RESEARCH ARTICLE

EFFECT OF SOIL PH, TYPES AND TEMPERATURE ON THE PERSISTENCE OF READY-MIX FORMULATION OF SULFOSULFURON AND METSULFURON-METHYL

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Received-01.02.2021, Revised-11.02.2021, Accepted-23.02.2021

Abstract: The present laboratory and pot experiment was conducted in during winter season of 2005-06 and 2006-07 at the Chaudhary Charan Singh Haryana Agricultural University, Hisar (India). To generate any sound and viable herbicidal recommendation for effective weed management in a crop, it is very important to explore the effect of different soil types, soil pH and temperature on the persistence of ready-mix formulation of sulfosulfuron and metsulfuron-methyl. The experiment was conducted in completed randomized design (CRD) with four replications. In the first experiment, two soil pH e.g., acidic and alkaline soils were used and four concentration (0, 20, 40, 80 g ha^{-1}) of ready-mix formulation of sulfosulfuron and metsulfuron-methyl were used at incubation period of 0, 10, 20, 40, 80 and 160 days. In the second experiment to access the effect of temperature on persistence of this ready-mix formulation, three temperature regimes including 15, 25, and 35 ºC were used at the same concentration and incubation period. In third experiment, two soils were used i.e., sandy and clay loam. In the first experiment, the growth indices *viz*., dry weight of shoot per plant and shoot length of maize decreased as the sulfosulfuron + metsulfuron-methyl concentration increased from 0 to 80 g ha^{-1}. Both these parameters increased with increase in incubation period.In acid soil, dry weight of shoot per plant was more than that recorded in alkaline soil at each concentration of sulfosulfuron + metsulfuron-methyl. The mean value showed that acidic soil produced 14 per cent more dry weight of shoot as compared to alkaline soil.The phytotoxicity decreased significantly with corresponding increase in incubation period, and the phytotoxicity decreased from 65 to 47 percent as incubation period increased from 0 to 160 days. Alkaline soil exhibited higher phytotoxicity in maize than that in acidic soil. In the second experiment, the germination percent of maize increased from 43% at 15ºC to 54% at 35ºC temperature.Visual phytotoxicity significantly increased with successive increase in sulfosulfuron + metsulfuron-methyl concentration. However, it decreased significantly as temperature increased from 15ºC to 35ºC and incubation increased from 0 to 160 days.The dry weight of maize shoot increased by 25 percent at 35ºC compared to 15ºC temperature significantly incubation period resulted in 17, 37, 50, 63 and 73 percent increase in dry weight of shoot at 10, 20, 40, 80 and 160 days, respectively in comparison to 0 day incubation.The growth parameters of maize *viz*., dry weight of shoot per plant and shoot length decreased with corresponding increase in sulfosulfuron + metsulfuron-methyl concentration and these both parameters increased with each successive increase in temperature and incubation period. In the third experiment, visual phytotoxicity increased with increase in sulfosulfuron + metsulfuron-methyl concentration and decreased with increase in incubation period in both types of soil. Visual toxicity was more in sandy soil as compared to clay loam.Various growth parameters of maize *viz*. dry weight of shoot per plant decreased significantly as sulfosulfuron + metsulfuron-methyl concentration increased from 0 to 80 g ha^{-1}. Whereas, all parameters increased significantly as incubation period increased from 0 to 160 days in both soil types.

Keywords: Concentration, Ready-mix, Soil pH, Soil type, Temperature

INTRODUCTION

Wheat (*Triticum aestivum* Linn.) is an important cereal crop of India as well as of the world. In India, it is being cultivated over an area of 29.32 M ha with the production of 103.4 Mt and productivity of 35.33 q ha^{-1} (FAOSTAT, 2021). Low productivity of wheat and weeds play an important role in total wheat production (Kakraliya *et al.*, 2017a, 2017b). The losses in wheat yield caused by weeds ranges between 25-50 per cent depending upon weed species, density of weeds and the crop, soil moisture and fertility status and emergence pattern of weeds in relation of crop (Chopra *et al*., 1999; Bahadur *et al*., 2015; Dahiya *et al.*, 2017). Among different methods of weed management, herbicides are most preferably used by growers.

Recently, there has been a tremendous increase in the use of herbicides for the last two decades in our country and at present, a variety of herbicides are available in the market for weed control in different crops. The safe and efficient use of these herbicides would require knowledge of their behavior in soil. Herbicides which decompose too rapidly are less desirable in some situations as they cannot provide effective control of weeds emerging late in the season. On the other hand, herbicides which have longer persistence are unsuitable as their phytotoxic residue can cause injury to sensitive crops grown in the rotation. In other words, persistence beyond the critical period of weed competition may lead to residue problems in succeeding crops. Ideally, an herbicide should therefore, remain active long enough to provide satisfactory weed control and then it should degrade to innocuous products before it becomes necessary to apply it again. Therefore, it is important to know as a herbicide applied to the soil would persist and accumulate or will disappear

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within a relatively short span of time (Kumar *et al.,* 2016).

The sulfonylurea group of herbicides provides high degree of weed control at relatively low doses but this low dose requirement of sulfonylureas is also associated with their high persistence in the soil. Persistence beyond the critical period for weed control leads to residual toxicity problems in the succeeding crops and most often resistance evolution in weeds. This can restrict their use in rotations where sensitive crops are included and may discharge the idea of crop diversification especially in rice-wheat rotation (Sihag*et al.,* 2015; Jangir *et al.,* 2017; Kumar *et al.,* 2017e, 2019). Irrigation scheduling and availability of moisture in the soil may modify the residual behavior of a chemical. Other factors which have an impact on persistence of sulfonylurea could be soil type, moisture, temperature, microbes etc. (Kumar *et al.,* 2021). Therefore, it is necessary to evaluate efficacy of ready-mix formulation of sulfosulfuron and metsufuron-methyl and also to study its persistence behavior in different soils before making any sound recommendation for farmers use.

MATERIALS AND METHODS

A field experiment was conducted in 2005-06 and 2006-07 at Agronomy Research Area, and laboratory and pot experiments were carried out during 2006-07 only in weed management laboratory and green house of the Department of Agronomy, Chaudhary Charan Singh, Haryana Agricultural University, Hisar (India). Hisar is located at 215.2 metres above mean sea level with a latitude of 29º10' North and longitude of 75º36' East.Climate of Hisar is semi-arid with hot and dry desiccating winds accompanied by frequent dust storms of high velocity in summer, severe cold during winter and humid warm monsoon seasons. The mean maximum temperature sometimes exceeds 48ºC during summer while minimum temperature falls to the level of 0ºC accompanied by frost in winter.The meteorological data were recorded at the meteorological observatory located near Agronomy Research Farm, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Meteorological data recorded during the crop season of experiment are given in tables 1a and 1b, and Figs. 1 and 2.

Table 1. Mean weekly meteorological data recorded during crop season 2005-06.

