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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 485-491

www.thepharmajournal.com
Received: 02-04-2023
Accepted: 07-05-2023

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Performance of growth characters of wheat crop as influenced by weed management through phyto-extracts and herbicides

Sushmita, RB Yadav, Vivek, Adesh and BP Dhyani

Abstract
A field trial was conducted at CRC Farm, Sardar Vallabhbhai Patel University of Agriculture & Technology in Meerut, Uttar Pradesh, India, to assess the impact of phyto-extracts and herbicides on weed control and the growth of wheat crops. The experiment followed a randomized block design (RBD) and included twelve treatments. These treatments were as follows: T_1: Weedy check (WC), T_2: Weed free (WF), T_3: Phyto-extract of Parthenium (PhE-Parthenium) (PP), T_4: PhE- Guava (PG), T_5: PhE-Mango (PM), T_6: PhE- Eucalyptus (PE), T_7: Sulfosulfuron 75 WP @ 25 g ha^{-1} PoE (S), T_8: Fenoxaprop-p-ethyl @ 120 g ha^{-1} PoE (F), T_9: PhE-Parthenium *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE (PP+F), T_{10}: PhE-Guava *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE (PG+F), T_{11}: PhE-Mango *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE (PM+F) and T_{12}: PhE-Eucalyptus *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE (PE+F) and this experiment was replicated thrice. The data obtained from the two-year experiment indicated that the different phyto-extracts and herbicides had significant effects on various growth parameters of the wheat crop. The weed-free treatment (T2) showed significantly higher values for all the growth characteristics of the wheat crop. This treatment exhibited the tallest plant height (106.40 and 104.87, respectively), the highest number of tillers per meter of row length (323.67 and 285.99, respectively), the greatest dry matter accumulation (1261.90 and 1108.88 g m-2, respectively), and the highest leaf area index (5.14 and 5.09, respectively) at the harvest stage in both years of the experiment. The treatments T9, T10, T11, T12, T8, T7, T3, T5, and T4 also showed varying degrees of improvement in these parameters compared to the weedy check treatment (T1), which exhibited the lowest values.

Keywords: Wheat, phyto-extract, herbicides, growth characters and weed management

Introduction

Wheat (*Triticum aestivum* L.) is a widely cultivated cereal crop and is considered one of the most important crops globally. India produces around 93.50 million tonnes of wheat on an estimated area of 30.23 million hectares, with an average yield of 3093 kg/ha. Weed infestation is a major contributing factor to this low wheat production not only in Uttar Pradesh but also nationwide. Weeds account for the highest percentage of crop loss in India, amounting to 33%, followed by pathogens (26%), insects (20%), storage pests (7%), rodents (6%), and other factors (8%) (Yaduraju and Mishra, 2018) [37].

Herbicides are substances applied to plants to kill them, effectively inhibiting weed growth. They are often based on plant hormones and offer a practical and cost-effective weed control solution compared to other methods.

Weeds in India cause significant production losses, estimated at approximately Rs. 16,500 million (Joshi, 2002) [15]. In order to address the issue of herbicide resistance and improve weed control, several alternative herbicides, including various herbicides and their combinations (ready/pre-mix or tank-mix), have been proposed (Walia *et al*., 2010; Kaur *et al*., 2017; Punia *et al*., 2017; Yadav *et al*., 2018; Banerjee *et al*., 2019) [30, 18, 24, 32, 3]. However, continuous application of these herbicides may lead to the emergence of resistant weed biotypes (Chhokar and Malik, 2002) [7]. Therefore, to prevent a significant shift in weed species, additional competitive herbicides are necessary for managing species like P. minor. Pinoxaden, a new herbicide from the phenylpyrazolin chemical class, has demonstrated post-emergence activity and effective control of resistant P. minor biotypes (Walia *et al*., 2007) [29].

Allelopathy presents a promising and innovative approach for organic farming, offering an environmentally friendly and natural method of weed management. It has been suggested that allelopathy can effectively reduce weed populations (Yongqing, 2005) [34] and has the potential to be utilized for weed management purposes (Farooq *et al*., 2011) [10].

