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Swarnayu Bagchi
Research Scholar, Department of Post-Harvest Technology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Suhrita Chakrabarty
Professor, AICRP on Floriculture, Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bangal, India

Corresponding Author:
Swarnayu Bagchi
Research Scholar, Department of Post-Harvest Technology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Effects of different herbicides on post-harvest behaviour of chrysanthemum (*Chrysanthemum species* L.)

Swarnayu Bagchi and Suhrita Chakrabarty

Abstract
Weeding is an important operation for chrysanthemum cultivation, which can combat a huge loss in terms of growth and productivity particularly during rainy season. The present experiment was carried out at Horticultural Research Station, Mondouri, B.C.K.V during 2014-15 to find out the effects of herbicides on weed control, plant growth, flowering and post harvest behaviour of chrysanthemum cv. Bidhan Tarun. The experiment consisted of three pre-emergence herbicide, two post-emergence herbicide; three hand-weddings at 25, 50 and 75 days after planting (DAP), weed free check and weedy check (Control). Among the treatments applied Pendimethalin, pre-transplanting pre-emergence @ 1.0 kg a.i./ha followed by hand weddings at 25 and 50 DAP showed better results to suppress the weeds, and results in higher plant growth, flowering, better post-harvest life and consumers acceptability.

Keywords: Weeds, herbicides, vase life

Introduction
Chrysanthemum (*Chrysanthemum species* L.), belonging to the family Asteraceae occupies a significant status in ornamental horticulture of India. The present area under chrysanthemum cultivation is more than 18.35 thousand hectare in India with a production of 206.19 thousand MT (NHB, Database 2014). The best temperature for growing chrysanthemum is 20-28 °C for day and 15-20 °C for night. Since chrysanthemum is a short day plant, to coincide flowering with short day conditions, it is planted during April-May in West Bengal, so that flowering occurs during September - December. In chrysanthemum control of weeds is an important operation. If the weeds are not removed on time, a great loss would occur in terms of growth and productivity of chrysanthemum particularly in open cultivation in West Bengal. Normally hoeing and weeding is recommended for at least 3 to 4 times during the crop period to make the soil loose and weed free. Due to scarcity of labour, hand weeding cannot be practiced on a large scale and it is time consuming also. Moreover, incessant rains during initial periods often render the hand-weeding impossible. Hence, an alternative method would be to use herbicides which is practically effective in reducing weed competition at right time so that it is possible to obtain higher flower yield. The use of herbicides in controlling weeds is comparatively economic, convenient and efficient by one or two applications (Yadav and Bose, 1987) [7]. A number of herbicides have become available in the market for controlling weeds in flower crops. However, detailed information on this choice of herbicides, their appropriate dosage and time of application is not fully standardized in chrysanthemum for farmers' usage. In the present study, an attempt was made to find out an effective weed management practice in chrysanthemum for optimum flower production, acceptable post harvest life and better acceptability.

Materials and Methods
Chrysanthemum was grown in an experimental plot at the Horticulture Research Station, Mandouri and post harvest experiments were conducted at the Laboratory of Department of Post Harvest Technology, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India. The meteorological data pertaining to minimum, maximum temperature (^{o}C) and relative humidity (%), total rainfall (mm) and sunshine (hour/day) during the crop growth for the year 2014 and 2015 and also the mean values of both the years of HRS, Mondouri, B.C.K.V, was recorded (Source: Department of Agricultural

Meteorology and Physics, B.C.K.V). The temperature (°C) inside the laboratory was recorded in Celsius scale and relative humidity (%) was recorded by psychrometer. Chrysanthemum cultivar Bidhan Tarun was one of the released varieties of B.C.K.V, Mohanpur, Nadia, West Bengal, India (Anon, 2007) [2] was planted at 30 x 30 cm spacing in 2 x 2 m sized plot. Each plot consist thirty numbers of plants. The treatments were, T_1= Atrazine, pre-transplanting pre-emergence @ 0.75 kg a.i./ha followed by hand weddings at 25 and 50 DAP. T_2= Pendimethalin, pre transplanting pre-emergence @ 1.0 kg a.i./ha followed by hand weddings at 25 and 50 DAP. T_3 = Oxyflurofen, pre-transplanting pre-emergence @ 0.2 kg a.i./ha followed by hand weedings at 25 and 50 DAP. T_4 = Isoproturon, post-emergence @ 0.75 kg a.i./ ha at 20 DAP followed by hand-weedings at 25 and 50 DAP. T_5 = Bispyribac-sodium, post-emergence @ 25 g/ha at 20 DAP followed by hand-weedings at 25 and 50 DAP. T_6 = Three hand-weddings at 25, 50 and 75 DAP. T_7 = Weed free check. T_8= Weedy check. The experiment was laid out in a Randomized block design with three replications.

