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Effect of different herbicides on weed control in China aster [*Callistephus chinensis* (L.) Nees]

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Abstract
The current investigation was carried out at College of Horticulture, SKLTSHU, Rajendranagar, Hyderabad during 2016-2017 to study the effect of different herbicides to control the weeds in China aster varieties of Kamini and Poornima. The experiment was conducted in factorial randomized block design with factorial concept with three replications. Factor I includes two varieties Kamini (V1) and Poornima (V2), factor II includes eight treatments viz., Pendimethalin (30EC), Oxyfluorfen (25EC) and Alachlor (50EC) as pre emergence herbicides in combination with Quizalofop ethyl (10EC) as post emergence followed by hand weeding at 20 DAT. At all the crop growth stages, pre emergence application of alachlor (50EC) @ 1.0 kg a.i ha-1 followed by hand weeding recorded lowest weed density and dry weight of weeds. The highest weed control efficiency, least weed index and higher yield were noticed in pendimethalin (30EC) @ 1.0 kg a.i ha-1 followed by hand weeding. However, unweeded control recorded highest weed count, dry weight, maximum weed index and lower weed control efficiency. Among the two varieties, minimum weed count, dry weight and maximum weed control efficiency were noticed in Kamini while Poornima recorded the minimum weed index. The interaction between treatments and varieties was found significant at 20, 40 and 60 DAT. Lower weed count, dry weight and higher weed control efficiency were noticed with alachlor (50EC) @ 1.0 kg a.i ha-1+ hand weeding. However, higher weed index was recorded with pre emergence application of pendimethalin (30EC) @ 1.0 kg a.i ha-1 + hand weeding.

Keywords: China aster, herbicides, yield, weed count, weed control efficiency, weed index

Introduction
China aster [*Callistephus chinensis* (L). Ness] a member of the family Asteraceae is one of the most annual flower crop of our country which is grown commercially in countries like Siberia, Russia, Japan, North America, Switzerland and Europe. It is native of China and has spread to Europe and other tropical countries during 1731 AD. Aster can be grown successfully in open conditions and its flowers are used for various purposes. Cut asters last long and are used in vases and flower decoration. It is also used in the preparation of bouquets, garlands, flower arrangement, interior decoration and loose flower for garland making and worshipping.
Besides, it is very popular as a bedding plant and they are also used to grow as potted plants. Dwarf types are suitable for edges and used as herbaceous border plant in parks and gardens. Though number of herbicides are available in the market for control of weeds in flower crops, a detailed information on this choice of herbicides, their appropriate dosage and time of application is not fully available to the farmers cultivating China aster.

Materials and Methods
The present study was conducted at department of Floriculture and Landscape Architecture, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, during 2016-2017 using China aster var. Kamini and Poornima.
The experiment was conducted in red sandy loam in a FRBD with three replications with factor 1 as varieties and factor 2 as herbicide treatments. The seeds were sown on raised nursery beds in lines and watered regularly with rose can. Four weeks old healthy and uniform seedlings were transplanted in well-prepared plots of 3x3 m^2, at a distance of 30 x 30 cm. The recommended dose of fertilizers was applied in the form of urea, single super phosphate and muriate of potash respectively. Half dose of N and full dose of P and K were applied in a circular band of about 3-4 cm around each plant at the time of transplanting and the crop was top dressed with remaining half dose of N at 30 days of transplanting.
The details of the treatments were as follows T1 - Pendimethalin (30 EC) as pre - emergence @ 1.0 kg a.i ha-1 followed by hand weeding at 30 DAT, T2 - Pendimethalin (30 EC) as pre

emergence @ 1.0 kg a.i ha-1 followed by Quizalofop ethyl(10 EC) as post emergence @ 50 g a.i ha-1 at 15 DAT, T3- Oxyfluorfen (25 EC) pre-emergence @ 0.15 kg a.i ha-1 followed by hand weeding at 30 DAT, T4 - Oxyfluorfen (25 EC) as pre-emergence @ 0.15 kg a.i ha-1 followed by Quizalofop ethyl (10 EC) as post emergence @ 50 g a.i ha-1 at 15 DAT, T5 - Alachlor (50 EC) as pre- emergence @ 1.0 kg a.i ha-1 followed by hand weeding at 30 DAT, T6 - Alachlor (50 EC) as pre- emergence @ 1.0 kg a.i ha-1 followed by Quizalofop ethyl as post emergence @ 50 g a.i ha-1 at 15 DAT, T7 - Farmer practices (Hand weeding at 20 and 40 days after transplanting), T8- Unweeded control. The data on weed flora i.e number and dry weight was taken at 20, 40 and 60 DAT in two quadrates in each treatment: weed control efficiency (WEC) is calculated

