-D, Economics, Grain and stover yields, Weed-control efficiency, Weed index

Maize is grown over more than 193 million ha of land in 170 countries with a production of 1147.7 million tonnes and on a larger range of soil, biodiversity, climates under different management systems (FAOSTATE, 2020). In India, however, maize productivity is just half (2.96 t/ha) than the average productivity of the rest of the world (Anonymous, 2020). After rice and wheat, maize is India's third most significant cereal crop. Recently in India, there is an increasing interest to promote non-rice crops such as maize that requires less water during the dry season to enhance food production and generate more income for farm-

Based on a part of M.Sc. Thesis of the first author submitted to Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh in 2022 (unpublished)

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ers (Sarangi *et al.*, 2020). It can be produced in a variety of climates, ranging from extreme semi-arid to sub-humid and humid, which predominantly occupies 82% area under cultivation in rainy (*khari*) season and nearly 10% in winter (*rabi*) season (Sairam *et al.*, 2023a). Broad-leaved weeds cause harm to crops in a variety of ways and this is because of unusual adaptation characteristics of the weeds and their regeneration ability. Therefore, weed management is the major and important part of crop production. At present we have many selective herbicides with different modes of action of weed control in maize. 2, 4 – D which kills broad leaf weeds after emergence by causing the cells in the tissues that carry water and nutrients to divide and grow without stopping (Raghuwanshi *et al.* 2023). In view of this we planned an experiment to find out the best dose of this herbicide for getting higher weed control efficiency and yields of *rabi* hybrid maize.

A field experiment was conducted during winter (*rabi*) season of 2021 at Agricultural Research Farm, of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The soil was sandy clay loam, with pH 7.40, low in available organic carbon (0.41%),

available nitrogen (207.47 kg/ha) and medium in available phosphorous (23.85 kg/ha) and potassium (219.60 kg/ha). The experiment was laid out in a randomized block design, comprising 8 treatments; weedy, 2-hand weedings at 20 and 40 DAS, Atrazine 50% WP 1,000 g/ha as post emergence (PE), 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS. 2, 4-D sodium salt 80% WP 1,000 g/ha, 2, 4-D sodium salt 80% WP 750 g/ha and weed free replicated thrice. Maize variety ‘DHM 121’ which has duration of 150 days and yield potentiality of 55–60 q/ha was sown manually during the first week of December using the seed rate of 25 kg/ha and 60 × 20 cm row-row and plant-plant spacing. Application of PE herbicide was done according to the treatments using knap-sack sprayer fitted with even-fan nozzle using water @ 300 litre/ha. Species-wise weed density and their biomass were measured at 45 days after sowing (DAS) by placing a quadrat of 0.50/m<sup>2</sup> randomly at two places in each plot. Data on weed density and biomass were subjected to square root transformation before analysis. The differences within the treatment means were examined by means of “Critical Difference” (CD) and mean comparison was done using “Duncan Multiple Range Test” (DMRT) test (Gomez and Gomez, 1984) with the help of software named “Statistical Package for Social Science” (SPSS) presently owned by international business machine (IBM) corporation.

The density of different weeds at 60 DAS application of herbicide as influenced by different weed control treatments were recorded (table 1). Lower density of *Physalis minima* and *Chenopodium album* were recorded in hand weeding twice at 20 and 40 DAS in comparison to atrazine 50% WP 1,000 g/ha as PE, 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS. Density was recorded lesser in 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS than 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS and both were statistically similar to each other. Density of *Melilotus indicus* and *Cichorium intybus* were found lowest in hand weeding twice at 20 and 40 DAS and atrazine 50% WP 1,000 g/ha as PE and both were statistically similar to each other. The density was observed lower in 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS in comparison to 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS, 2, 4-D and 2, 4-D sodium salt 80% WP 750 g/ha at 25 DAS and these were recorded statistically similar with each other. The dry weight of *Physalis minima* was recorded lower in hand weeding twice at 20 and 40 DAS as compared to Atrazine 50% WP 1,000 g/ha as PE. Application of 2, 4-D sodium salt 80% WP @ 1250 g/ha at 25 DAS found lower dry