Observations recorded

The weed count (m^{-2}) was recorded at 25 and 50 days after transplanting by throwing quadrate (0.50 m × 0.50 m) randomly at three places in each plot. Subsequently the fresh weight (g m^{-2}) of those weeds was recorded and thereafter oven dried at 65 ºC temperature till constant weight and subsequently their dry weight (g m^{-2}) was measured. Weed control efficiency (WCE) (%) is calculated with the help of the following formula.

$$WCE = \frac{(WDC - WDT)}{WDC} X \quad 100$$

Where, WDC = Weed dry matter in weedy check; WDT = Weed dry matter in a particular treatment.

Plant height (cm) was measured in five randomly selected and tagged plants from each replication from the base of the plant to the tip of the main stem at first flower bud appearance stage i.e. 60 days after transplanting. The maximum horizontal spread (cm) and the number of primary branches arising from the main stem was recorded at 90 days after transplanting. Days to flowering was recorded by counting the number of days taken from date of transplanting to bud starts showing colour in a net plot area. The physiological loss in weight of the flowers was estimated by using the formula given below and expressed in percentage.

$$PLW (\%) : \frac{\text{Initial weight-Final weight}}{\text{Initial weight}} X\ 100$$

The freshness of flowers was recorded at alternate days from harvesting to end of storage by using 9 point Hedonic scale (Joshi, 2006) [3]. The judges were made familiarized with the products prior to evaluation. Coded samples were given to the judges in their respective chambers and evaluated on the hedonic scale. The data of 2 years collected from the investigations were analysed according to different design i.e., Randomized block design (RBD) in each experiment by software SPSS. But the graphs were drawn by software MS Excel.

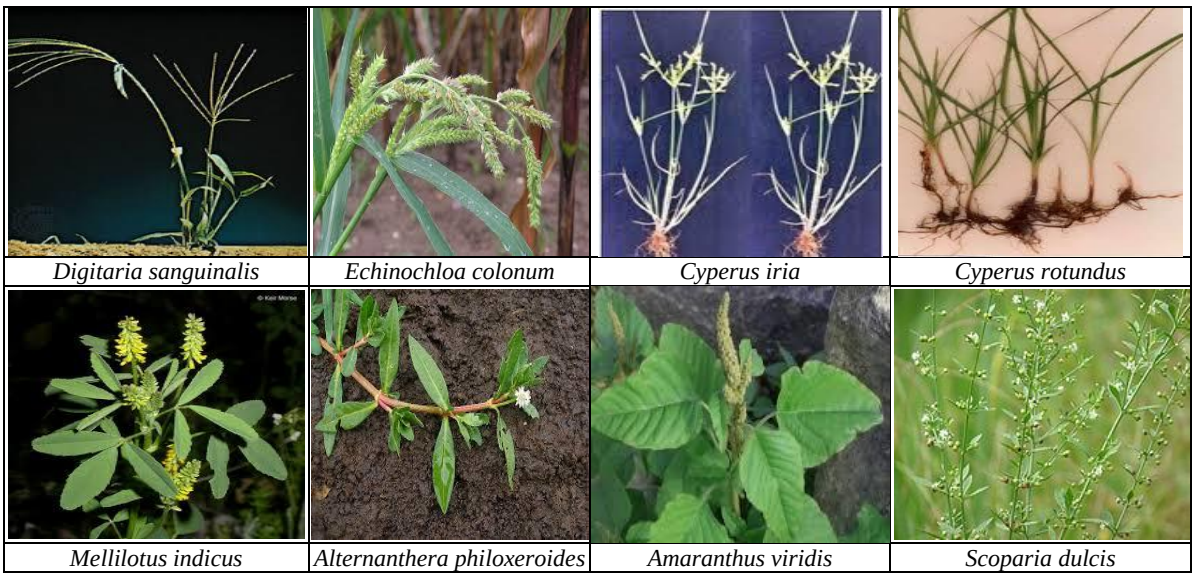
Results and discussion

Weed community observed in the chrysanthemum field

Data presented in Table 1 has shown eight weed species belonging to five families which infested the experimental plots of chrysanthemum. Among these, grasses and sedges infest more.