Standard weeks	Mean temperature (ºC)		Mean relative humidity (%)		Mean sunshine (hours)	Mean pan evaporation (mm)	Rainfall (mm)
	Max.	Min.	Morn.	Eve.			
42	33.4	16.7	85	32	8.0	4.0	0
43	31.9	12.4	83	24	8.6	3.9	0
44	31	12.8	77	33	7.9	4.5	3.2
45	28.3	10.2	89	43	7.5	2.5	0
46	29.1	8.7	83	23	8.9	3.5	0
47	28.2	7.4	85	27	8.5	2.7	0
48	24.4	6.7	84	42	6.8	2.7	0
49	23.4	3.1	93	41	8.2	2.1	0
50	22.2	1.6	90	33	7.8	1.6	0
51	20.7	2.2	95	44	5.4	1.1	0
52	19.7	4.3	94	49	4.4	1.3	0
1	19.1	3.6	93	50	6.0	1.6	0
2	19.7	0.6	93	37	7.7	1.7	0
3	22.1	8.5	90	47	7.8	2.0	0
4	20.3	2.6	93	39	4.3	2.9	0
5	25.2	6.6	93	42	8.2	2.1	0
6	27.2	7.7	91	44	6.8	2.0	0
7	28.4	11.7	94	53	8.1	2.4	0
8	28.4	11.3	97	54	6.7	2.5	0
9	27.2	8.5	93	42	7.0	2.4	0
10	28.6	12.2	91	53	8.1	2.9	15
11	24.2	11.6	95	60	6.5	3.3	11
12	29.6	12.8	94	46	6.0	2.5	0
13	29.9	12.2	89	43	9.3	4.5	1
14	36.3	14.9	82	34	9.1	4.3	0
15	36.2	15.4	63	23	9.9	7.1	0

Table 2. Mean weekly meteorological data recorded during crop season 2006-07.

Standard weeks	Mean temperature (ºC)		Mean relative humidity (%)		Mean sunshine (hours)	Mean pan evaporation (mm)	Rainfall (mm)
	Max.	Min.	Morn.	Eve.			
42	33.7	18.0	81	39	8.1	5.6	0.0
43	30.2	15.0	90	44	5.3	4.0	0.0
44	30.7	13.9	95	38	4.0	3.1	0.0
45	32.3	13.0	83	32	7.5	2.7	0.0
46	29.4	12.8	92	53	5.7	2.5	0.0
47	25.7	9.7	96	72	6.8	2.5	0.0
48	24.4	4.8	92	50	8.3	2.8	0.0
49	22.3	7.8	94	49	5.6	2.1	2.2
50	20.8	4.3	96	46	5.8	1.4	0.0
51	23.	6.4	95	39	7.1	2.1	0.0
52	20.5	4.2	98	53	7.0	1.5	3.8
1	17.0	1.9	97	48	5.4	1.4	0.0
2	18.0	0.7	93	41	6.9	1.3	0.0
3	20.4	3.2	94	34	7.0	1.8	0.0
4	22.8	4.5	90	39	8.2	2.1	0.0
5	25.4	7.6	97	69	5.9	2.0	0.0
6	22.0	10.2	95	80	2.7	1.5	59.3
7	20.8	8.8	97	83	6.5	1.6	16.0
8	23.2	8.4	94	55	8.4	2.8	0.0
9	23.2	9.6	97	60	6.7	2.6	4.1
10	26.0	9.8	83	36	9.2	3.9	0.0
11	23.4	10.5	97	57	6.8	2.2	40.2
12	29.5	13.0	91	45	8.5	4.2	0.0
13	33.8	13.8	80	35	9.9	5.1	0.0
14	34.1	14.0	84	28	9.6	5.3	2.0
15	37.9	16.4	66	18	10.1	7.2	0.0

Crop growth and yield parameters were recorded during bot the years of experimentation. In this line, for pot experiments, sandy soil (S_1) was taken from dry land Area, CCS HAU, Hisar. Clay loam (S_2) was taken from Regional Research Station Kaul. Acidic soil (S_3) was taken from Research Farm, Himanchal Pradesh Krishi Vishwavidyalaya, Palampur (H.P.). Alkaline soil (S_4) was taken from Research Area CCS HAU, Hisar.These soils were separately passed through the 2 mm sieve and allowed to air dry for 24 hours under shade.

Table 3a. Physical composition of soil used in pot culture

Components	Soil type			
	Sandy (S_1)	Clay loam (S_2)	Acidic (S_3)	Alkaline (S_4)
Sand (%)	87.0	47.8	20.4	62.26
Silt (%)	8.0	24.2	43.8	21.43
Clay (%)	5.0	28.0	35.8	16.37
F.C. (%)	18.7	21.2	23.8	19.7

Table 3b. Chemical composition of soil used in pot culture

Components	Soil type			
	Sandy (S_1)	Clay loam (S_2)	Acidic (S_3)	Alkaline (S_4)
OC (%)	0.18	0.76	1.0	0.45
Available N (kg ha^{-1})	1.95	310	360	198
Available P (Kg ha^{-1})	9.0	22	18.8	13
Available K (Kg ha^{-1})	215	260	295	238
pH	8.4	8.18	5.1	8.5
EC	0.09	0.27	0.08	0.23

A stock solution of 20 ppm was prepared by dissolving 26.6 mg of sulfosulfuron + metsulfuron-methyl (Total) in one liter of distilled water. Three lots of 12 kg each of sand (S_1), clay loam (S_2) alkaline (S_3) and acidic (S_4) soils were sieved and weighed. One additional lot of 12 kg of alkaline soil (S_3) was also weighed separately. All of the five lots of 12 kg each were divided into six and parts (2 kg each) and were treated with sulfosulfuron + metsulfuron-methyl to make the concentration equal to 80 ppb by addition of 8 ml of stock solution per two kg of soil. These six admixed soil samples, representing six incubation periods, were then transferred to wide mouth steel containers. Constant soil moisture was maintained by adding the amount of distilled water needed to bring the soil at field capacity. The containers were tightly covered with silver foil and weighed accurately before putting into incubators, yet moisture from the soil was checked frequently to maintain the moisture level at field capacity by keeping the initial weight of the containers constant. The incubation of different sets of treated soil samples started on November 5th 2006. The three lots *viz.* sandy (S_1), clay loam (S_2) soil and acidic (S_3) soil (each set containing 6 samples of 2 kg) were kept in incubator maintained at 25ºC. The remaining two sets of alkaline soil were transferred to incubators maintained at 15ºC and 35ºC, respectively. After completion of the desired incubation periods, the respective containers were taken out from incubators (one by one from each set) and stored in deep freezer at -4ºC in order to avoid further degradation of herbicide.At the incubation period of 160 days, all the samples from incubator as well as deep freezer were removed and air dried in shade. The soil was pulverized with the help of pestle and mortar. Each 2 kg sulfosulfuron + metsulfuron-methyl (80 ppb) treated soil samples were mixed with fresh 2 kg untreated soil in order to dilute it to 40 ppb. Out of this 4 kg soil, 2 kg was taken out to fill four pots of 500g, each representing one replication and remaining 2 kg soil was again mixed with 2 kg untreated soil to dilute it to 20 ppb untreated checks from each soil weighing 2 kg each regarding six incubation were maintain. Two wicks of equal size (approximately 9 inches) wrapped with cotton in the center were sterilized in boiling water and dried. These wicks were placed in the bottom of earthenpots (10cm x 8.5cm size) in such a way that half of the wicks' portion was coming out of the pot from below in order to regulate uniform supply of water by capillary movement as and when water was supplied from below.The sowing of African tall variety of maize in the green house was done on April 25 just after filling the pots. Initially ten seeds per pot were sown but after 15 days only 5 plants per pot were maintained by thinning. The moisture content in pots was maintained at field capacity by filling the pitchers placed below the pots with water regularly.

