



E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(1): 126-131
Received: 18-11-2017
Accepted: 22-12-2017

Tasmiya Kowser
Department of Agronomy, UAS,
Raichur, Karnataka, India

AS Halepyati
Dean Agri, College of
Agriculture, Raichur,
Karnataka, India

BM Chittapur
Chief Scientific Officer,
Agricultural Extension
Education Centre, Koppal, UAS
Raichur, Karnataka, India

AS Channabasavanna
Professor of Agronomy,
Department of Agronomy, UAS
Raichur, Karnataka, India

I Shanker Goud
Directorate of Research, UAS
Raichur, Karnataka, India

Basave Gowda
Special Officer Seeds, UAS
Raichur, Karnataka, India

Correspondence
Tasmiya Kowser
Department of Agronomy, UAS,
Raichur, Karnataka, India

Phyto toxicity and weed control efficiency of castor (*Ricinus communis* L.) as influenced by weed management practices

Tasmiya Kowser, AS Halepyati, BM Chittapur, AS Channabasavanna, I Shanker Goud and Basave Gowda

Abstract

Field experiment on effect of different weed management practices in castor (*Ricinus communis* L.) was conducted at the Agricultural College Farm, UAS, Raichur, during *kharif* 2015 and 2016 in the clay soil. Pooled mean indicated that, application of pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ fb imazethapyr (10% SL) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS was very effective in controlling all types of weeds (3.23, 3.85, 4.07 and 6.54 m², respectively) and dry weight of weeds (0.74, 0.88, 1.12, 1.82 g m²) at 20, 40, 60 DAS and at harvest. Significantly higher weed control efficiency (72.66%), bean yield (1202 kg ha⁻¹), stalk yield (2718 kg ha⁻¹) and harvest index (30.66 %) were recorded over unweeded check. Application of clomazone (20% EC) @ 750 g a.i. ha⁻¹ as a pre emergent revealed minor phyto toxicity which ranged between 2.0 to 1.0. Hence, sequential application of pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ fb imazethapyr (10% SL) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS is a best weed control method as it recorded higher harvest index whereas application of post emergent herbicides alone was not much effective for the control of weeds and to obtain higher bean yield.

Keywords: Weed, Pre emergent, Post emergent, Intercultivation, Phyto toxicity

Introduction

Among oilseeds, castor (*Ricinus communis* L.) is the most primitive non-edible crop belonging to the family Euphorbiaceae grown under tropical, sub-tropical and temperate regions. India ranks first with respect to area and production of castor. India's share in the world's area and production of castor is 68 and 85 per cent, respectively (Anon, 2016)^[2]. As a non-edible and industrial crop, castor plays an important role in Indian economy because of better export potential. During 2014-15, the country earned a foreign exchange worth of 4364.33 crores through export of castor oil and cake.

Rapid deprivation of available nutrients leads to faster growth of weeds than the castor crop. Hence, weed management during the early period of castor is one of the most critical factor for successful production of castor bean. Manual weeding is effective method of weed control. However, it is not advantageous as it is costlier, time consuming and labour scarcity. In such a situation, the chemical weed control becomes an alternative method for weed control. Preferably the application of pre-emergent chemical herbicide is a vital tool for effective and cost efficient weed control in castor, which encounters weed competition from the day of germination. Herbicides used alone or in combination with other weed control method reduced the crop-weed competition and the risk of weeds growing in adverse weather or soil condition that would hinder the use of more traditional weed control methods (Patel and Virdia, 2011)^[17]. Alachlor herbicide applied as pre-emergence was effective against *Amaranthus* in castor (Chenault *et al.*, 1969)^[5].

Research Procedure

A field experiment was conducted during *kharif* 2015-16 and 2016-17 at the Agricultural College Farm, University of Agricultural Sciences, Raichur, Karnataka, India. Total 14 weed control treatments were assigned in Randomized Block Design with three replications. The castor hybrid DCH-177 was sown at 90 x 60 cm spacing. The soil of the experimental field was clayey in texture and showed low, medium and high rating for available nitrogen (226.00 kg ha⁻¹), phosphorus (29.4 kg ha⁻¹) and potassium (320.00 kg ha⁻¹), respectively. The soil was found alkaline in respect of pH (8.3) and normal electric conductivity (0.32 ds m⁻¹). Pendimethalin, clomazone and Alachlor was sprayed next DAS. Chlorimuron ethyl sprayed at 15-20 DAS as early post-emergent quizalofop-ethyl and imazethapyr was sprayed at 25-30

DAS as a post emergent herbicide and intercultivation was done at 60 DAS. The weeds were counted at 20, 40, 60 DAS and at harvest. Monocot and dicot weeds present within 0.5 m x 0.5 m random quadrant in each net plot were counted separately and expressed as number of weeds per m² similarly weed dry weight was taken. The weed control efficiency expresses the percentage reduction in weed population due to weed management practices over control. It is worked out by using weed population present in control and treated plots (Devasenapathy *et al.*, 2008) [7].

$$\text{WCE} = \frac{\text{WPC} - \text{WPT}}{\text{WPC}} \times 100$$

Where,

WPC=Weed population (No. m⁻²) in unweeded control plot

WPT= Weed population (No. m⁻²) in treated plot

Harvest index was calculated by the formula given by Donald (1962) [8].