Water extracts containing allelochemicals can serve as organic herbicides, providing an alternative to synthetic herbicides. In India, where labor shortages and increasing wages are prevalent, herbicides constitute approximately 16% of the pesticide market and are extensively used in crops such as rice, wheat, and soybean (www.ficci.com). Allelochemicals offer an advantageous substitute for synthetic herbicides due to their lack of hazardous or persistent side effects (Bhadoria, 2011) [4].

While the use of herbicides can save effort and be cost-effective in weed control, excessive reliance on herbicides with a similar mode of action can accelerate the development of herbicide-resistant weeds (Shaw *et al*., 2012) [26]. For example, in India, the heavy dependence on isoproturon, a substituted phenyl urea herbicide, has led to the emergence of *Phalaris minor* populations resistant to this herbicide, resulting in a significant decline in wheat productivity in affected regions (Malik and Singh, 1995) [20].

According to Zhang *et al*. (2010) [36], Eucalyptus roots and rhizosphere soil have significant allelopathic effects on target species. Many Eucalyptus species possess allelopathic properties, which inhibit the growth of certain weed species (Dadkhah *et al*., 2010) [8]. These allelopathic effects of Eucalyptus are attributed to the presence of allelochemicals, such as phenolic and volatile compounds, found in its foliage.

Guava (*Psidium guajava*), a member of the Myrtaceae family, their leaves contain a variety of bioactive substances, including avicularin, quercetin, and guaijaverin (Jefferson and Pennacchio, 2003) [13]. Additionally, the guava leaves contain possible allelopathic metabolites (Jindal and Singh, 1975) [14], such as flavonoids, terpenoids, and cyanogenic acids (Kalburtji and Gagianas, 1997) [16].

The mango tree (*Mangifera indica*), offers various valuable components, including its leaves. Mango leaves have been found to contain substances that have herbicidal properties. Extracts from mango leaves can effectively kill weeds or suppress their growth (Rudramuni *et al*., 2006) [25]. These compounds possess allelochemical properties that can inhibit weed growth, making mango leaves a promising bioresource (Yulifianti *et al*., 2015) [35].

Parthenium hysterophoresus, known as an allelopathic weed, has the potential to inhibit the germination and growth of various crop plants and trees. Tefera (2002) [28] discovered that the allelochemicals found in Parthenium can be utilized as alternatives for sustainable weed management practices..

Materials and Methods

The field experiment was carried out at CRC Farm, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India. The experiments were conducted in field conditions. During the trial period, the mean weekly meteorological data was gathered from the SVPUA&T meteorological observatory in Modipuram, Meerut. The SVPUA&T meteorological observatory in Modipuram, Meerut, recorded the weekly distribution of rainfall, maximum and minimum temperature, relative humidity, wind velocity, mean evaporation rate and sunshine hours during the crop period of both years. The data are presented in Fig. 1 and 2.

Edaphic conditions

The soil samples were taken randomly from 10 locations within the experimental field using a soil auger, and they were then examined to assess the physico-chemical features of the soil and its fertility condition. The outcomes of the mechanical and chemical analyses are shown in Table 1.

Table 1: Physico-chemical properties of the experimental field

Particulars	Values		Method adopted
	2021-22	2022-23	
Sand (%)	62.14	61.92	Hydrometer Method (Bouyoucus, 1962)
Silt (%)	20.69	20.59	
Clay (%)	18.45	18.37	
Textural class	Sandy loam	Sandy loam	Triangular basis
Soil pH (1:2.5 soil water)	7.61	7.63	pH meter (Jackson, 1973)
Organic carbon (g kg^{-1})	4.53	4.57	Walkley and Black (1934) method
EC (dSm^{-1} at 25^0C) (1:2.5 soil:water)	0.32	0.33	EC meter (Bower and Wilcox, 1965)
Available nitrogen (kg ha^{-1})	217.89	218.23	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available phosphorus (kg ha^{-1})	12.49	12.54	Olsen's method (Olsen *et al.*, 1954)
Available potassium (kg ha^{-1})	223.45	224.73	1 N NH_4OAC Extraction Method (Hanway and Heidal, 1952)

Collection of phyto-extract (donor) plant material

The fresh biomass of congress weed (*Parthenium hysterophorus),* guava, mango and eucalyptus was collected from the campus of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh during *rabi* season 2021-22 and 2022-23.