Number of plant germinated per plot at 15 DAS were counted before thinning and germination percentage was compared. Visual phytotoxicity (using 0-100 scale, where 0 = no mortality and 100=complete mortality) of sulfosulfuron + metsulfuron was recorded 30 days after sowing before taking other observations. The height (cm) of main shoot of maize was recorded from the five selected plants at 30 DAS. It was measured from the base of the main shoot to the base of fully opened leaf. Then the average height of five plants was calculated.The shoot portions of the harvested plants were packed separately in paper bags and kept in oven at 65ºC for 72 hours till constant weight was obtained and then their dry weight (mg) was recorded after taking their mean.

Data collected during the study were statistically analyzed using the techniques of analysis of variance. The results were tested for treatment means by applying F-test of significance on the basis of null hypothesis suggested by Cochran and Cox (1957). To judge the significance of difference between means of two treatments, critical difference (C.D.) was computed.

RESULTS

Experiment – 1

Germination percentage

The data presented in Table 4revealed that increasing concentration of sulfosulfuron + metsulfuron significantly decreased the germination of maize. As incubation period increased, the germination also increased and it was 40.4, 44.7, 51.3, 59.8 and 64.6 per cent under 10, 20, 40, 80 and 160 days, respectively. Germination percentage significantly decreased with increasing concentration of herbicide under both high and low pH. However, the germination was higher in acidic soil (50%) as compared to alkaline soil (46.8%).

Table 4. Residual effects of sulfosulfuron + metsulfuron (R. mix) at different concentration and incubation periods in alkaline and acidic soils on germination (%) of maize at 15 DAS (Expt. 2)

SSN + MSN (g ha^{-1})	Incubation period (days)						Soil type		Mean
	0	10	20	40	80	160	Alkaline	Acidic	
0	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)
20	24.6 (17.5)	28.2 (22.5)	36.2 (35.0)	44.9 (50.0)	55.4 (67.5)	62.2 (77.5)	39.7 (41.6)	44.1 (48.3)	41.9 (45.0)

40	4.0 (0.50)	24.6 (17.5)	29.8 (25.0)	39.1 (40.0)	525.3 (62.5)	58.6 (72.5)	32.2 (33.3)	36.6 (39.2)	34.4 (36.2)
80	2.0 (0.25)	20.5 (12.5)	24.6 (24.6)	33.1 (30.0)	43.5 (47.5)	49.4 (57.5)	27.0 (24.2)	31.4 (30.9)	29.2 (27.5)
Mean	29.7 (29.5)	40.4 (38.1)	44.7 (44.7)	51.3 (54.9)	59.8 (69.3)	64.6 (76.8)	46.8	50.0	

CD at 5%

Conc.	Period	Conc.xPeriod	Soil	Soil x Conc.
1.22	1.50	3.0	0.86	1.7

Note: The data in parentheses are original, which have been subjected to *arc. sin* transformation

Shoot length of maize

Perusal of data given in Table 5 indicate that when sulfosulfuron + metsulfuron concentration were averaged over incubation periods and soil types, the shoot length of maize at 30 DAS decreased significantly with corresponding increase in sulfosulfuron + metsulfuron concentration. The shoot length reduced from 12.5cmat0 g ha^{-1} to 7.5, 5.3 and 3.4 cm under 20, 40 and 80 g ha^{-1}. However, the shoot length was higher in low pH soil (7.5cm) compared to high pH soil (6.1cm).

The interaction effects of sulfosulfuron + metsulfuron concentration with incubation period showed that maize shoot length at 30 DAS increased significantly with increase in incubation period at all the sulfosulfuron + metsulfuron concentrations except variation in trend at 0 day incubation. The shoot length reduced significantly as thesulfosulfuron + metsulfuron concentration increased from 0 to 80 g ha^{-1} at each incubation period.

Table 5. Residual effects of sulfosulfuron + metsulfuron (R. mix) at different concentration and incubation periods in alkaline and acidic soils on shoot length (cm) of maize at 30 DAS (Expt. 2)

SSN + MSN (g ha^{-1})	Incubation period (days)						Soil type		Mean
	0	10	20	40	80	160	Alkaline	Acidic	
0	12.8	11.7	12.9	13.2	13.5	12.9	11.8	13.2	12.5
20	4.8	6.1	6.6	8.1	9.3	10.0	7.2	7.7	7.5
40	0.0	4.4	5.2	6.7	7.6	8.1	5.1	5.5	5.3
80	0.0	3.0	3.8	4.2	4.5	5.1	3.2	3.6	3.4
Mean	4.4	6.6	7.1	7.9	8.7	9.0	6.1	7.5	

CD at 5%

Conc.	Conc.xPeriod	Soil	Soil x Conc.
0.36	0.90	0.26	0.52

Dry weight of shoot per plant of maize

Averaging the soil types over incubation periods at different concentration ofsulfosulfuron + metsulfuron (Table 6) indicated that average shoot dry weight (mg) of maize was significantly higher (291.8 mg/plant) in acidic soil than that in alkaline soil (256.7 mg/plant). When sulfosulfuron + metsulfuron concentrations were averaged over incubation period and soil types, there was significant decrease in shoot dry weight from 812 mg under 0 g ha^{-1} to 37 mg/plant under 80 g ha^{-1}. The average reduction in dry weight of shoot was 646.1. 729.0 and 774.8 mg/plant with 20, 40 and 80 g ha^{-1} of sulfosulfuron + metsulfuron, respectively. Averaging incubation periods over sulfosulfuron + metsulfuron concentrations and soil types,the dry weight of shoot of maize increased significantly with corresponding increase in incubation period. The average increase in dry weight of maize shoot dry weight was 21.8, 54.2, 80.8, 107.2 and 21.8 mg/plant at 10, 20, 40, 80 and 160 days of incubation period, respectively compared to dry weight of shoot at 0 day incubation. Interaction of sulfosulfuron + metsulfuron concentration and soil types showed that acid soil had significantly higher shoot dry weight than alkaline soil at all concentration of sulfosulfuron + metsulfuron. The dry weight of shoot decreased significantly with increasing concentration of sulfosulfuron + metsulfuronin both the soil (Table 6).