$$WCE = \frac{DMC-DMT}{DMC} \times 100$$

Where, DMC= dry matter of weed in control plot
DMT= dry matter of weed in treatment plot
WCE= weed control efficiency
Weed index (WI) is calculated

$$WI = \frac{X - Y}{X} \times 100$$

Where, X = China aster yield from minimum weed competition plot
Y = China aster yield from the treated plot
WI= Weed index

Results and Discussion

Weed flora observed during the crop period of China aster was categorized as broad leaved weeds and grasses. Observations were recorded on weed count per m^2, dry weight of weeds at 20 days interval, weed control efficiency and weed index.

Among the grasses, *Cynodon dactylon* was predominant. Grasses viz., *Leptochloa chinensis*, *Cynodon dactylon* L. and *Dactyloctenium aegyptium* L. *Beauv* were predominant. Among BLWs, *Parthenium hysterophorus Argemone mexicana Cassia tora*, *Digera arvensis Forsk*, *Euphorbia hirta* L., *Phyllanthus* niriuri L. and *Tridax* proicumbensis L. and Tiribulus *terristres were* the major weeds.

Among the weed treatments, the minimum count of broad and grass leaved weeds were observed in alachlor @1.0 kg a.i ha-1 + hand weeding (3.6, 3.3, 6.3, 6.9, 10.8 and 10.9 g respectively) at 20, 40 and 60 DAT. Among the two varieties, Poornima recorded minimum count of broad and grass leaved weeds (4.9, 10.2, 9.9, 5.5, 23.1 and 13.0 g respectively) compared with variety Kamini. Interaction effects between the varieties, and weed control treatments reported that Poornima variety along with alachlor + hand weeding produced lowest broad and grass leaved weeds (3.2 and 2.8 g) followed by pendimethalin+ hand weeding (3.7, 6.2, 6.5, 10.0, 10.2 and 3.6 g).

The different weed control treatments influencing the broad and grass leaved weeds is presented in table 1. Irrespective of treatments, broad leaved weeds and grass weed populations were least in the earlier stages, and later on, it increased. Intensity of broad leaved weeds was more as compared to grass weeds in the early stages of crop growth which may be due to staggered germination of seeds, shorter duration of weeds and crop inhibitory effect on weeds. Kothari *et al.* (2002) [5] reported similar results in Rose scented geranium (*Pelargonium* spp.) where in pre-emergence application of pendimethalin @ 1.00 kg ha-1 highly effective to reducing weed density. Shalini and Patil (2006) [9] also reported similar results with alachlor and pendimethalin @ 1.0kg ha-1. Shalini and Patil (2006) [9] (pendimethalin @ 1.0 kg ha-1) was recorded zero weed population at all the stages of growth. All the weed control treatments recorded lower values of weed count of weeds as compared to control which recorded significantly higher weed count weeds at all the stages of crop growth.

The data pertaining to dry weight of broad and grass weeds at 20, 40 and 60 days after transplanting under different weed control treatments is presented in Table 2. The data indicated that significant differences were found in dry weight of weeds due to treatments at all the stages of crop growth. Alachlor@1.0 kg a.i ha-1+ hand weeding (0.5, 0.3, 2.7, 2.6, 4.2 and 4.0 g respectively) was superior than unweeded check which was inferior to rest of the weed control treatments. Poornima recorded minimum dry weight of broad and grass leaved weeds (2.1, 1.5, 5.3, 4.5 8.5 and 7.0 g respectively) compared with Kamini. Interaction effects between the varieties, and weed control treatments reported that Poornima variety along with alachlor+hand weeding produced minimum dry weight of broad and grass leaved weeds (0.5, 0.2,2.5, 2.1, 3.8 and 3.9g respectively). This was due to the dominance of some weeds which accumulated the biomass, suppressing the other and also the effectiveness of herbicide gets decreased with advanced growth of weed. However, dry weights of weeds were less even at later stages in case of treatments like alachlor+hand weeding and pendimethalin+hand weeding which were more effective than other treatments due to their effectiveness in controlling the weeds. Hand weeding treatment throughout the crop period was effective in reducing the weeds which clearly indicated that manual hand weeding was effective in checking the number and dry weight of weeds. However, this method was costly, since it was labor consuming and also time consuming. These results are in close conformity with Acharya *et al.* (2003) [1] who observed that pendimethalin @ 1.0 kg ha-1 recorded minimum dry weight of weeds in marigold. Manuja *et al.* (2005) [6] also reported lowest weed dry matter in gladiolus with application of pendimethalin @ 1.0 kg ha-1 and alachlor followed by Quizalofop ethyl.