Results and Discussion

Weeds are the major impediment to castor production through their ability to compete for resources and their impact on product quality. Weed infestation is one of the major constraints for low productivity of castor. Results revealed minor phytotoxicity with clomazone (20% EC) @ 750 g a.i. ha⁻¹ as a pre emergent which ranged between 2.0 to 1.0 (Table 1 and plate 1). Although some early symptoms of toxicity may be found for castor, the plants were subsequently recovered and the product is considered to be selective in doses of up to 750 g ha⁻¹. Similar results were reported by Maciel (2007) [15], Sofiatti (2012) [21, 22] and Silva (2010) [1] have also found very mild symptoms of intoxication. However, with respect to growth characteristics (plants height) evaluated at the time of harvesting, it was not possible to confirm differences among treatments. Such little phytotoxicity is common in many PRE chemicals at the rates tested due to tender nature of emerging crop seedlings, slow assimilation of chemicals by crop plants though described as selective and harmful nature of pre-emergent herbicides and their longer persistence in soil.

The effect of pre emergent herbicides was very effective at early stage and among the different weed control practices at 20 DAS, application of pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ fb imazethapyr (10% SL) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS was very effective in controlling all types of weeds (3.23/ m²) over weedy check (7.85/ m²) (Table 2). These might be due to residual effect of pre-emergent herbicides resulted in remarkable reduction in weed population during critical period of crop growth. These findings are confined with those reported by Bhagriya (2006) [4] in green gram, Gamit (2009) [9] in mustard and Patel and Virdia (2011) [17] in castor.

However, from 40 DAS onwards the total weed count recorded with the application of pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ fb imazethapyr (10% SL) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS (3.85, 4.07 and 6.54, respectively) at 40, 60 DAS and at harvest, respectively) was lower and it was followed by application of pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ + IC at 30 and 60 DAS (4.04, 4.20 and 6.85, respectively at 40, 60 DAS and at harvest), pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ fb quizalofop-ethyl (5% EC) @ 50 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS (4.12, 4.28 and 6.99, respectively at 40, 60 DAS and at harvest) and clomazone

(20% EC) @ 750 g a.i. ha⁻¹ fb imazethapyr (10% SL) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS (5.42, 5.54 and 7.41, respectively at 40, 90 DAS and at harvest) over weedy check (9.35, 10.39 and 12.47, respectively at 40, 60 DAS and at harvest, respectively) the possibility of applying herbicides in pre-emergence, alone or in combination, followed by post emergence applications, alongwith the intercultural operations can be a strategy to control early and late emerging weeds. Similar results were also reported by Costa *et al.* (2015) [6].

In this instance, because pendimethalin acts by inhibiting cell division and cell elongation thereby it resulted in weeds death shortly after germination. Whereas, imazethapyr which inhibits branched chain amino acid synthesis (ALS or AHAS), by reducing the levels of valine, leucine and isoleucine led to disruption of protein and DNA synthesis, and thereby, finally caused death of weeds shortly after application. Hence, weed density in this treatment was less when compared to rest of the treatments. These results are in agreement with experiments of Younesabadi *et al.* (2014) and Godra and Deshmukh (2002) [11] in soybean, Ram *et al.* (2011) [19] in field pea, and Ram *et al.* (2012) [20] in rajmash.

The similar trend as that of weed count was followed with total dry weight of weeds. Herbicide application in sequence along with the intercultural operation was found to be better than single application of herbicides. Application of pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ fb imazethapyr (10% SL) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS recorded significantly lower total dry weight of weeds (0.74, 0.88, 1.12 and 1.82/m², respectively) compared to weedy check (1.34, 1.58, 1.87 and 2.40 g/m², respectively) at 20, 40, 60 DAS and at harvest, respectively (Table 3). The next best treatments with respect to total dry weight of weeds were application of pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ + IC at 30 and 60 DAS (0.79, 1.01, 1.18 and 1.84 g/m², respectively), pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ fb quizalofop-ethyl (5% EC) @ 50 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS (0.80, 1.08, 1.25 and 1.85 g/m², respectively) and clomazone (20% EC) @ 750 g a.i. ha⁻¹ fb imazethapyr (10% SL) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS (1.00, 1.10, 1.28 and 1.88 g/m², respectively) at 20, 40, 60 and at harvest. Similar results were reported by Kaneria and Patel (1994) and Bhadoriya and Chauhan (1995) in mustard.