Table 6. Residual effects of sulfosulfuron + metsulfuron (R. mix) at different concentration and incubation periods in alkaline and acidic soils on shoot dry weight (mg/plant) of maize at 30 DAS (Expt. 2)

SSN + MSN (g ha^{-1})	Incubation period (days)						Soil type		Mean
	0	10	20	40	80	160	Alkaline	Acidic	
0	811.50	810.5	813.6	812.5	812.7	810.2	779.6	844.0	811.8
20	28.8	67.2	137.1	216.6	253.3	291.2	149.3	182.1	165.7
40	0.0	35.0	66.2	90.9	148.1	156.9	70.0	95.7	82.8
80	0.0	14.6	40.1	43.5	55.0	69.2	28.1	46.0	37.0
Mean	210.0	231.8	264.2	290.8	317.2	231.8	256.7	291.8	

CD at 5%

Conc.	Conc.xPeriod	Soil	Soil x Conc.
18.3	44.9	12.9	25.9

Visual phytotoxicity

The degradation of sulfosulfuron + metsulfuron in alkaline and acidic soils were assessed by an index of plant growth in terms of visual estimation of phytotoxicity percentage (Table 7). When sulfosulfuron + metsulfuron concentration were averaged over incubation periods and soil types, there was significant increase in residual phytotoxicity (0 to 94%) due to sulfosulfuron + metsulfuron on maize with increase in its concentration from 0 to 80 g ha^{-1}. As evident from mean values, the phytotoxic decreased significantly with corresponding increase in incubation period (Table 7) and the phytotoxicity decreased from 65 to 47 per cent as incubation period increased from 0 to 160 days. Alkaline soil exhibited higherphytotoxicity than that in acidic soil to maize plant.

The interaction effects between sulfosulfuron + metsulfuron concentration and incubation periods indicated that the visual phytotoxicity increased with increasing sulfosulfuron + metsulfuronconcentrations at all incubation periods. The phytotoxicity decreased with corresponding increase in incubation under all the sulfosulfuron + metsulfuron concentration. The maximum phytotoxicity (88%) was observed at 0 days incubation with 80 g ha^{-1} of sulfosulfuron + metsulfuron whereas in contrast to this minimum phytotoxicity (51%) was recorded at 160 days incubation with 20 g ha^{-1} of sulfosulfuron + metsulfuron (excluding untreated control).

Table 7. Residual effects of sulfosulfuron + metsulfuron (R. mix) at different concentration and incubation periods in alkaline and acidic soils in terms of phytotoxicity in maize at 30 DAS (Expt. 2)

SSN + MSN (g ha^{-1})	Incubation period (days)						Soil type		Mean
	0	10	20	40	80	160	Alkaline	Acidic	
0	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)
20	77.7 (93.9)	72.6 (90.2)	64.2 (71.2)	57.7 (71.2)	54.5 (66.1)	51.0 (66.3)	66.5 (81.5)	59.4 (72.6)	63.0 (77.1)
40	88.1 (99.9)	77.5 (94.3)	72.1 (86.7)	69.6 (86.7)	63.4 (79.0)	62.5 (77.7)	75.1 (91.0)	69.2 (84.8)	72.2 (87.9)
80	88.1 (99.9)	81.0 (96.6)	77.3 (92.5)	75.1 (92.5)	73.1 (91.0)	70.9 (88.1)	80.5 (95.9)	74.7 (91.3)	77.6 (93.6)
Mean	64.5 (73.5)	58.8 (70.4)	54.4 (62.7)	51.6 (62.7)	48.8 (59.1)	47.1 (56.6)	56.5 (67.2)	51.8 (62.3)	

CD at 5%

Conc.	Period	Conc.xPeriod	Soil	Soil x Conc.
1.9	2.3	4.7	1.3	2.7

Note: The data in parentheses are original, which have been subjected to *arc. sin* transformation

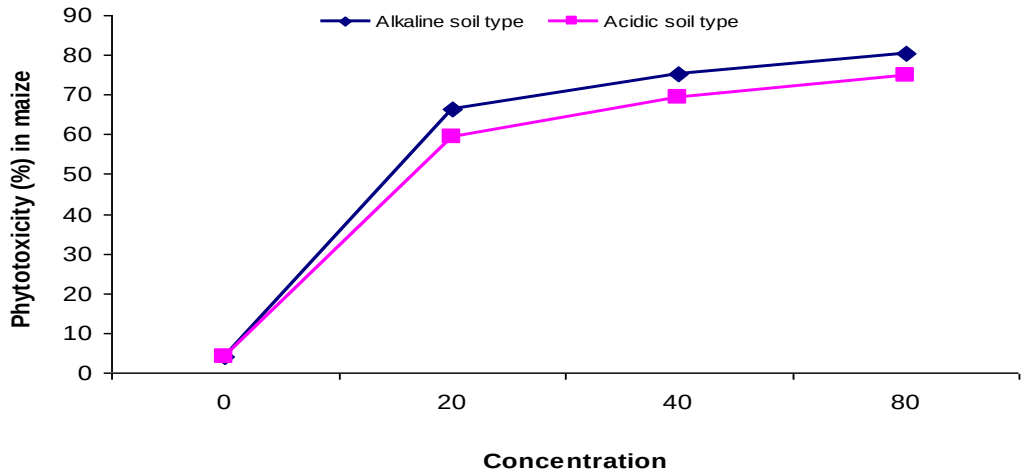

Fig. 3: Phytotoxicity of sulfosulfuron + metsulfuron-methyl at different concentration under alkaline and acidic soil.

Experiment - 2

Germination percentage

The data revealed that increase in concentration of sulfosulfuron + metsulfuron decreased germination significantly and germination reduced up to 84% at 80g ha^{-1}at 0 incubation period. The germination increased from 37.2% at 0 incubation to 63% at 160 days incubation (Table 8). The germination also increased from 43% at 15ºC to 54% at 35ºC temperature.