The data on the of weed control efficiency (%) as influenced by different weed control treatments is furnished in table 3. Weed control efficiency followed similar trends as that of weed dry matter. Among all the treatments maximum weed control efficiency was recorded in alachlor @1.0 kg a.i ha-1 +hand weeding (90.3, 73.2 and 80.0% respectively). Among the two varieties, Poornima recorded highest weed control efficiency (57.9, 49.4 and 62.1% respectively) compared with Kamini. Interaction effects between the varieties, and weed control treatments reported that Poornima variety along with alachlor+hand weeding produced maximum weed control efficiency (90.1, 74.2 and 81.1% respectively). Lowest weed control efficiency was observed in unweeded control (0.0%). Similar results were also reported by Chawla (2008) in African marigold, Santhosh kumar (2010) [8] in rose and Solaiman (2008) in aster, Shalini and Patil (2006) [9] in gerbera, Sharadamma *et al.* (2002) [10] in crossandra and Sharma *et al.* (2009) [11] in onion. Further, the best weed control efficiency was observed with pendimethalin + hand weeding (Higher weed control efficiency under these treatments can be accounted to lower dry weight of weeds in

these treatments. The lowest weed control efficiency was observed in unweeded control due to poor or no control of weeds. All other treatments recorded comparatively higher weed control efficiency due to lower dry weight of weeds as compared to unweeded control.

From the table 3 it is evident that the flower yield (t ha-1) varied significantly among the weed control treatments, Significantly maximum flower yield of (5.1 t ha-1) was recorded in pendimethalin as pre emergence + hand weeding which was statistically superior over rest of the treatments. Among the two varieties, Kamini recorded maximum flower yield (4.4 t ha-1) compared with Poornima (3.2 t ha-1). Interaction effects between the varieties, and weed control treatments reported that Kamini variety along with pendimethalin as pre emergence + hand weeding was recorded maximum flower yield (6.0 t ha-1). This was due to fact that more number of flowers (t ha-1) were obtained in comparison to control treatment which yielded less due to higher weed count which resulted in higher competition of weeds with the crop plants which ultimately suppressed the growth and flowering of marigold. These results are in agreement with those reported by Shalini and Patil (2006) [9] in Gerbera with application pendimethalin @ 1.5 kg ha-1. Acharya *et al*. (2003) [1] observed with application of pendimethalin @ 1.0 kg ha-1 resulted maximum flower yield in African marigold. Das and Mishra (2005) [4] also reported similar results in African marigold.

The weed index computed is presented in table 5. Among all the treatments, pendimethalin + hand weeding showed lesser weed index due to higher yield of flowers which indicates that the losses are caused due to uncontrolled weed growth. Treatment pendimethalin with hand weeding followed by alachlor + hand weeding and hand weeding (0.0, 7.4 and 12.4%,) resulted in lower weed index.

Among the two varieties, Poornima recorded lowest weed index (22.8%) compared with Kamini (27.5%). Interaction effects between the varieties, and weed control treatments reported that Kamini variety along with pendimethalin +hand weeding treatment minimum weed index (0.0%). Among the other treatments, alachlor + hand weeding and pendimethalin + hand weeding showed lesser weed index due to higher yield of flowers. Similar results were also obtained by Shalini and Patil (2006) [9] in Gerbera. Dungarwal *et al*. (2002) observed that application of pendimethalin @ 1.0 kg ha-1 recorded lower weed index in fenugreek, coriander (Meena and Mehta, 2009) [7] and in crossandra (Sharadamma *et al*. 2002) [10]. Channappagoudar and Biradar (2007) [2] reported that pendimethalin in combination with hand weeding recorded less weed index compared to other treatments.