Table 1: Weed community observed in the experimental field of chrysanthemum

Common name	Scientific name	Family	Type of weed	Life cycle
1.Crab grass	*Digitaria sanguinalis*	Poaceae	Grass	Annual
2. Jungle rice	*Echinochloa colonum*	Poaceae	Grass	Annual
3. Jalmutha	*Cyperus iria*	Cyperaceae	Sedge	Annual
4.Motha	*Cyperus rotundus*	Cyperaceae	Sedge	Perennial
5.Ban methi	*Mellilotus indicus*	Fabaceae	Broad leaved	Annual
6. Sechi	*Alternanthera philoxeroides*	Amaranthaceae	Broad leaved	Perennial
7. Amaranthus	*Amaranthus viridis*	Amaranthaceae	Broad leaved	Annual
8. Goat weed	*Scoparia dulcis*	Plantaginaceae	Broad leaved	Annual



Digitaria sanguinalis | *Echinochloa colonum* | *Cyperus iria* | *Cyperus rotundus*

Mellilotus indicus | *Alternanthera philoxeroides* | *Amaranthus viridis* | *Scoparia dulcis*

Plate 1: Different weed species found in chrysanthemum plot

Effect of herbicides on weed population of chrysanthemum

Weed population among the treatments is highest in weedy check (T_8) for both the years presented in Table 2. The mean value of weedy check (T_8) was 76.9 and 81.6 per m^2 at 25 and 50 days after transplanting (DAT) respectively in 2014. During 2015 the mean value of weed population is 36.7 and 38.4 per m^2 at 25 and 50 days after transplanting (DAT) respectively. The lowest weed growth i.e. 1.0 per m^2 was observed in weed free treatment (T_7) for the two years in at both 25 and 50 days after transplanting (DAT). Plots treated with herbicides or plots which are hand weeded were showed lesser amount of weed population than the weedy checked. Our results corroborated with the findings of Singh *et al*., (2000) [6] they also found that the highest weed population was in the weedy control on potato cultivar Kufri Ashoka (PJ-376). The pooled analysed data of fresh weight of weed (g/m^2) at 25 and 50 days after transplanting (DAT) of weedy check (T_8) was 209.5 and 114.8 respectively showed significance. Pooled data of the treatment weed free check (T_7) was recorded 1.0 g/m^2, the lowest among the weed control treatments throughout the crop growth period (Table 2). Pooled data on dry weight of weeds of weedy check (T_8) was highest among the treatments throughout the crop growth period in chrysanthemum which was 69.4 and 37.3 g/m^2. Weed free treatment (T_7) showed lowest weed dry weight in 2014 and 2015 i.e. 1.0 g/m^2 at both 25 and 50 days after transplanting (DAT) presented in Table 2. Highest weed control efficiency (100%) was recorded at weed free treatment (T_7) and the lowest weed control efficiency was observed at weedy checked (T_8). Among the herbicides, highest weed control efficiency i.e. 36.6% was observed in pendimethalin (T_2).

Table 2: Effect of herbicides on weed count (No/per m^2), fresh weight and dry weight of weeds (g/m^2) of chrysanthemum

Treatments (T)	Weed count (No/per m^2)				Fresh weight of weed (g/m^2)		Dry weight of weed (g/m^2)		Weed Control Efficiency (%)
	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT	
T_1 (Atrazine)	72.5	66.9	34.2	24.6	203.5	106.2	68.55	35.8	2.2
T_2(Pendamethalin)	11.75	16.2	13.9	8.9	119.3	73.9	44.0	23.6	36.6
T_3(Oxyflurofen)	57.2	57.7	27.6	17.0	186.3	103.2	60.5	34.3	11.1
T_4(Isoproturon)	18.6	35.2	25.9	15.1	160.8	93.6	53.8	31.5	20.0
T_5 (Bispyribac-sodium)	23.7	18.7	24.4	13.2	159.1	92.7	53.6	30.5	21.1
T_6 (Three hand weeding)	21.3	9.4	9.7	8.7	60.9	58.0	20.4	19.8	62.3
T_7 (Weed free check)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	100
T_8 (Weedy Check)	76.9	81.6	36.7	38.4	209.5	114.8	69.4	37.3	0.0
SEm (±)	-	-	-	-	11.3	15.5	4.3	5.1	-
CD at 5%	-	-	-	-	32.8	45.1	12.6	14.8	-