Among various herbicide treatments, the herbicide treatments such as T₉, T₁, T₇, T₁₂, and T₃ recorded significantly lower weed dry weight and were comparable to that of standard check which resulted into lowest weed counts and finally reduced the dry weight of weeds at harvest. This could be attributed to effective control of weeds by use of pre and post emergent herbicides in sequence along with the intercultural operations which led to rapid growth of castor crop as indicated by taller plants and more number of branches per plant, greater crop canopy which did not allow the weeds to grow vigorously due to smothering effect. The various workers Jain *et al.* (2006) [12], Patel and Virdia (2011) [17] and Tomer and Tomer (2014) [23] also reported significantly lower weed dry weight when the herbicides were used in sequence. The variations in weed dry weight could be attributed to variations in weed population (grassy, sedges and broad leaved weeds).

The crop performance in terms of growth and yield has direct relationship with the weed control efficiency. The crop performance in terms of growth and yield has direct relationship with the weed control efficiency. The weed control efficiency determined from weed population was significant at harvest. Weed free check recorded maximum

and weedy check showed the minimum weed control efficiency. Pooled data at harvest, states that the sequential application of pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ fb imazethapyr (10% SL) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS (72.66 %), pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ + IC at 30 and 60 DAS (70.04 %) and pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ fb quizalofop-ethyl (5% EC) @ 50 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS (68.79 %) (Table 4) were the next best treatments recorded higher weed control efficiency indicating that the effect of sequential application of pre fb post emergent along with the intercultural operation helped in maintaining higher weed control efficiency at harvest. This might be due to effect of herbicides which resulted in remarkable reduction in weed population and ultimately low dry weight of weeds observed under these treatments were responsible for higher weed control efficiency. These results are confirmed by those reported by Gill *et al.* (2002) [10] and Patel and Virdia (2011) [17].

The data revealed that significantly higher bean yield of 1268 kg ha⁻¹ and stalk yield of 2783 kg ha⁻¹ were recorded in weed-free check (Table 4). The higher bean yield in weed-free check was mainly due to the complete elimination of weed competition for growth resources during the critical stage of crop-weed competition which enabled better plant growth. Among the herbicidal treatments, pendimethalin (38.7% CS)

@ 1000 g a.i. ha⁻¹ fb imazethapyr (10% SL) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS recorded higher bean yield (1202 kg ha⁻¹) and straw yield (2718 kg ha⁻¹) as a consequence of enhanced growth and yield attributes, due to improved WCE (72.66% at harvest). While, the lowest bean and stalk yield was obtained in unweeded check (707 and 2193 kg ha⁻¹, respectively). In unweeded check the competition from weeds prevailed for the entire season and hence reduced the bean yield. This gives the clear indication that, under scarcity of labour, use of sequential application of herbicide could be followed as an alternative method of weed control. Bean yield was closely associated with stalk yield which followed similar trend. The above results are in accordance with the findings of Malik *et al.* (2006), Khedkar *et al.* (2009), Pratap Singh *et al.* (2010) and Sofiatti *et al.* (2012) [21, 22]. Harvest index was significantly higher with weed free check (31.30 %) but it was found to be on par with the application of pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ fb imazethapyr (10% SL) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS (30.66 %), pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ + IC at 30 and 60 DAS (30.16 %) and pendimethalin (38.7% CS) @ 1000 g a.i. ha⁻¹ fb quizalofop-ethyl (5% EC) @ 50 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS (29.08 %). Significantly lower harvest index was recorded in weedy check (24.36 %).



Plate 1: Phyto toxicity of clomazone (20% EC) @ 750 g a.i. ha⁻¹ pre emergent herbicide

Table 1: Crop phytotoxicity ratings due to pre and post-emergent herbicides in castor

Treatment	Crop phytotoxicity ratings				
	10 DAS	15 DAS	20 DAS	25 DAS	30 DAS
Pendimethalin 38.7% CS @ 1000 g a.i. ha ⁻¹ (PRE)	-	-	-	-	-
Alachlor 50% EC @ 1000 g a.i. ha ⁻¹ (PRE)	-	-	-	-	-
Clomazone 20% EC @ 750 g a.i. ha ⁻¹ (PRE)	2.0	1.0	0.0	0.0	0.0
Quizalofop-ethyl 5% EC @ 50 g a.i. ha ⁻¹ (POE)	-	-	-	-	-
Chlorimuron ethyl 25% WP @ 15 g a.i. ha ⁻¹ (EPOE)	-	-	-	-	-
Imazethapyr 10% SL @ 75 g a.i. ha ⁻¹ (POE)	-	-	-	-	-