Table 1: Effect of weed control treatments on weed count of broad leaved weeds m^{-2} in China aster

Treatments	Days after transplanting								
	20			40			60		
	Kamini (V_1)	Poornima (V_2)	Treatment mean	Kamini (V_1)	Poornima (V_2)	Treatment mean	Kamini (V_1)	Poornima (V_2)	Treatment mean
T_1	2.1 (3.7)	2.3 (4.3)	2.2 (4.0)	2.6 (6.5)	2.9 (6.6)	2.7 (6.6)	3.6 (12.2)	3.8 (13.7)	3.7 (12.9)
T_2	2.2 (4.6)	2.3 (4.7)	2.4 (4.8)	2.8 (7.9)	3.0 (8.1)	2.9 (7.9)	4.1 (16.3)	4.2 (17.4)	4.3 (16.7)
T_3	2.5 (4.9)	2.6 (5.3)	2.4 (5.1)	3.4 (11.1)	3.5 (11.9)	3.6 (11.5)	4.6 (20.5)	4.7 (21.3)	4.8 (20.9)
T_4	2.4 (4.7)	2.3 (5.0)	2.5 (4.8)	3.1 (9.0)	3.2 (9.1)	3.3 (9.1)	4.4 (18.7)	4.5 (19.6)	4.6 (19.2)
T_5	2.0 (3.2)	2.2 (4.0)	2.1 (3.6)	2.5 (6.2)	2.6 (6.3)	2.7 (6.3)	3.3 (10.0)	3.5 (11.5)	3.4 (10.8)
T_6	2.2 (4.5)	2.3 (4.6)	2.4 (4.6)	2.9 (7.8)	3.0 (8.0)	2.8 (7.9)	4.1 (16.2)	4.2 (17.3)	4.3 (16.7)
T_7	2.5 (6.0)	2.6 (6.3)	2.3 (6.1)	3.7 (13.5)	3.8 (13.7)	3.9 (13.6)	5.1 (25.3)	5.5 (29.6)	5.3 (27.5)
T_8	2.8 (7.9)	2.9 (7.6)	3.0 (7.8)	4.6 (20.4)	4.6 (20.5)	4.6 (20.5)	8.2 (67.2)	8.3 (68.4)	8.2 (67.8)
Variety M ean	2.5 (4.9)	2.4 (5.2)		3.3 (10.2)	3.3 (10.5)		4.9 (23.1)	5.0 (24.3)	

	SEm ±	CD at 5%	SEm ±	CD at 5%	SEm ±	CD at 5%
Variety (V)	0.01	0.03	0.07	0.21	0.08	0.69
Treatment (T)	0.03	0.09	0.06	0.18	0.16	0.47
Interaction (VxT)	0.04	0.12	0.05	0.17	0.23	0.69

Data transformed to square root transformation. Figures in parenthesis are indicating original values

Table 2: Effect of weed control treatments on dry weight of broad leaved weeds m^{-2} in China aster

Treatments	Days after transplanting								
	20		Treatment mean	40		Treatment mean	60		Treatment mean
	Kamini (V_1)	Poornima (V_2)		Kamini (V_1)	Poornima (V_2)		Kamini (V_1)	Poornima (V_2)	
T_1	1.3 (0.7)	1.4 (0.8)	1.2 (0.8)	1.9 (2.7)	2.1 (3.8)	2.0 (3.2)	2.2 (4.0)	2.4 (5.2)	2.3 (4.6)
T_2	1.5 (1.5)	1.6 (1.8)	1.4 (1.6)	2.6 (4.8)	2.4 (5.1)	2.3 (4.9)	2.7 (6.5)	2.9 (7.4)	2.8 (6.9)
T_3	1.9 (3.0)	2.1 (3.2)	2.0 (3.1)	2.9 (6.3)	2.8 (7.3)	2.7 (6.8)	3.0 (8.3)	3.2 (9.2)	3.1 (8.7)
T_4	1.7 (2.2)	1.9 (2.3)	1.8 (2.2)	2.5 (5.7)	2.7 (6.2)	2.6 (5.9)	2.8 (7.4)	3.0 (8.6)	2.9 (8.0)
T_5	1.4 (0.5)	1.3 (0.6)	1.2 (0.5)	1.8 (2.5)	2.0 (2.9)	1.9 (2.7)	2.1 (3.8)	2.3 (4.7)	2.2 (4.2)
T_6	1.5 (1.3)	1.7 (1.6)	1.6 (1.4)	2.0 (3.3)	2.3 (4.3)	2.1 (3.8)	2.5 (5.3)	2.7 (6.4)	2.6 (5.8)
T_7	2.3 (3.7)	2.2 (3.9)	2.1 (3.8)	2.9 (7.7)	3.1 (8.9)	3.0 (8.3)	3.9 (13.7)	3.9 (14.5)	3.8 (14.1)
T_8	2.4 (4.1)	2.3 (4.4)	2.2 (4.2)	3.2 (9.6)	3.3 (10.5)	3.1 (10.0)	4.7 (19.7)	4.6 (20.6)	4.5 (20.1)
Variety Mean	1.7 (2.1)	1.8 (2.3)		2.4 (5.3)	2.6 (6.1)		3.0 (8.5)	3.1 (9.5)	