Collection of test materials

Wheat (*Triticum aestivum* L.) *Phalaris minor* and *Rumex dentata* were used to test the allelopathic potential of phyto-extracts of *Parthenium*, guava, mango and eucalyptus. The seeds of wheat, *Phalaris minor and Rumex dentata* were collected from CRC, SVPUA&T, Meerut, U.P. during *rabi* season 2021-22 and 2022-23.

Preparation of phyto-extracts from plant samples

All plant material was first air dried at room temperature for at least five days. To obtain phyto-extracts, 1 kg of each dried product were soaked in 10 L of distilled water (weight/volume ratio: 1/10) and put in constant stirring with a speed rotation of 70 rounds/min for at least 10 h. At the end of the extraction process, the mass was filtered through filter paper (Whatman No. 4), and the obtained extracts were refrigerated at 4 °C until used. (Carrubba, 2020) [6].

Experimental design and treatment details

The experiment was conducted in randomized block design (RBD) with twelve treatments namely- T_1: Weedy check (WC), T_2: Weed free (WF), T_3: Phyto-extract of Parthenium (PhE-Parthenium) (PP), T_4: PhE- Guava (PG), T_5: PhE-Mango (PM), T_6: PhE- Eucalyptus (PE), T_7: Sulfosulfuron 75 WP @ 25 g ha^{-1} PoE (S), T_8: Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE (F), T_9: PhE-Parthenium *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE (PP+F), T_{10}: PhE-Guava *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE (PG+F), T_{11}: PhE-Mango *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE (PM+F) and T_{12}:PhE-Eucalyptus *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE (PE+F) and this experiment was replicated thrice.

Measurement of crop growth parameters

As to find out the effect of treatments on growth of the crop, observations on plant height, number of tillers, dry matter accumulation were recorded at 30, 60, 90 days after sowing and at harvest as under:

Plant height

Five plants were tagged randomly in each net plot and their individual height were recorded in centimetres with the help of meter scale from the ground surface to the tip of fully expanded leaves. Height of all the five plants were summed and averaged to express plant height in centimetres.

Number of tillers m^{-2}

Number of tillers were recorded by using one m^{-2} quadrate fromthree places from each net plot and average weretaken for analysis.

Dry matter accumulation (g m^{-2})

The plant samples for dry matter accumulation were taken at 30, 60, 90 DAS and at harvest after sowing from 0.25 m row length selected randomly from each plot. The samples were sun dried and then dried in oven at 72ºC ± 0.5ºC for 72 hours or till the constant were achieved. The dry matter was expressed in g m^{-2}.

Leaf area index

For measuring leaf area, plants were also taken from two locations in each plot's second row that were 25 cm apart. The base of the lamina and the leaves were distinct. With the aid of a leaf area metre, leaf area will be measured every 30 days until the crop reaches senescence (L1 3000 Area metre LICOR Ltd. Nebraska, USA). The following formula was used to calculate the leaf area index:

$$\text{Leaf area index} = \frac{\text{Total leaf area (cm2)}}{\text{Total land area (cm2)}}$$

Statistical Analysis

Data for each parameter over two years was subjected to analysis of variance using for RBD design with arrangement according to OP-STAT. treatment means were compared using least significant difference test at $p \leq 0.05$.

Result and Discussion

The perusal of data showed that the different weed management practices including phyto-extracts and herbicides had the significant effect on various growth characters of wheat crop.