DAT = Days after transplanting

Effect of herbicides on plant growth parameters of chrysanthemum

Data presented in Table 3 showed that maximum plant height of chrysanthemum i.e. 31.5 cm was observed in weedy check (T_8) and the plots treated with pendimethalin (T_2) showed minimum plant height i.e. 16.5 cm. Maximum plant spread was 15.3 cm (north x south) and 15.3 cm (east x west) were recorded at pendimethalin (T_2) treated plot. The minimum plant spread was found at weedy check (T_8) which was 3.2 cm for (north x south) and 3.3 cm for (east x west) presented in Table 3. Maximum and minimum numbers of primary branches of chrysanthemum plants were recorded at Pendimethalin (T_2) and weedy checked (T_8) which was 6.7 and 2.7 respectively. Data presented in Table 4 showed that maximum days to flowering i.e. 16.8 were noted in plants planted at weedy checked plots (T_8). Plants of pendimethalin treated plots (T_2) exhibited shortest time 14.3 days to flower in chrysanthemum. Pooled data presented in Table 4 has shown that the maximum number of flowers produced per plant of chrysanthemum was 31.2 in (T_2). The minimum number of flowers per plant i.e. 12.0 was recorded in weedy checked (T_8). Similar results were found by Acharya *et al*., (2003) [1] in African marigold (*Tagetes erecta* cv. Pusa Basanti Gainda), they also observed that the pendimethalin at 1 kg/ha + weeding at 30 and 60 DAT was reduced mean weed dry weight by 60.2, 75.8 and 92.5 g compared to two hand weeding's, one weeding and the weedy control, respectively, and also produced the highest flower yield.

Effect of herbicides on post harvest behaviour of chrysanthemum

The two years pooled data (Table 4) showed that highest flower diameter i.e. 6.17 was noted in the flowers of pendimethalin treated plots (T_2) and the lowest flower diameter i.e. 4.50 was recorded in weedy checked (T_8). The two years pooled data (Table 4) showed that maximum vase life was noted in the flowers of pendimethalin treated plots (T_2) (14.8 days) and the minimum vase life was recorded in weedy checked (T_8) (9.3 days). Maximum score of freshness was recorded in flowers of pendimethalin treated plants (T_2) at 7 th and 12 th day after harvesting which was 7.5 and 4.5. The minimum score was recorded at weedy checked (T_8) which was 5.5 and 2.5 at 7 ^{rth} and 12 th day after harvesting showed in Figure 1. Minimum and maximum physiological loss in weight (%) was recorded at (T_3) Oxyflurofen followed by (T_2) pendimethalin and weedy checked (T_8) respectively in all the observation periods showed in Figure 2. Weeds compete with the crops for nutrients, soil moisture, sun light etc. which affects badly to the well being of crop plants and lead to reduction in the crop yield, quality etc. and ultimately affects the post harvest life and quality. The growth of the plants and flower yield depends on the cultivation practices adopted and weed free environment right from the early stage (Rao, 2005) [5].

Table 3: Effect of herbicides on plant growth parameters of chrysanthemum

Treatments (T)	Plant height at first flower bud appearance stage (cm)	Number of primary branches/plant	Plant spread (North x South) (cm)	Plant spread (East xWest) (cm)
T1 (Atrazine)	17.8	4.0	13.2	12.2
T2(Pendamethalin)	16.5	6.7	15.3	15.3
T3(Oxyflurofen)	23.0	6.0	13.3	12.0
T4(Isoproturon)	22.5	4.2	9.0	8.7
T5 (Bispyribac-sodium)	19.2	4.0	7.5	8.7
T6 (Three hand weeding)	27.3	4.3	5.8	4.7
T7 (Weed free check)	18.5	2.9	13.3	13.3
T8 (Weedy Check)	31.5	2.7	3.2	3.3
SEm (±)	1.9	0.6	1.6	1.4
CD at 5%	5.7	1.7	4.8	4.1

Table 4: Effect of herbicides on flowering and vase life of chrysanthemum

Treatments (T)	Days to flowering	Number of flowers / plant	Flower diameter (cm)	Vase life (Days)
T1 (Atrazine)	15.2	30.7	5.42	11.8
T2(Pendamethalin)	14.3	31.2	6.17	14.8
T3(Oxyflurofen)	14.8	29.7	5.33	14.3
T4(Isoproturon)	16.3	27.0	5.08	12.7
T5 (Bispyribac-sodium)	15.7	30.0	5.42	12.3
T6 (Three hand weeding)	16.3	22.2	5.25	11.7
T7 (Weed free check)	15.7	14.0	5.00	10.3
T8 (Weedy Check)	16.8	12.0	4.50	9.3
SEm (±)	0.3	2.1	0.1	0.3
CD at 5%	1.04	6.1	0.4	1.05