**Table 1.** Effect of herbicidal treatments on density, dry weight (g), weed control efficiency and weed index of broad-leaf weeds at 60 DAS in rabi maize

Treatment	Weed density (No. /m <sup>2</sup> )			Weed dry weight (g/m <sup>2</sup> )			Weed control efficiency (%)	Weed Index (%)
	<i>Physalis minima</i> (L.)	<i>Chenopodium album</i> L.	<i>Melilotus Indicus</i> (L.)	<i>Physalis minima</i> L.	<i>Chenopodium album</i> L.	<i>Melilotus indicus</i> (L.)		
Weedy	16.6 (276)	6.5 (42)	4.7 (22)	10.3 (105.7)	5.1 (25.6)	3.5 (11.8)	60 DAS	75.1
Hand weeding twice at 20 and 40 DAS	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	4.1 (16.9)	16.8
Atrazine 50% WP 1,000 g/ha as PE	1.1 (1)	0.9 (1)	0.7 (0)	0.9 (0.4)	0.7 (0.1)	0.7 (0.0)	0.7 (0.0)	28.4
2, 4-D sodium salt 80% WP 750 g/ha at 25 DAS	2.2 (5)	3.2 (11)	1.3 (1)	1.8 (2.8)	1.6 (2.1)	0.8 (0.2)	1.1 (0.8)	58.5
2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS	1.8 (3)	2.6 (7)	1.1 (1)	1.4 (1.5)	1.5 (1.9)	0.7 (0.1)	1.2 (1.0)	43.2
2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS	1.3 (2)	1.6 (3)	0.9 (1)	1.2 (0.9)	1.4 (1.5)	0.7 (0.1)	1.1 (0.9)	34.9
Weed-free	0.7 (0)	0.7 (0)	0.7 (0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.0
SEm±	0.12	0.09	0.10	0.07	0.02	0.02	0.39	-
CD (P=0.05)	0.38	0.28	0.31	0.23	0.08	0.07	0.70	-

Data were subjected to square root ( $\sqrt{x+0.5}$ ) transformation; figures in parentheses are original values.

weight as compared to 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS. 2, 4-D sodium salt 80% WP 1000 g/ha at 25 DAS recorded lesser dry weight than 2, 4-D sodium salt 80% WP 750 g/ha at 25 DAS. Lesser dry weight of *Cenopodium album* was reported in hand weeding twice at 20 and 40 DAS as compared to atrazine 50% WP 1,000 g/ha as PE and both were found statistically at par with each other. Dry weight was found lower in 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS in comparison of 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS and 2, 4-D sodium salt 80% WP 750 g/ha at 25 DAS and all were found statistically similar to each other. Dry weight of *Melilotus indicus* and *Cichorium intybus* were found lowest in Atrazine 50% WP 1,000 g/ha as PE and hand weeding twice at 20 and 40 DAS and both were recorded statistically similar to each other. Dry weight was recorded lesser in 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS as compared to 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS. The application of post-emergence herbicides decreases the density of the weeds due to non-disturbance of the soil which does not allow the second flush to come out (Joshi *et al.*, 2018 and Mandi *et al.*, 2019). Amongst the different weed management treatments, the higher weed control efficiency (83.3%) was found in hand weeding twice at 20 and 40 DAS followed by atrazine 50% WP 1,000 g/ha as PE, 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS, 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS, 2, 4-D sodium salt 80% WP 750 g/ha at 25 DAS (Table 1). This might be due to more weed killing efficiency which resulted in lower weed dry matter accumulation. Similar findings also reported in maize by Triveni *et al.*, 2017. The lower weed index (16.8%) was recorded in hand weeding twice at 20 and 40 DAS in comparison of atrazine 50% WP 1,000 g/ha as PE. Weed index was found lower in 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS as compared to 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS possessed lower weed index in comparison of 2, 4-D sodium salt 80% WP 750 g/ha at 25 DAS (Raghuwanshi *et al.*, 2023).