Table 8. Germination (%) of maize (30 DAS) as influenced by residues of sulfosulfuron and metsulfouron-methyl applied at varying concentrations in soil at different incubation periods and temperatures (Expt. 3)

SSN + MSN (g ha^{-1})	Incubation period (days)						Temperature (ºC)			Mean
	0	10	20	40	80	160	15	25	35	
0	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)
20	24.7 (18.3)	29.5 (25.0)	37.0 (36.6)	44.0 (48.3)	54.9 (66.6)	60.4 (75.6)	36.3 (36.6)	39.7 (41.6)	49.2 (56.6)	41.8 (45.0)
40	4.0 (0.5)	24.7 (19.0)	29.0 (25.0)	37.0 (36.3)	47.9 (55.0)	57.0 (70.0)	26.7 (24.5)	32.9 (33.4)	40.2 (45.0)	33.3 (31.7)
80	4.0 (0.5)	19.9 (13.0)	24.7 (19.0)	32.5 (30.0)	43.0 (46.6)	48.9 (56.6)	21.4 (16.9)	27.5 (25.0)	37.6 (40.9)	28.8 (26.1)
Mean	30.2 (0.5)	40.6 (39.2)	44.7 (45.1)	56.4 (53.7)	58.5 (67.0)	63.6 (75.3)	43.2 (44.5)	47.1 (50.0)	53.8 (60.6)	

CD at 5%

Conc.	Period	Conc.xPeriod	Temp.	Temp. x Conc.
0.97	1.19	2.3	0.84	1.6

Note: The data in parentheses are original, which have been subjected to *arc. sin* transformation

Shoot length of maize

When temperature levels were averaged over incubation period and sulfosulfuron + metsulfuron concentration, the plant height of maize increased significantly with corresponding increase in temperature levels and incubation periods (Table 9).The relative increase in plant height of maize was 2 and 40% at 25 and 35ºC, respectively compared to 15ºC (Table 9). Similarly, the percent increase in plant height of maize at different incubation periods when compared with 0 day incubation was 42, 62, 78, 80 and 109% at 10, 20, 40, 80 and 160 days incubation period, respectively. The plant height of maize significantly decreased with increasing levels of sulfosulfuron + metsulfuron concentration. The relative decrease in plant height of maize was found to be 40, 57 and 73% with 20, 40 and 80 g ha^{-1}sulfosulfuron + metsulfuroncompared to untreated control, respectively.

Interaction of various sulfosulfuron + metsulfuron concentration with different incubation periods reflected that plant height of maize decreased significantly with increasing sulfosulfuron + metsulfuron concentration at each incubation period. The relatively reduction in plant height of maize at 80 g ha^{-1} concentration in comparison to untreated control was 100, 76, 71, 67, 63 and 61 per cent at 0, 10, 20, 40, 80 and 160 days' incubation period, respectively.

Table 9. Plant height (cm) of maize (30 DAS) as influenced by residues of sulfosulfuron and metsulfuron-methyl applied at varying concentrations in soil incubated for varying periods at different temperatures (Expt. 3)

SSN + MSN (g ha^{-1})	Incubation period (days)						Temperature (ºC)			Mean
	0	10	20	40	80	160	15	25	35	
0	12.75	11.20	12.50	11.75	11.60	12.70	11.20	12.20	12.60	12.00
20	4.46	5.66	6.23	7.80	9.00	9.83	6.50	7.71	7.28	7.16
40	0.0	4.26	4.86	6.39	7.13	7.70	4.46	5.53	5.18	5.06
80	0.0	2.66	3.53	3.86	4.26	4.89	2.63	3.75	3.23	3.20
Mean	4.17	5.93	6.78	7.445	7.49	8.75	5.21	7.30	7.8	

CD at 5%

Conc.	Period	Conc.xPeriod	Temp.	Temp. x Conc.
0.29	0.35	0.71	0.25	0.50

Dry weight of shoot of maize

Averaging temperature levels over incubation periods and sulfosulfuron + metsulfuronconcentrationsindicated significant increase in shoot dry weight with corresponding increase in temperature levels and incubation periods (Table 10). The relative increase in shoot dry weight of maize was 25 percent at 35°C as compared to 15ºC (Table 10). Similarly, the percent increase in shoot dry weight of maize at different incubation periods as compared to 0 day incubation was 17, 37, 50, 63 and 73 per cent at 10, 20, 40, 80 and 160 days incubation periods, respectively. The dry weight of shoot significantly decreased with increasing levels of sulfosulfuron + metsulfuron concentration. The relative decrease in dry weight of shoot was found to be 75, 88 and 94 per cent with 20, 40 and 80 g ha^{-1}of sulfosulfuron + metsulfuron as compared to untreated control, respectively. Interaction at various sulfosulfuron + metsulfuron concentrations with different incubation period revealed that the dry shoot weight of maize decreased significantly with increasing sulfosulfuron + metsulfuron concentration. At each incubation period the relative reduction in dry shoot weight at 80 g ha^{-1} concentration in comparison to untreated control was 100, 96, 93, 93 91 and 89 per cent at 0, 10, 20, 40, 80 and 160 days incubation period, respectively. At 160 days incubation, the relative increase in dry shoot weight in comparison to dry shoot weight at 0 day incubation was 96, 99 and 100 per cent at 20, 40 and 80 g ha^{-1} concentration, respectively.

Table 10. Dry weight of shoot (mg/plant) of maize (30 days) as influenced by residues of sulfosulfuron and metsulfouron-methyl applied at varying concentrations in soil incubated for varying periods at different temperatures

SSN + MSN (g ha^{-1})	Incubation period (days)						Temperature (ºC)			Mean
	0	10	20	40	80	160	15	25	35	
0	780.4	782.3	781.2	780.1	782.6	774.5	781.6	782.4	779.2	780.4
20	13.33	70.06	154.8	261.0	310.2	347.2	143.6	149.3	285.4	192.8
40	0.6	43.6	74.5	100.9	158.9	166.6	68.9	69.4	133.9	90.7
80	0.0	28.4	51.2	52.2	64.1	80.8	26.7	26.5	85.0	46.1
Mean	198.4	231.9	260.4	298.5	324.9	343.5	255.2	256.1	320.1	

CD at 5%

Conc.	Period	Conc.xPeriod	Temp.	Temp. x Conc.
17.9	22.0	44.0	15.5	31.1

Visual phytotoxicity

The visual phytotoxicity due to sulfosulfuron + metsulfuronresidues on maize at 30 DAS decreased significantly with increase in temperature when averaged over herbicide concentration and incubation periods (Table 11). The phytotoxicity reduced significantly from 66 per cent at 0 day incubation to 47.3 per cent at 160 days. The phytotoxicity increased from 0 to 84 per cent as the concentration of sulfosulfuron + metsulfuron increased from 0 to 80 g ha^{-1}. The interaction between temperature and sulfosulfuron + metsulfuron concentration revealed that visual phytotoxicitiy due to sulfosulfuron + metsulfuron increased significantly at each level of temperature with increasing sulfosulfuron + metsulfuron concentration from 0 – 80 g ha^{-1} whereas with the increase in temperature from 15-35ºC the phytotoxicity significantly reduced at each concentration of Sulfosulfuron and Metsulfuron. The interaction between temperature and incubation period revealed that visual phtotoxicity due to incubation period decreased significantly from 0 to 160 days and with increasing temperature from 15 to 35ºC visual phytotoxicity decrease 57.7 to 49.7%.