	SEm ±	CD at 5%	SEm ±	CD at 5%	SEm ±	CD at 5%
Variety (V)	0.05	0.16	0.02	0.06	0.05	0.16
Treatment (T)	0.11	0.32	0.04	0.12	0.11	0.32
Interaction (VxT)	0.15	N.S	0.05	0.17	0.16	0.48

Data transformed to square root transformation. Figures in parenthesis are indicating original values.

Table 3: Effect of weed control treatments on weed control efficiency (%) in China aster

Treatments	Weed control efficiency (%)								
	20		Treatment mean	40		Treatment mean	60		Treatment mean
	Kamini (V_1)	Poornima (V_2)		Kamini (V_1)	Poornima (V_2)		Kamini (V_1)	Poornima (V_2)	
T_1	85.1	86.2	85.6	71.5	63.8	67.6	77.4	74.1	75.7
T_2	63.5	58.7	61.1	54.7	49.5	52.1	65.1	63.6	64.3
T_3	31.1	31.2	31.1	34.7	25.0	29.8	54.5	53.7	54.1
T_4	45.9	46.2	46.0	43.6	36.7	40.1	61.1	57.4	59.2
T_5	90.1	90.5	90.3	74.2	72.3	73.2	81.1	78.3	80.0
T_6	68.9	65.1	67.0	67.8	56.9	62.3	69.1	67.1	68.1
T_7	20.2	20.1	20.1	23.1	13.8	18.4	27.1	28.1	27.6
T_8	-	-		-	-		-	-	
Variety Mean	57.9	56.8		49.4	42.3		62.1	60.3	

Data was not analyzed by statistically

Table 4: Effect of weed control treatments on flower yield t ha-1 in China aster

Treatments	Flower yield t ha^{-1}		Treatment mean
	Kamini (V_1)	Poornima (V_2)	
T_1	6.0	4.2	5.1
T_2	4.6	3.4	4.0
T_3	3.8	2.7	3.3
T_4	3.2	2.5	2.9
T_5	5.4	3.9	4.7
T_6	4.1	3.1	3.6
T_7	5.1	3.7	4.4
T_8	2.6	1.9	2.3
Variety mean	4.4	3.2	
	SE m ±		CD at 5%
Variety(V)	0.04		0.14
Treatment (T)	0.07		0.21
Interaction (VxT)	0.06		0.18

Table 5: Effect of weed control treatments on weed index (%) in China aster.

Treatments	Weed index (%)		Treatments mean
	Kamini (V_1)	Poornima (V_2)	
T_1	0.0	0.0	0.0
T_2	23.3	17.1	20.2
T_3	36.6	34.1	35.4
T_4	46.7	39.0	42.9
T_5	10.0	4.8	7.4
T_6	31.6	24.4	28.0
T_7	15.0	9.7	12.4
T_8	56.6	53.6	55.1
Variety Mean	27.5	22.8	

DAT= Days after transplanting
PE = Pre-emergence
POE = Post-emergence

Conclusions

The treatment alachlor (50EC) @ 1.0 kg a.i ha-1 at all the crop growth stages followed by hand weeding recorded lowest weed density and dry weight of weeds. The highest weed control efficiency and least weed index was noticed in pendimethalin (30EC) @ 1.0 kg a.i ha-1 followed by hand weeding. However, unweeded control recorded highest weed count, dry weight, maximum weed index and lower weed control efficiency. Among the two varieties, minimum weed count, dry weight and maximum weed control efficiency noticed in Kamini, while Poornima recorded minimum weed index. The interaction between treatments and varieties was found significant at 20,40 and 60 days intervals at DAT. Weed count, dry weight of weeds and weed control efficiency were noticed with alachlor (50EC) @ 1.0 kg a.i ha-1 + hand weeding except weed index was minimum recorded with pendimethalin (30EC) @ 1.0 kg a.i ha-1 + hand weeding.

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