The significantly maximum plant height of wheat crop was recorded under weed free treatment (T_2) which was statistically at par with treatments T_9 (PhE-Parthenium *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_{10} (PhE-Guava *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_{11} (PhE-Mango *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_{12} (PhE-Eucalyptus *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_8 (Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_7 (Sulfosulfuron 75 WP @ 25 g ha^{-1} PoE), T_3 (PhE-*Parthenium*), T_5 (PhE- Mango) and T_4 (PhE-Guava) in first years and almost all treatment in second year except T5 and T1 in second year of experiment. The minimum plant height was found under weedy check treatment (T_1) in both years of trial. Majeed*et al*. (2012) also found similar results when they tested the allelopathic potentials of water soluble leaf extracts of *Chenopodium album* at lower concentrations in wheat crop.

The study of data revealed that the significantly maximum number of tillers m^{-2} of wheat crop was recorded under weed free treatment (T_2) which was statistically at par with treatments T_9 (PhE-Parthenium *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_{11} (PhE-Mango *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_{10} (PhE-Guava *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_{12} (PhE-Eucalyptus *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_8 (Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_7 (Sulfosulfuron 75 WP @ 25 g ha^{-1} PoE), T_3 (PhE-*Parthenium*), T_5 (PhE- Mango) and T_4 (PhE- Guava) in first year while in second year of experiment, with T_9, T_8 and T_{12}. However, the lowest number of tillers was observed under weedy check treatment (T_1) for both experimental years. Walia *et al. (*2010) [30] observed the similar findings in Punjab.

The scrutiny of data showed that the maximum dry matter accumulation (g m^{-2}) of wheat crop was attained under weed free treatment (T_2) which was statistically at par with treatments T_9 (PhE-Parthenium *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE) in second year of field experiment. While, the minimum maximum dry matter accumulation by wheat crop was found under weedy check treatment (T_1) both years of field trial. Miri and Armin (2013) also reported the relative results.

The highest leaf area index of wheat crop was recorded under weed free treatment (T_2) which was statistically at par with treatments T_9 (PhE-Parthenium *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_{11} (PhE-Mango *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_{10} (PhE-Guava *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_{12} (PhE-Eucalyptus *fb* Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE), T_8 (Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE) and T_7 (Sulfosulfuron 75 WP @ 25 g ha^{-1} PoE) first year of experiment and almost all treatments in second experimental year except T_4, T_6 and T_1. However, the lowest leaf area index was observed in treatment T_1 (weedy check).

Table 2: Effect of phyto-extracts and herbicide on plant height (cm) of wheat at different stages

Treatments		Plant height (cm)							
		30 DAS		60 DAS		90 DAS		At Harvest	
		2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1	Weedy check	16.23	16.10	56.63	55.05	89.43	87.91	99.27	97.84
T_2	Weed – free	20.35	19.32	61.10	59.01	96.13	94.50	106.40	104.87
T_3	PhE - Parthenium	18.01	17.33	58.53	56.33	91.37	88.99	103.40	101.91
T_4	PhE - Guava	17.92	17.55	56.93	56.08	90.03	87.69	102.70	101.22
T_5	PhE – Mango	17.92	17.57	57.60	54.67	91.07	88.70	102.97	101.48
T_6	PhE - Eucalyptus	17.18	16.87	56.67	54.45	89.87	88.34	100.80	99.35
T_7	Sulfosulfuron 75 WP @ 25 g ha^{-1}PoE	18.08	18.52	58.70	55.92	92.33	91.69	103.90	102.40
T_8	Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE	18.14	18.00	58.67	55.29	92.47	91.82	104.67	103.16
T_9	PhE - Parthenium fb Fenoxaprop-p-ethyl	20.35	17.84	59.83	59.95	95.83	95.16	106.08	104.55
T_{10}	PhE – Guava fb Fenoxaprop-p-ethyl	18.81	19.28	58.90	59.59	92.90	91.32	105.37	103.85
T_{11}	PhE – Mango fb Fenoxaprop-p-ethyl	19.79	19.72	59.80	59.69	93.80	90.33	105.07	103.55
T_{12}	PhE - Eucalyptus fb Fenoxaprop-p-ethyl	18.18	18.04	58.70	58.83	92.80	89.37	105.00	103.49
SEm$\pm$		0.79	0.66	0.86	0.77	1.11	1.08	1.32	1.31
C.D (P=0.05)		NS	1.93	2.52	2.25	3.25	3.17	3.89	3.84