Table 11. Visual phytotoxicity (%) to maize (30 DAS) as influenced by residues of sulfosulfuron and matsulfouron-methyl applied at varying concentrations in soil incubated for varying periods at different temperatures

SSN + MSN (g ha^{-1})	Incubation period (days)						Temperature (°C)			Mean
	0	10	20	40	80	160	15	25	35	
0	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)
20	83.4 (98.2)	74.9 (92.1)	64.4 (80.7)	56.3 (68.7)	51.9 (61.5)	49.4 (57.4)	68.4 (83.3)	66.7 (81.5)	55.2 (64.4)	63.4 (76.4)
40	88.2 (99.9)	77.5 (93.8)	73.1 (90.3)	70.7 (87.6)	63.9 (79.4)	60.0 (78.2)	75.9 (91.6)	75.0 (90.7)	67.3 (82.3)	72.7 (88.2)
80	88.2 (99.9)	81.3 (96.3)	78.2 (94.4)	75.8 (93.1)	75.1 (91.8)	73.0 (90.0)	82.4 (97.7)	81.2 (96.4)	72.3 (88.6)	78.6 (94.2)
Mean	66.0 (74.6)	59.4 (70.7)	54.9 (66.5)	51.7 (62.5)	48.7 (58.3)	47.3 (56.5)	57.7 (68.3)	56.7 (67.3)	44.7 (58.9)	

CD at 5%

Conc.	Period	Conc.xPeriod	Temp.	Temp. x Conc.
1.56	1.92	3.8	1.35	2.7

Note: The data in parentheses are original, which have been subjected to *arc. sin* transformation

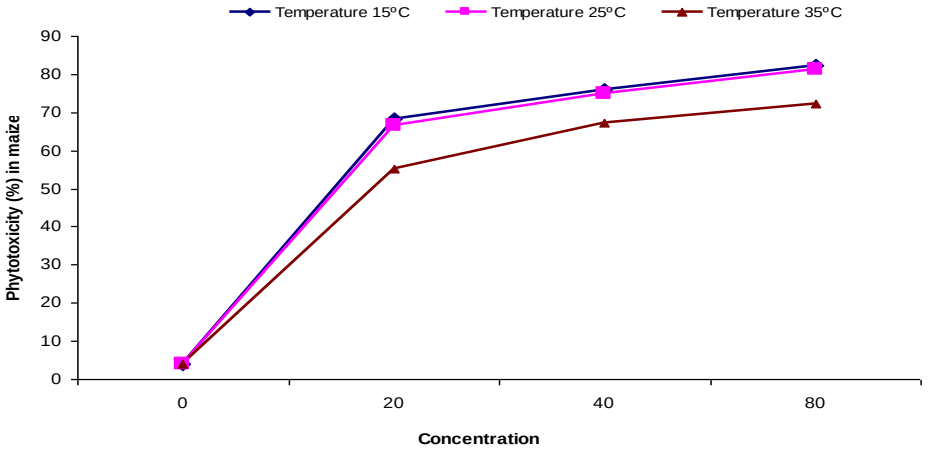

Fig. 4: Phytotoxicity of sulfosulfuron + metsulfuron-methyl at different concentration under different temperatures.

Table 12. Visual phytotoxicity (%) to maize (30 DAS) as influenced by residues of sulfosulfuron + metsulfouron-methyl applied at varying concentrations in sandy and clay loam soils incubated for varying periods at different temperatures (Expt. 3)

Temperature °C	Incubation period (days)						Mean
	0	10	20	40	80	160	
15	66.7 (74.9)	62.3 (73.3)	58.4 (70.1)	55.4 (66.9)	52.2 (62.9)	51.1 (61.7)	57.7 (68.3)
25	66.0 (74.7)	62.2 (72.7)	57.1 (68.7)	54.1 (65.6)	51.2 (61.9)	49.6 (66.0)	56.7 (67.3)
35	65.2 (74.2)	53.7 (70.7)	49.3 (60.6)	45.7 (54.8)	42.9 (50.1)	41.3 (47.9)	49.7 (58.9)
Mean	66.0 (74.6)	59.4 (70.7)	54.9 (66.5)	51.7 (62.5)	48.7 (58.3)	47.3 (56.5)	

C'D at 5%

Temp. x Period

3.3

Note: The data in parentheses are original, which have been subjected to arc. sin transformation

Experiment- 3

Germination

The germination of maize decreased significantly with increase in the concentration of sulfosulfuron + metsulfuron. Similarly the germination increased from 34.7% under 0 incubation to 63.2% at 160 days incubation (Table 13). In clay loam soil, the germination percentage was more (55%) as compared to sandy soil (43.7%).

Table 13. Residual effects of sulfosulfuron + metsulfuron (R. mix) at different concentrations and incubation periods in sandy and clay loam soils on germination (%) of maize at 15 DAS

SSN + MSN (g ha^{-1})	Incubation period (days)						Soil type		Mean
	0	10	20	40	80	160	Sandy	Clay loam	
0	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)	88.2 (99.9)
20	24.1 (17.5)	32.4 (30.0)	37.4 (37.5)	49.6 (57.5)	55.9 (67.3)	59.7 (72.5)	34.8 (34.1)	51.6 (60.0)	43.2 (47.0)
40	15.2 (10.2)	25.1 (18.5)	31.3 (27.5)	40.6 (42.5)	49.4 (57.5)	57.0 (70.0)	30.9 (30.4)	41.9 (45.0)	36.4 (37.7)
80	11.2 (5.2)	15.2 (10.2)	27.3 (22.5)	32.4 (30.0)	43.5 (47.5)	48.0 (55.0)	20.7 (16.8)	38.5 (40.0)	29.6 (28.4)
Mean	34.7 (33.2)	40.2 (39.6)	46.6 (46.8)	52.7 (57.4)	59.2 (68.1)	63.2 (74.3)	43.7 (45.3)	55.0 (61.2)	

CD at 5%

Conc.	Period	Conc.xPeriod	Soil	Soil x Conc.
1.28	1.5	3.1	0.90	1.8

Note: The data in parentheses are original, which have been subjected to *arc. sin* transformation

Shoot length

When sulfosulfuron + metsulfuron concentration were averaged over incubation periods and soil types, the shoot length of maize decreased significantly with corresponding increase in sulfosulfuron + metsulfuron concentration (Table 14). Compared to untreated check, the shoot length reduced by 39, 58 and 75 cm at 20, 40 and 80 g ha^{-1}of sulfosulfuron + metsulfuron, respectively. The shoot length increased by 12, 35, 51, 65 and 76 per cent at 10, 20, 40, 80 and 160 days of incubation, respectively.

The interaction effect of sulfosulfuron + metsulfuron concentration with incubation period showed that plant height increased significantly with increase in incubation period under all the sulfosulfuron + metsulfuron concentrations. The shoot height reduced significantly as the sulfosulfuron + metsulfuron concentration increased from 0 to 80 g ha^{-1} at each incubation period (Table 14). The plant height decreased significantly with corresponding increase in the sulfosulfuron + metsulfuron concentration in both sandy and clay loam soils.