Table 2: Total weed count per m² at different growth stages of castor as influenced by weed management practices

Treatment	Total weed count (No. m ²)											
	20 DAS			40 DAS			60 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T ₁	3.29 (10.33)	3.39 (10.97)	3.34 (10.65)	3.99 (15.40)	4.10 (16.28)	4.04 (15.84)	4.11 (16.40)	4.28 (17.87)	4.20 (17.13)	6.81 (45.88)	6.88 (46.88)	6.85 (46.38)
T ₂	4.20 (17.15)	4.25 (17.57)	4.23 (17.36)	6.01 (35.60)	6.13 (37.12)	6.07 (36.36)	6.09 (36.58)	6.22 (38.27)	6.15 (37.42)	7.75 (59.50)	7.90 (61.88)	7.82 (60.69)
T ₃	5.04 (24.91)	5.12 (25.71)	5.08 (25.31)	5.58 (30.64)	5.73 (32.33)	5.65 (31.49)	5.75 (32.66)	5.89 (34.33)	5.82 (33.49)	7.55 (56.55)	7.66 (58.22)	7.61 (57.38)
T ₄	7.20 (51.43)	7.35 (53.65)	7.28 (52.54)	6.74 (44.97)	6.83 (46.22)	6.79 (45.59)	6.86 (46.55)	7.01 (48.65)	6.93 (47.60)	9.08 (81.89)	9.20 (84.22)	9.14 (83.06)
T ₅	7.30 (52.83)	7.42 (54.68)	7.36 (53.76)	6.96 (47.92)	7.05 (49.25)	7.00 (48.58)	7.07 (49.47)	7.21 (51.62)	7.14 (50.54)	9.47 (89.19)	9.61 (91.85)	9.54 (90.52)
T ₆	6.94 (47.67)	7.08 (49.67)	7.01 (48.67)	6.50 (41.80)	6.63 (43.47)	6.57 (42.63)	6.60 (43.13)	6.73 (44.80)	6.67 (43.97)	8.80 (76.88)	8.92 (79.00)	8.86 (77.94)
T ₇	3.43 (11.25)	3.50 (11.75)	3.46 (11.50)	4.06 (16.00)	4.17 (16.93)	4.12 (16.47)	4.21 (17.25)	4.35 (18.45)	4.28 (17.85)	6.96 (47.92)	7.01 (48.67)	6.99 (48.29)
T ₈	3.54 (12.00)	3.63 (12.67)	3.58 (12.33)	6.08 (36.42)	6.35 (39.88)	6.22 (38.15)	6.30 (39.13)	6.39 (40.33)	6.34 (39.73)	7.93 (62.40)	8.09 (65.07)	8.01 (63.73)
T ₉	3.19 (9.67)	3.27 (10.17)	3.23 (9.92)	3.81 (14.02)	3.89 (14.76)	3.85 (14.39)	3.97 (15.33)	4.16 (16.87)	4.07 (16.10)	6.45 (41.17)	6.63 (43.48)	6.54 (42.33)
T ₁₀	5.12 (25.73)	5.17 (26.23)	5.15 (25.98)	5.74 (32.44)	5.85 (33.77)	5.80 (33.10)	5.94 (34.76)	6.09 (36.57)	6.01 (35.67)	7.60 (57.33)	7.74 (59.33)	7.67 (58.33)
T ₁₁	5.17 (26.25)	5.21 (26.67)	5.19 (26.46)	6.20 (37.93)	6.46 (41.18)	6.33 (39.56)	6.36 (39.94)	6.49 (41.69)	6.43 (40.81)	8.04 (64.17)	8.22 (67.17)	8.13 (65.67)
T ₁₂	4.92 (23.75)	5.01 (24.58)	4.97 (24.17)	5.34 (27.98)	5.50 (29.88)	5.42 (28.93)	5.46 (29.42)	5.61 (31.08)	5.54 (30.25)	7.34 (53.40)	7.47 (55.40)	7.41 (54.40)
T ₁₃	7.81 (60.48)	7.88 (61.63)	7.85 (61.06)	9.29 (85.85)	9.40 (87.92)	9.35 (86.89)	10.32 (106.00)	10.45 (108.82)	10.39 (107.41)	12.41 (153.67)	12.52 (156.33)	12.47 (155.00)
T ₁₄	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
S.Em.±	0.17	0.19	0.17	0.08	0.10	0.08	0.11	0.14	0.11	0.06	0.10	0.07
C.D. at 5%	0.49	0.55	0.49	0.23	0.29	0.25	0.31	0.41	0.33	0.18	0.29	0.19