*PhE- Phyto-extract

Table 3: Effect of phyto-extracts and herbicide on number of tillers (number of tillers m^{-1} row length) of wheat at different stages

Treatments		Number of tillers m^{-1} row length							
		30 DAS		60 DAS		90 DAS		At Harvest	
		2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1	Weedy check	131.67	111.92	325.67	276.82	315.33	268.03	299.00	254.15
T_2	Weed – free	141.00	125.18	352.00	313.87	342.67	303.79	323.67	285.99
T_3	PhE - Parthenium	137.33	120.85	345.00	303.60	333.00	293.04	312.00	274.56
T_4	PhE - Guava	137.00	120.56	341.33	300.37	331.67	291.87	311.67	274.27
T_5	PhE – Mango	137.33	120.85	344.00	302.72	332.33	292.45	311.67	274.27
T_6	PhE - Eucalyptus	137.33	119.48	339.33	295.22	327.67	285.07	306.33	266.51
T_7	Sulfosulfuron 75 WP @ 25 g ha^{-1}PoE	138.33	120.35	346.00	301.02	334.00	290.58	314.18	273.33
T_8	Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE	139.67	121.51	346.00	301.02	334.00	290.58	317.00	275.79
T_9	PhE - Parthenium *fb* Fenoxaprop-p-ethyl	140.67	124.19	351.67	314.98	341.33	298.31	321.33	281.20
T_{10}	PhE – Guava *fb* Fenoxaprop-p-ethyl	140.33	122.90	349.67	311.20	339.67	291.27	318.96	275.12
T_{11}	PhE – Mango *fb* Fenoxaprop-p-ethyl	140.33	119.28	350.67	298.07	340.33	289.28	320.33	272.28
T_{12}	PhE - Eucalyptus *fb* Fenoxaprop-p-ethyl	140.00	119.00	348.00	295.80	338.00	287.30	317.67	275.68
SEm$\pm$		1.62	1.53	4.39	3.62	4.34	3.49	4.29	3.75
C.D (P=0.05)		4.76	4.50	12.88	10.61	12.73	10.23	12.60	11.00

Table 4: Effect of phyto-extracts and herbicide on dry matter accumulation (g m^{-2}) of wheat at different stages

Treatments		Dry matter accumulation (g m^{-2})							
		30 DAS		60 DAS		90 DAS		At Harvest	
		2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1	Weedy check	56.23	47.49	355.43	312.78	797.27	701.59	941.67	828.67
T_2	Weed – free	60.20	52.77	395.00	343.03	854.99	735.29	1261.90	1108.88
T_3	PhE - Parthenium	57.03	50.19	371.23	326.69	815.30	717.46	1083.52	953.50
T_4	PhE - Guava	56.83	48.88	365.47	314.30	810.59	697.11	1013.89	871.95
T_5	PhE – Mango	57.05	49.07	370.70	318.80	808.92	695.67	1011.42	869.82
T_6	PhE - Eucalyptus	56.63	48.70	362.43	311.69	806.62	693.69	1050.71	903.61
T_7	Sulfosulfuron 75 WP @ 25 g ha^{-1}PoE	57.47	51.72	371.53	334.38	825.90	743.31	1137.19	1023.48
T_8	Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE	57.87	52.08	380.60	342.54	830.21	747.19	1150.64	1035.58
T_9	PhE - Parthenium *fb* Fenoxaprop-p-ethyl	58.87	51.98	388.47	348.62	843.01	758.71	1232.08	1085.23
T_{10}	PhE – Guava *fb* Fenoxaprop-p-ethyl	58.98	51.91	381.77	335.95	840.02	739.22	1195.52	1052.06
T_{11}	PhE – Mango *fb* Fenoxaprop-p-ethyl	58.83	50.53	387.33	332.68	842.93	724.00	1218.18	1046.30
T_{12}	PhE - Eucalyptus *fb* Fenoxaprop-p-ethyl	58.44	50.20	381.30	327.50	838.67	720.33	1207.48	1037.11
SEm$\pm$		0.79	0.97	6.17	5.45	11.94	10.55	9.37	8.20
C.D (P=0.05)		2.32	2.84	18.10	15.99	35.03	30.93	27.48	24.04