Table 14. Residual effects of sulfosulfuron + metsulfuron (R. mix) at different concentrations and incubation periods in sandy and clay loam on shoot length (cm) of maize at 30 DAS

SSN + MSN (g ha^{-1})	Incubation period (days)						Soil type		Mean
	0	10	20	40	80	160	Sandy	Clay loam	
0	11.50	11.90	12.0	12.30	12.50	12.10	9.5	14.5	12.0
20	4.8	5.7	6.8	8.2	8.8	9.6	5.8	8.9	7.3
40	1.9	3.2	4.6	5.5	6.9	7.8	4.2	5.7	5.0
80	0.9	1.3	2.9	3.8	4.6	5.0	2.0	4.1	3.0
Mean	4.9	5.5	6.6	7.4	8.1	8.6	5.4	8.3	

CD at 5%

Conc.	Period	Conc.xPeriod	Soil	Soil x Conc.
0.35	6.43	0.80	0.25	0.56

Shoot dry weight (mg/plant) of maize

When the sulfosulfuron + metsulfuron concentration were averaged over incubaton periods and soil types (Table 15), the shoot dry weight of maize was significantly higher (342 mg/plant) in clay loam soil than sandy soil (206 mg/plant). There was significant decrease (from 802 to 44 mg/plant) in dry weight of maize shoot with increasing sulfosulfuron + metsulfuron concentrations from 0 to 80 g ha^{-1}. As compared to untreated control, the per cent reduction

in dry weight of shoot was 80, 88 and 95 per cent, with 20, 40 and 80 g ha^{-1} at sulfosulfuron + metsulfuron, respectively. Compared to 0 day incubation, the per cent increase in dry weight of maize shoot was 4, 22, 40, 50 and 55 per cent at 10, 20, 40, 80 and 160 days of incubation period, respectively. Interaction of sulfosulfuron + metsulfuron concentrations and soil type showed that clay loam soil had significantly higher dry shoot weight than that in sandy soil at all concentrations of sulfosulfuron + metsulfuron. The dry weight of shoot decreased significantly with increasing concentration of sulfosulfuron + metsulfuron in both the soils.

Table 15. Residual effects of sulfosulfuron + metsulfuron (R. mix) at different concentrations and incubation periods in sandy and clay loam soils on shoot dry weight (mg/plant) of maize at 30 DAS

SSN + MSN (g ha^{-1})	Incubation period (days)						Soil type		Mean
	0	10	20	40	80	160	Sandy	Clayloam	
0	799.4	801.7	802.5	802.7	801.5	802.5	628.4	974.7	801.5
20	34.3	45.8	130.6	212.8	249.9	267.2	118.1	195.8	156.8
40	18.4	31.2	74.3	121.6	153.5	169.3	56.7	132.7	94.7
80	2.5	10.6	39.0	57.8	70.7	83.8	22.3	65.8	44.0
Mean	213.6	222.3	261.3	298.4	318.9	330.5	206.3	341.8	

CD at 5%

Conc.	Period	Conc.xPeriod	Soil	Soil x Conc.
18.5	22.6	45.3	13.1	26.1

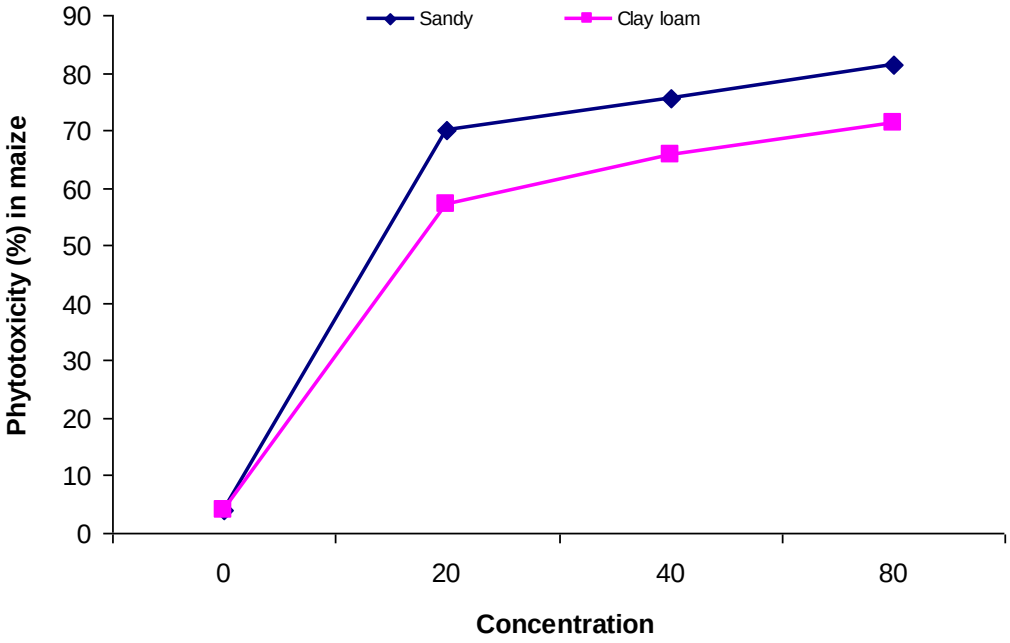

Fig. 5: Phytotoxicity of sulfosulfuron + metsulfuron-methyl at different concentration under sandy and clay loam.

Visual phytotoxicity

The degradation of sulfosulfuron + metsulfuron in sandy and clay loam soils were assessed by an index of plant growth in terms of visual estimation of phytotoxicity percentage. When sulfosulfuron + metsulfuron concentrations were averaged over incubation periods and soil types, there was significant increase in phytotoxicity (0 to 91%) due to sulfosulfuron + metsulfuron residues on maize with increase in its concentration from 0 to 80 g ha^{-1}. As evident from mean values, the phytotoxicty decreased significantly with corresponding increase in incubation periods (Table 16). The phytotoxicity decreased from 63 to 44 per cent as incubation period increased from 0 to 160 days. Sandy soil exhibited higher phytotoxicity in maize than that in clay loam soil . The maximum phytotoxicity (87%) was observed at 0 day incubation with 80 g ha^{-1} of sulfosulfuron + metsulfuron, where as in contrast minimum phytotoxicity (51%) was recorded at 160 days incubation with 20 g ha^{-1} of sulfosulfuron + metsulfuron.