Figures in the parentheses indicate the original value, data subjected for transformation using $\sqrt{x+0.5}$, where x is weed count

T₁: Pendimethalin 38.7% CS @ 1000 g a.i. ha⁻¹ T₈: Pendimethalin 38.7% CS @ 1000 g a.i. ha⁻¹ (PRE) fb Chlorimuron ethyl 25% (PRE) + IC at 30 and 60 DAS
WP @ 15 g a.i. ha⁻¹ (EPOE) at 15-20 DAS + IC at 60 DAS

T₂: Alachlor 50% EC @ 1000 g a.i. ha⁻¹ (PRE) + ICT₉: Pendimethalin 38.7% CS @ 1000 g a.i. ha⁻¹ (PRE) fb Imazethapyr 10% SL @ 75 g a.i. ha⁻¹ (POE) at 30 DAS + IC at 60 DAS

T₃: Clomazone 20% EC @ 750 g a.i. ha⁻¹ (PRE) +T₁₀: Clomazone 20% EC @ 750 g a.i. ha⁻¹ (PRE) fb Quizalofop-ethyl 5% EC @ 50 g a.i. ha⁻¹ (POE) at 30 DAS + IC at 60 DAS

T₄ Quizalofop-ethyl 5% EC @ 50 g a.i. ha⁻¹ (POE) T₁₁: Clomazone 20% EC @ 750 g a.i. ha⁻¹ (PRE) fb Chlorimuron ethyl 25% WP @ 15 g a.i. ha⁻¹ (EPOE) at 15-20 DAS + IC at 60 DAS

T₅: Chlorimuron ethyl 25% WP @ 15 g a.i. ha⁻¹ T₁₂: Clomazone 20% EC @ 750 g a.i. ha⁻¹ (PRE) fb Imazethapyr (10% SL) (EPOE) at 15-20 DAS + IC at 60 DAS
(POE) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS

T₆: Imazethapyr 10% SL @ 75 g a.i. ha⁻¹ (POE) at T₁₃: Weedy check
30 DAS + IC at 60 DAS

T₇: Pendimethalin 38.7% CS @ 1000 g a.i. ha⁻¹ T₁₄: Weed free check
(PRE) fb Quizalofop-ethyl (5% EC) (POE) @ 50 g
a.i. ha⁻¹ at 30 DAS + IC at 60 DAS

Table 3: Dry weight of weeds per m² at different growth stages of castor as influenced by weed management practices