Table 5: Effect of phytoextracts and herbicide on leaf area index of wheat at different stages

Treatments		Leaf area index					
		30 DAS		60 DAS		90 DAS	
		2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
T_1	Weedy check	0.393	0.403	3.06	3.05	4.77	4.77
T_2	Weed – free	0.403	0.410	3.26	3.27	5.14	5.09
T_3	PhE - Parthenium	0.397	0.403	3.11	3.06	4.92	4.90
T_4	PhE - Guava	0.397	0.390	3.10	3.06	4.82	4.84
T_5	PhE – Mango	0.397	0.403	3.11	3.06	4.91	4.89
T_6	PhE - Eucalyptus	0.393	0.400	3.08	3.11	4.81	4.80
T_7	Sulfosulfuron 75 WP @ 25 g ha^{-1}PoE	0.400	0.400	3.12	3.11	4.97	4.93
T_8	Fenoxaprop-p-ethyl @ 120 g ha^{-1}PoE	0.400	0.407	3.12	3.13	4.97	4.94
T_9	PhE - Parthenium fb Fenoxaprop-p-ethyl	0.403	0.407	3.24	3.24	5.12	5.08
T_{10}	PhE – Guava fb Fenoxaprop-p-ethyl	0.400	0.400	3.21	3.18	5.10	5.04
T_{11}	PhE – Mango fb Fenoxaprop-p-ethyl	0.400	0.403	3.23	3.20	5.12	5.05
T_{12}	PhE - Eucalyptus fb Fenoxaprop-p-ethyl	0.400	0.403	3.15	3.17	5.05	4.99
SEm±		0.0058	0.0049	0.04	0.0491	0.05	0.0683
C.D (P=0.05)		NS	NS	0.11	0.1440	0.17	0.2005