Higher number of leaves were recorded in 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS than 2, 4-D sodium salt 80% WP 750 g/ha at 25 DAS and both were found statistically similar to each other. Plant height followed the trend: atrazine 50% WP 1,000 g/ha as PE *fb* hand weeding twice at 20 and 40 DAS, 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS and all were found statistically similar to each other. Plant height was increased with application of 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS followed by 2, 4-D sodium salt 80% WP 750 g/ha at 25 DAS and all were recorded statistically at par to each other. The similar observation reported by Pasha *et al.* (2012).

Number of cobs per plant was found higher in 2, 4-D

**Table 3.** Effect of herbicidal treatments on number of leaves/plant, plant height, number of cobs, number of grains, number of grains/row, seed index, grain yield and economics of *rabi* maize

Treatment	Numbers of leaves/plant	Plant height (cm)	No. of cobs/plant	No. of grain rows/cob	No. of grains/row	Seed index (g)	Grain yield (t/ha)	Net return ( $\times 10^3$ ₹/ha)
Weedy	7.6	21.6	2.4	10.9	22.1	30.9	1.4	57.4
Hand weeding twice at 20 and 40 DAS	11.0	25.2	3.2	15.5	31.6	36.4	4.8	74.3
Atrazine 50% WP 1,000 g/ha as PE	10.6	24.2	3.0	15.4	30.3	35.2	4.1	71.3
2, 4-D sodium salt 80% WP 750 g/ha at 25 DAS	8.3	22.6	2.4	13.7	25.9	33.6	2.4	27.7
2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS	9.6	23.0	2.7	14.7	28.4	34.7	3.3	50.1
2, 4-D sodium salt 80% WP 1250 g/ha at 25 DAS	10.3	23.4	2.9	15.2	29.3	34.9	3.7	62.5
Weed-free	13.3	25.5	3.4	16.2	33.1	37.7	5.8	87.8
SEm $\pm$	0.37	0.41	0.06	0.29	0.65	0.36	0.83	-
CD (P=0.05)	1.14	1.25	0.20	0.90	1.98	1.11	2.54	-

sodium salt 80% WP 1,250 g/ha at 25 DAS as followed by 2, 4-D sodium salt 80% WP 1,000 g/ha than others. Number of kernel rows per cobs was recorded higher in hand weeding twice at 20 and 40 DAS in comparison to atrazine 50% WP 1,000 g/ha as PE, 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS and 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS. Number of grains per row was found higher in 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS in comparison to 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS over other treatments. Seed index was recorded higher in hand weeding twice at 20 and 40 DAS in comparison to Atrazine 50% WP 1,000 g/ha as PE followed by 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS, 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS (table 4). The more weed competition might also lead to decreased seed size and thus decreased 1,000-grain weight while it increased the kernel weight in more resource available plots with the lesser crop-weed competition. The similar observation were reported by Sanodiya *et. al.* (2013). Higher kernel yield was obtained under hand weeding twice at 20 and 40 DAS followed by atrazine 50% WP 1,000 g/ha as PE, 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS, 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS and 2, 4-D sodium salt 80% WP 750 g/ha at 25 DAS. This might be due to better growth parameters and better yield parameters i.e., number of cobs/plant, number of grain rows/cob, number of grains per row and seed index (table 4). The similar findings also reported by Sairam, *et. al.* (2023).

Amongst the different weed management treatments higher net return ( $74.3 \times 10^3$  ₹/ha) were obtained in hand weeding twice 20 and 40 DAS followed by atrazine 50% WP 1,000 g/ha as PE, 2, 4-D sodium salt 80% WP 1,250 g/ha at 25 DAS, 2, 4-D sodium salt 80% WP 1,000 g/ha at 25 DAS and 2, 4-D sodium salt 80% WP 750 g/ha at 25 DAS. The similar observations were reported by Sinodiya and Jha (2014).

Based on the present study it can be concluded that 2, 4-D sodium salt 80% WP @ 1,250 g/ha at 25 DAS was found effective in controlling weeds in *rabi* hybrid maize and recorded higher net return with B: C ratio of (2.67). Thus, for effective control of weeds and higher yield and nutrient uptake of *rabi* maize, this treatment can be suggested under agro-climatic conditions of Varanasi, Uttar Pradesh.

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