Treatment	Dry weight of weeds (g m ²)											
	20 DAS			40 DAS			60 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T ₁	0.78 (4.00)	0.80 (4.38)	0.79 (4.19)	1.00 (8.05)	1.02 (8.55)	1.01 (8.30)	1.16 (12.55)	1.20 (13.97)	1.18 (13.26)	1.83 (66.18)	1.85 (68.04)	1.84 (67.11)
T ₂	1.13 (11.50)	1.14 (11.92)	1.14 (11.71)	1.18 (13.21)	1.20 (14.00)	1.19 (13.60)	1.36 (20.67)	1.38 (22.18)	1.37 (21.43)	1.93 (84.00)	1.94 (85.58)	1.94 (84.79)
T ₃	1.00 (8.00)	1.01 (8.33)	1.01 (8.17)	1.15 (12.15)	1.17 (12.82)	1.16 (12.48)	1.29 (17.42)	1.32 (19.08)	1.31 (18.25)	1.90 (76.85)	1.90 (78.37)	1.90 (77.61)
T ₄	1.28 (17.00)	1.31 (18.55)	1.30 (17.78)	1.26 (16.08)	1.29 (17.33)	1.27 (16.71)	1.54 (32.88)	1.56 (34.10)	1.55 (33.49)	2.08 (118.33)	2.09 (120.33)	2.08 (119.33)
T ₅	1.28 (17.25)	1.33 (19.33)	1.31 (18.29)	1.29 (17.39)	1.30 (17.89)	1.29 (17.64)	1.60 (38.00)	1.61 (38.67)	1.61 (38.33)	2.09 (120.48)	2.10 (123.48)	2.09 (121.98)
T ₆	1.27 (16.50)	1.28 (17.17)	1.27 (16.83)	1.22 (14.72)	1.24 (15.33)	1.23 (15.03)	1.51 (30.00)	1.52 (30.85)	1.51 (30.43)	2.07 (115.48)	2.08 (117.00)	2.07 (116.24)
T ₇	0.79 (4.23)	0.81 (4.52)	0.80 (4.38)	1.06 (9.45)	1.09 (10.45)	1.08 (9.95)	1.23 (15.15)	1.26 (16.34)	1.25 (15.74)	1.85 (68.18)	1.86 (70.70)	1.85 (69.44)
T ₈	0.81 (4.50)	0.84 (4.88)	0.83 (4.69)	1.21 (14.33)	1.23 (15.00)	1.22 (14.67)	1.42 (24.33)	1.45 (26.33)	1.44 (25.33)	2.01 (100.00)	2.01 (101.33)	2.01 (100.67)
T ₉	0.72 (3.25)	0.75 (3.67)	0.74 (3.46)	0.86 (5.33)	0.89 (5.83)	0.88 (5.58)	1.11 (10.85)	1.14 (11.85)	1.12 (11.35)	1.81 (63.00)	1.82 (64.62)	1.82 (63.81)
T ₁₀	1.02 (8.43)	1.03 (8.68)	1.02 (8.56)	1.18 (13.17)	1.20 (13.83)	1.19 (13.50)	1.34 (20.00)	1.39 (22.67)	1.37 (21.33)	1.92 (81.85)	1.93 (83.03)	1.93 (82.44)
T ₁₁	1.05 (9.17)	1.06 (9.58)	1.06 (9.38)	1.22 (14.61)	1.24 (15.28)	1.23 (14.95)	1.44 (25.67)	1.46 (26.82)	1.45 (26.24)	2.03 (105.22)	2.04 (106.88)	2.03 (106.05)
T ₁₂	0.99 (7.77)	1.01 (8.18)	1.00 (7.98)	1.09 (10.38)	1.12 (11.05)	1.10 (10.72)	1.26 (16.28)	1.30 (17.80)	1.28 (17.04)	1.87 (72.67)	1.88 (74.67)	1.88 (73.67)
T ₁₃	1.31 (18.33)	1.37 (21.33)	1.34 (19.83)	1.56 (34.00)	1.60 (38.00)	1.58 (36.00)	1.85 (68.83)	1.88 (74.00)	1.87 (71.42)	2.40 (250.00)	2.40 (250.00)	2.40 (250.00)
T ₁₄	0.30 (0.00)	0.30 (0.00)	0.30 (0.00)	0.30 (0.00)	0.30 (0.00)	0.30 (0.00)	0.30 (0.00)	0.30 (0.00)	0.30 (0.00)	0.30 (0.00)	0.30 (0.00)	0.30 (0.00)
SE.m.±	0.08	0.08	0.06	0.08	0.10	0.08	0.08	0.05	0.08	0.07	0.06	0.05
C.D. at 5%	0.22	0.22	0.18	0.24	0.28	0.24	0.24	0.14	0.23	0.21	0.18	0.15

Figures in the parentheses indicate the original value, data subjected for transformation using $\log(x+2)$, where x is weed count

T₁: Pendimethalin 38.7% CS @ 1000 g a.i. ha⁻¹ (PRE)T₈: Pendimethalin 38.7% CS @ 1000 g a.i. ha⁻¹ (PRE) fb Chlorimuron ethyl 25% WP @ 15 g a.i. ha⁻¹ (EPOE) at 15-20 DAS + IC at 60 DAS
T₂: Alachlor 50% EC @ 1000 g a.i. ha⁻¹ (PRE) + IC at 30 and 60 DAS
T₃: Clomazone 20% EC @ 750 g a.i. ha⁻¹ (PRE) + ICT₁₀: Clomazone 20% EC @ 750 g a.i. ha⁻¹ (PRE) fb Quiazalofop-ethyl 5% EC @ 50 g a.i. ha⁻¹ (POE) at 30 DAS + IC at 60 DAS
T₄: Quiazalofop-ethyl 5% EC @ 50 g a.i. ha⁻¹ (POE) at 30 DAS + IC at 60 DAS
T₅: Chlorimuron ethyl 25% WP @ 15 g a.i. ha⁻¹ (EPOE) at 15-20 DAS + IC at 60 DAS
T₆: Imazethapyr 10% SL @ 75 g a.i. ha⁻¹ (POE) at 30 DAS + IC at 60 DAS
T₇: Pendimethalin 38.7% CS @ 1000 g a.i. ha⁻¹ (PRE)T₁₂: Clomazone 20% EC @ 750 g a.i. ha⁻¹ (PRE) fb Imazethapyr (10% SL) (POE) @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS
T₁₃: Weedy check
T₁₄: Weed free check
fb Quiazalofop-ethyl (5% EC) (POE) @ 50 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS

Table 4: Weed control efficiency, Bean yield, straw yield and harvest index of castor as influenced by weed management practices