Table 16. Residual effects of sulfosulfuron + metsulfuron (R. mix) at different concentrations and incubation periods in sandy and clay loam soils in terms of phytotoxicity in maize at 30 DAS

SSN + MSN (g ha^{-1})	Incubation period (days)						Soil type		Mean
	0	10	20	40	80	160	Sandy	Clay loam	
0	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)	4.0 (0.5)
20	77.6 (92.8)	72.0 (88.9)	65.6 (82.2)	58.7 (72.4)	55.5 (60.6)	51.3 (85.5)	69.9 (85.5)	57.0 (69.2)	63.4 (77.3)
40	84.5 (97.7)	78.9 (94.9)	72.8 (90.0)	67.9 (84.7)	63.4 (68.8)	56.2 (90.7)	75.5 (90.7)	65.7 (80.7)	70.0 (85.7)
80	87.1 (92.7)	82.0 (96.9)	77.3 (94.4)	74.2 (91.4)	71.1 (81.1)	66.1 (96.6)	81.5 (96.6)	71.2 (87.2)	76.3 (91.9)
Mean	63.3 (72.7)	59.2 (70.2)	54.9 (66.8)	51.2 (62.2)	48.5 (52.8)	44.4 (68.3)	57.7 (68.3)	49.5 (59.4)	

CD at 5%

Conc.	Period	Conc.xPeriod	Soil	Soil x Conc.
1.9	2.4	4.8	1.3	2.7

Note: The data in parentheses are original, which have been subjected to *arc. sin* transformation

DISCUSSION

Experiment 2: Effect of different temperatures on persistence of ready mix formulation of sulfosulfuron + metsulfuron-methyl

Three temperatures (15, 25 and 35ºC) maintained in the studies provided a wide range of possibilities that may exist under field conditions. Field capacity was maintained to provide uniform conditions under all temperature levels.

The growth parameters of maize i.e. plant height and dry weight of shoot decreased with corresponding increase in concentration of sulfosulfuron + metsulfuron from 0 to 80 g ha^{-1} at each temperature. However, visual phytoxicity increased with increasing sulfosulfuron + metsulfuron concentration from 0 to 80 g ha^{-1} at each temperature. The temperature mediated response of maize in the presence of range of concentrations of sulfosulfuron + metsulfuron indicated that the magnitude of decrease in plant growth in terms of plant height and dry weight of shoot was less at 35ºC as compared to 15ºC, which showed more degradation of sulfosulfuron + metsulfuron at higher temperature.

The increase in each of these growth parameters was discernible even at lowest concentration i.e. 20 g ha^{-1} of sulfosulfuron + metsulfuron. Similarly, dry weight of shoot was more at 35ºC than that at 15 and 25ºC at different incubation periods.

The mean dry weight of shoot recorded an increase of 17, 35, 50, 63 and 77 percent after 10, 20, 40, 80 and 160 days incubation, respectively. The results are in close conformity with the findings of Kotoviasyka*et al.* (1993) and Dharambir (1993) and Brar*et al.* (2006).

Experiment 3: Effect of soil pH on the persistence of ready mix formulation of sulfosulfuron + metsulfuron-methyl

Soil pH is the most important factor governing degradation of sulfonylurea herbicide. Sulfosulfuron + metsulfuron caused lesser toxicity in acidic soil as compared to alkaline soil for all of the growth parameters *viz.* germination percent, shoot length and dry weight of shoot. These parameters were superior in acid soil than in alkaline soil.

The rate of degradation of sulfosulfuron + metsulfuron was higher in acidic soil as compared to alkaline soil. Degradation of sulfonylureas was negatively correlated with soil pH hence their persistence was shorter in acid soil. As sulfonylureas are weak organic acid, they are present in anionic from under field conditions in alkaline soils. Thus, these have high availability in soil particularly during first few days of application and these are much less subjected to chemical hydrolysis (Jangir *et al.*, 2017a; Jakhar*et al.*, 2018; Kakraliya*et al.*, 2018). As the pH increases, the rate of chemical hydrolysis in soil decreases. In acidic soils, contribution of chemical hydrolysis is much more than the microbial degradation (Bajiya*et al.*, 2017; Hingonia*et al.*, 2018; Punia*et al.*, 2020). Therefore, it might be due to increased chemical hydrolysis in acidic soil and the duration of sulfosulfuron + metsulfuron activity was less as compared to alkaline soil. Brar *et al.* (2006) also reported similar results.

Experiment 4: Effect of different soil types on the persistence of ready mix formulation of sulfosulfuron + metsulfuron-methyl

In different soil types, the growth parameter of maize i.e. germination percent, shoot length and shoot dry weight were significantly lower in sandy soil as compared to the clay loam soil which indicated that the degradation of sulfosulfuron and metsulfuron by microorganisms was more under clay loam soil. The dry weight of shoot increased significantly with corresponding increase of incubation period from 0-

160 days in both types of soil (Sandy and clay loam). As compared to untreated control, the percent reduction in dry weight of shoot was 80, 88 and 95 percent at 20, 40 and 80 g h^{-1} of sulfosulfuron + metsulfuron, respectively. In general, growth of maize was low in sandy soil than in clay loam soil (Kumar *et al*., 2017s, b, c, d; Sheoran *et al.*, 2021). The similar findings were observed by Vicari*et al*. (1994).

CONCLUSION

In the first experiment, the growth indices *viz*., dry weight of shoot per plant and shoot length of maize decreased as the sulfosulfuron + metsulfuron-methyl concentration increased from 0 to 80 g ha^{-1}. Both these parameters increased with increase in incubation period.In acid soil, dry weight of shoot per plant was more than that recorded in alkaline soil at each concentration of sulfosulfuron + metsulfuron-methyl. The mean value showed that acidic soil produced 14 per cent more dry weight of shoot as compared to alkaline soil.As evident from mean values, the phytotoxicity decreased significantly with corresponding increase in incubation period, and the phytotoxicity decreased from 65 to 47 percent as incubation period increased from 0 to 160 days. Alkaline soil exhibited higher phytotoxicity in maize than that in acidic soil. In the second experiment, the germination percent of maize increased from 43% at 15ºC to 54% at 35ºC temperature.Visual phytotoxicity significantly increased with successive increase in sulfosulfuron + metsulfuron-methyl concentration. However, it decreased significantly as temperature increased from 15ºC to 35ºC and incubation increased from 0 to 160 days.The dry weight of maize shoot increased by 25 percent at 35ºC compared to 15ºC temperature significantly incubation period resulted in 17, 37, 50, 63 and 73 percent increase in dry weight of shoot at 10, 20, 40, 80 and 160 days, respectively in comparison to 0 day incubation.The growth parameters of maize *viz*., dry weight of shoot per plant and shoot length decreased with corresponding increase in sulfosulfuron + metsulfuron-methyl concentration and these both parameters increased with each successive increase in temperature and incubation period. In the third experiment, visual phytotoxicity increased with increase in sulfosulfuron + metsulfuron-methyl concentration and decreased with increase in incubation period in both types of soil. Visual toxicity was more in sandy soil as compared to clay loam.Various growth parameters of maize *viz.* dry weight of shoot per plant decreased significantly as sulfosulfuron + metsulfuron-methyl concentration increased from 0 to 80 g ha^{-1}. Whereas, all parameters increased significantly as incubation period increased from 0 to 160 days in both soil types.

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