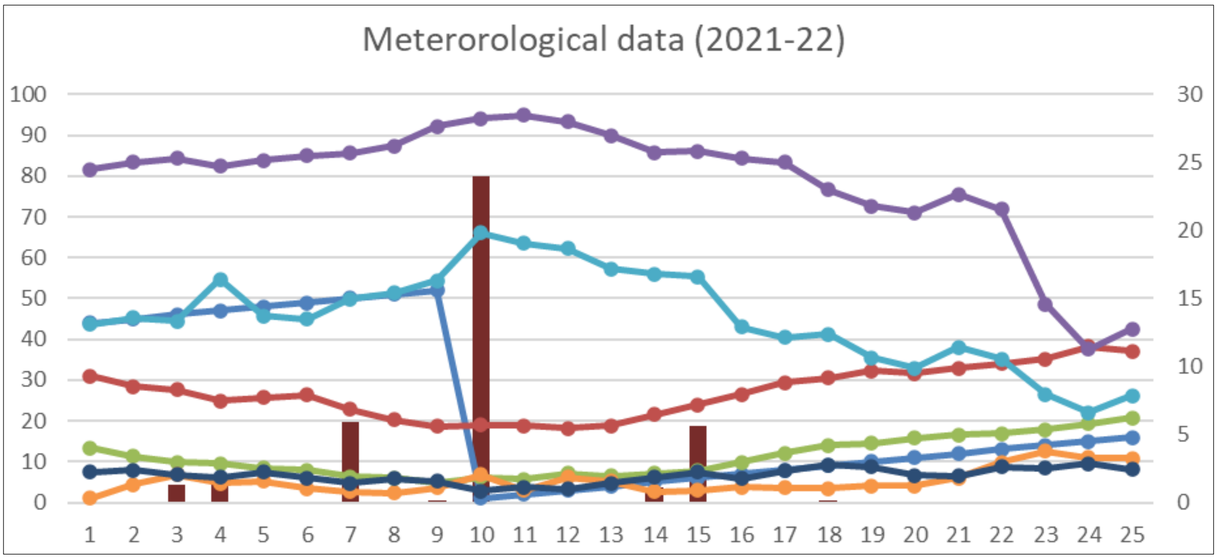

Fig 1: Weekly meteorological data during crop season 2021-22 (November to April)

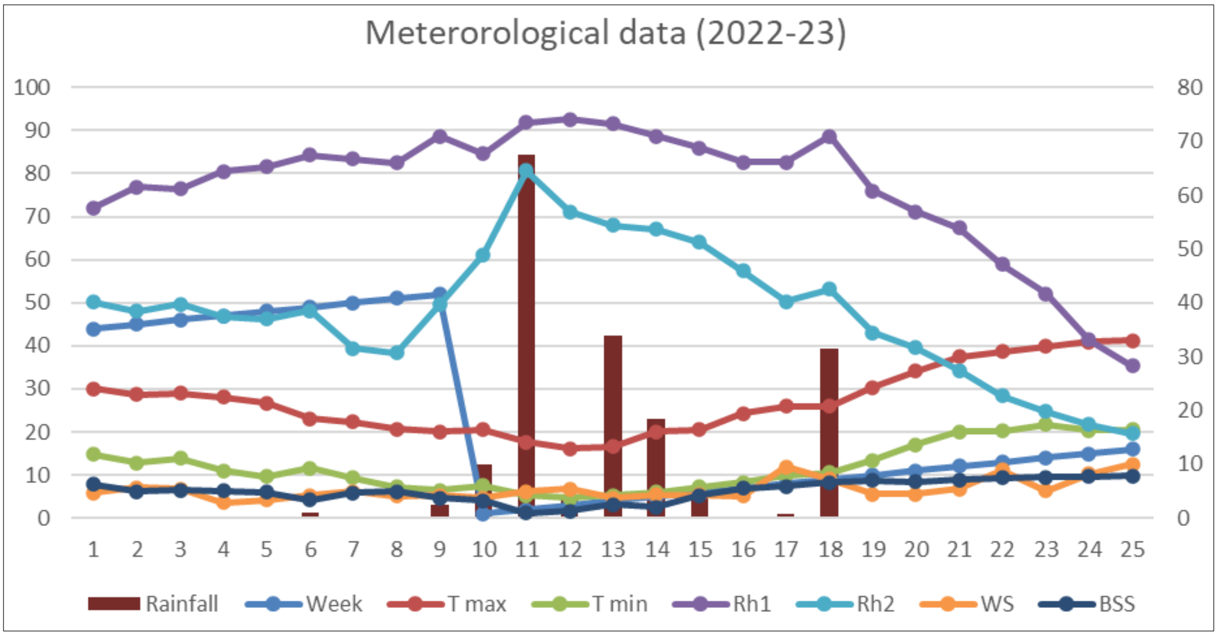

Fig 2: Weekly meteorological data during crop season 2022-23 (November to April)

Conclusion

This study highlights the use of phyto-extracts and herbicides are the useful methods to control the weeds in wheat crop and obtain the good growth and development of crop. So that farmers can use the phyto-extracts for weed suppression in wheat with herbicides or sole alone for getting good crop growth and development.

Acknowledgement

Author is Ph.D. scholar at Department of Agronomy of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India under guidance of Dr. R.B. Yadav, who guided and helped the author for all type of their research. Dr. Adesh, Dr. Vivek and Dr. B.P. Dhyani are the members of advisory committee of author, who provided the all equipment's and methods for research. The author is thankful to all co-authors for their support and help.

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