Treatment	Weed control efficiency (%) at harvest			Bean yield (kg ha ⁻¹)			Stalk yield (kg ha ⁻¹)			Harvest index (%)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T ₁	70.08	70.00	70.04	1183	1157	1170	2714	2704	2709	30.36	29.97	30.16
T ₂	61.21	60.41	60.80	933	919	926	2611	2592	2602	26.33	26.17	26.25
T ₃	63.14	62.75	62.95	1032	1022	1027	2662	2652	2657	27.94	27.82	27.88
T ₄	46.61	46.11	46.37	865	840	846	2558	2452	2505	25.27	25.52	25.25
T ₅	41.86	41.18	41.52	840	830	814	2540	2440	2490	24.85	25.38	24.64
T ₆	49.87	49.45	49.67	893	848	870	2574	2472	2523	25.76	25.54	25.64
T ₇	68.76	68.83	68.79	1141	1071	1106	2708	2685	2697	29.64	28.51	29.08
T ₈	59.31	58.38	58.85	919	871	895	2596	2490	2543	26.15	25.91	26.03
T ₉	73.17	72.16	72.66	1217	1186	1202	2725	2710	2718	30.87	30.44	30.66
T ₁₀	62.63	62.02	62.33	992	978	985	2625	2618	2622	27.43	27.20	27.31
T ₁₁	58.19	57.06	57.63	911	863	887	2586	2480	2533	26.05	25.82	25.94
T ₁₂	65.20	64.58	64.90	1073	1036	1054	2686	2675	2681	28.54	27.92	28.22
T ₁₃	0.00	0.00	0.00	708	705	707	2200	2185	2193	24.47	24.26	24.36
T ₁₄	100.00	100.00	100.00	1291	1244	1268	2800	2765	2783	31.56	31.03	31.30
S.Em.±	0.62	1.00	0.66	59	55	59	15	15	16	0.39	0.37	0.40
C.D. at 5%	1.80	2.91	1.91	172	160	172	45	45	48	1.14	1.13	1.16

T₁: Pendimethalin 38.7% CS @ 1000 g a.i. ha⁻¹T₈: Pendimethalin 38.7% CS @ 1000 g a.i. ha⁻¹ (PRE) fb Chlorimuron ethyl 25% (PRE) + IC at 30 and 60 DAS
 WP @ 15 g a.i. ha⁻¹ (EPOE) at 15-20 DAS + IC at 60 DAS
 T₂: Alachlor 50% EC @ 1000 g a.i. ha⁻¹ (PRE) + ICT₉: Pendimethalin 38.7% CS @ 1000 g a.i. ha⁻¹ (PRE) fb Imazethapyr 10% SL @ 30 and 60 DAS
 75 g a.i. ha⁻¹ (POE) at 30 DAS + IC at 60 DAS
 T₃: Clomazone 20% EC @ 750 g a.i. ha⁻¹ (PRE) +T₁₀: Clomazone 20% EC @ 750 g a.i. ha⁻¹ (PRE) fb Quizalofop-ethyl 5% EC @ IC at 30 and 60 DAS
 50 g a.i. ha⁻¹ (POE) at 30 DAS + IC at 60 DAS
 T₄ Quizalofop-ethyl 5% EC @ 50 g a.i. ha⁻¹ (POE)T₁₁: Clomazone 20% EC @ 750 g a.i. ha⁻¹ (PRE) fb Chlorimuron ethyl 25% WP at 30 DAS + IC at 60 DAS
 @ 15 g a.i. ha⁻¹ (EPOE) at 15-20 DAS + IC at 60 DAS
 T₅: Chlorimuron ethyl 25% WP @ 15 g a.i. ha⁻¹T₁₂: Clomazone 20% EC @ 750 g a.i. ha⁻¹ (PRE) fb Imazethapyr (10% SL) (POE) (EPOE) at 15-20 DAS + IC at 60 DAS
 @ 75 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS
 T₆: Imazethapyr 10% SL @ 75 g a.i. ha⁻¹ (POE)atT₁₃: Weedy check
 30 DAS + IC at 60 DAS
 T₇: Pendimethalin 38.7% CS @ 1000 g a.i. ha⁻¹T₁₄: Weed free check
 (PRE) fb Quizalofop-ethyl (5% EC) (POE) @ 50 g a.i. ha⁻¹ at 30 DAS + IC at 60 DAS