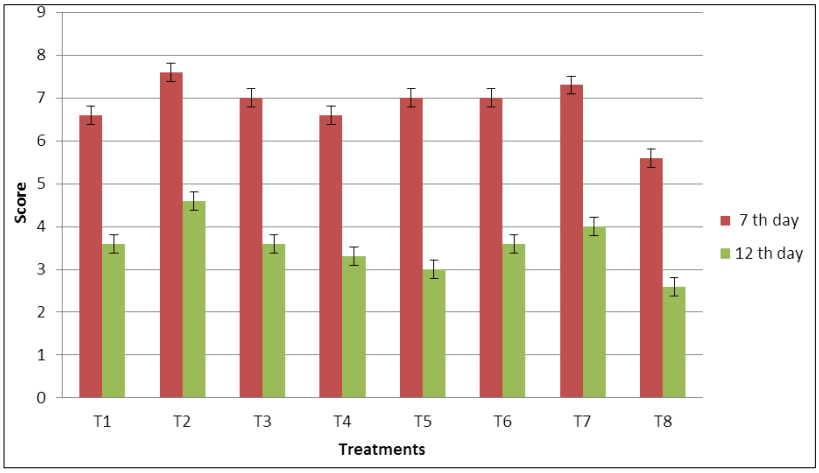


Fig 1: Effect of herbicides on freshness of chrysanthemum (on 9 point Hedonic scale) at different days after harvesting

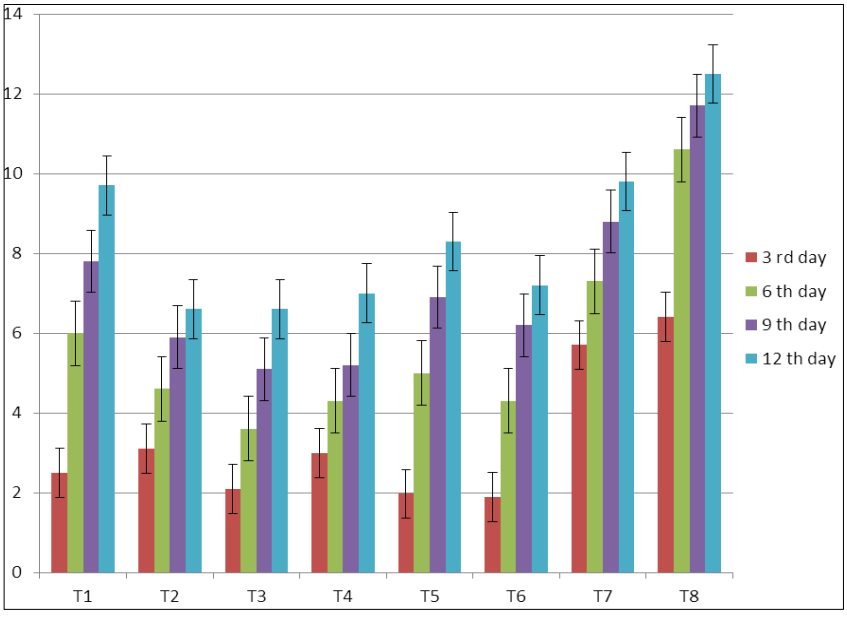


Fig 2: Effect of herbicides on physiological loss in weight (%) of chrysanthemum at different days after harvesting

Conclusion

Results of our experimemt revealed that Pendimethalin (T_2) applied as pre-emergence @ 1.0 kg a.i./ha + two hand weeding (at 25 and 50 DAP) was found to suppress the weeds and results in higher plant growth, flowering, better post-harvest life and consumers acceptability of chrysanthemum. Herbicides, by reducing the weed count, facilitate the crops to obtain nutrients, soil moisture, sun light etc in a better way leading to higher crop yield, quality etc. and ultimately improving the post harvest life and quality. Being the best treatment among all, pendimethalin controlled primarily annual grasses (*Digitaria sp.*, *Echinochloa sp.*) and broad leaf weeds (*Mellilotus sp.*, *Amaranthus sp.*, *Scoparia sp.*) as a systemic and selective pre-emergence herbicide. At the present state of labour shortage in the floricultural industry, our findings may be a useful way out against weeding of chrysanthemum.

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