References

- Silva FM O. Tolerancia da mamoneira ao herbicida chlorimuron-ethyl em solos com diferentes capacidades de adsorcao. Monografia (Graduacao em Ciencias Biologicas)-Universidade Estadual da Paraiba, Campina Grande, 2010.
- Anonymous, 2016, www.indiastat.com
- Bhadoriya RBS, Chauhan DVS. Efficacy of herbicides in the control of weeds infesting Indian mustard (*Brassica juncea*). Indian J. Agron. 1995; 40(2):327-329.
- Bhagriya SN. Response of *Rabi* green gram (*Vigna radiate* L.) to weed management under South Gujarat conditions. M.Sc. (Agri) Thesis, Navsari Agril. Unvi., Navsari, Gujarat (India), 2006.
- Chenault EW, Wiese AF, Scott D, Hudspeth EB, Smith DT, Fryrear DW. Book Prog.Rep. 2705 Texas Agriculture Experiment Station.1969, 14.
- Costa AGF, Sofiatti V, Maciel CDG, Lira AJS, Cordeiro JR, Silva RLM. Weed management with herbicides applied in pre and post emergence on castor crop. Planta Daninha, Vicoso. 2015; 33(3):551-559.
- Devasenapathy P, Ramesh RT, Gangwar B. Efficiency indices for agriculture research. New India Publishing Agency, Pitampera, New Delhi. 2008, 65-113.
- Donald CM. In search of yield. J. Austria Inst. Agric. Sci. 1962; 28:171-178.
- Gamit NH. Integrated weed management in mustard (*Brassica juncea* L.) under south Gujarat condition. M.Sc. (Agri) Thesis, Gujarat Agril. Univ. Navsari, Gujarat (India), 2009.
- Gill, BS, Randhava GS, Saini SS. Integrated weed management in fenugreek (*Trigonella foenum-graecum*). Indian J. Agron. 2002; 47(2):284-288.
- Godra SP, Deshmukh SC. Weed biomass, weed control efficiency and yield of soybean (*Glycine max* L.) as influenced by various weed control measures. In: Proc. 2nd Int. Agronomy Congress on Balancing Food and Environment Security- A Continuing Challenge, 26-30 November 2002, IARI, New Delhi. 2002; 1198-1200.
- Jain N, Kewat ML, Mishra JS, Jain V. Effect of tillage and herbicides on weeds and wheat in transplanted rice-wheat system. *Indian J. Weed Sci.* 2006; 38(1&2):16-19.
- Kaneria BB, Patel ZG. Response of mustard (*Brassica juncea* L.) Czern and Coss. Ex. Coss. to weed management practices and nitrogen levels and their residual effect on succeeding summer greengram with and without nitrogen. J. Oilseeds Res. 1994; 11(1):66-71.
- Khedkar HP, Patel BD, Patel RB. Effect of post emergence herbicides on yield and economics of kharif soybean. Indian J. Weed Sci. 2009; 41(3&4):204-206.
- Maciel CDG. Seletividade de herbicidas em cultivares de mamona. R. Bras. Oleag. Fibr. 2007; 11(1):47-54.
- Malik RS, Yadav A, Malik RK. Integrated weed management in soybean (*Glycine max*). Indian J. Weed Sci. 2006; 38(1&2):65-68.
- Patel AJ, Virdia HM. Effect of weed management on weeds and nutrient uptake in rabi castor (*Ricinus communis* L.) under south Gujarat conditions. Adv. Res. J. Crop Improvement. 2011; 2(2):147-150.
- Pratap Singh V, Singh SP, Kumar A, Neeta Tripathi Nainwal RC. Efficacy of haloxyfop a post emergence herbicide on weeds and yield of soybean. Indian J. Weed Sci. 2010; 42(3&4):83-86.
- Ram B, Punia SS, Meena DS, Tetarwal JP. Bio-efficacy of post-emergence herbicides to manage weeds in field pea. J. Food Legumes. 2011; 24:254-257.
- Ram B, Punia SS, Meena DS, Tetarwal JP. Efficacy of post-emergence herbicides on weed control and seed yield of Rajmash (*Phaseolus vulgaris* L.). J. Food Legumes. 2012; 25:306-309.
- Sofiatti V. Pre and post emergence herbicides for weed control in castor crop. Indust. Crops Products. 2012; 37(1):235-237.
- Sofiattia V, Severino LS, Silva FMO, Silva VNB, Brito GG. Pre and post emergence herbicides for weed control in castor crop. Int. J. Industrial Crops Products. 2012; 33(1): 235-237.
- Tomer SK Tomer TS. Effect of herbicides and their tank mixture on weed dynamics and yield of zero tilled wheat (*Triticum aestivum*) under rice (*Oryza sativa*)-wheat cropping system of Eastern Uttar Pradesh. Indian J. Agron. 2014; 59(4):624-628.
- Younesabadi M, Das TK, Pual S. Tillage and weed management effect on weeds, non target toxicity in soil and yield of soybean. Int. J. Farm Allied Sci. 2014; 3(9):962-969.