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Effect of different herbicides on density and dry matter production of major weeds in chickpea (*Cicer arietinum* L.)

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Abstract

A field experiment was conducted in the experimental plots of Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) during *rabi* season 2019-20. The soil of experimental field was clayey (*Vertisols*) in texture, which was low, medium and high in available N (223 kg/ha.), P (12.24 kg/ha.) and K (382.6 kg/ha.), respectively. The experiment was laid out in Randomized Block Design with four replications. The treatment of Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 21 DAS (T₂), Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃), Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS (T₄), Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS (T₅), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing at 30 DAS (T₆), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS (T₈), Weed free check (weeding at 20 and 40 DAS) (T₉), Weedy check (T₁₀). Results revealed that the experimental field *Medicago denticulate*, *Chenopodium album*, *Echinochloa colona*, and some other weeds were dominant and observed throughout the crop growth period. Weed free (weeding at 20 and 40 DAS) (T₉) followed by Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg/ha PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), and Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇) were most appropriate for reducing weed density, weed dry matter production, lowest weed growth rate and gave highest weed control efficiency.

Keywords: Topramezone, chickpea (*Cicer arietinum* L.), weed control efficiency, weed density, weed dry matter production

Introduction

Chickpea (*Cicer arietinum* L.) is an important pulse crop grown and consumed all over the world, especially in the Afro-Asian countries. It is a good source of carbohydrates and protein, and protein quality is considered to be better than other pulses. Chickpea has significant amounts of all the essential amino acids except sulphur-containing amino acids, which can be complemented by adding cereals to the daily diet. Starch is the major storage carbohydrate followed by dietary fiber, oligosaccharides and simple sugars such as glucose and sucrose. Although lipids are present in low amounts, chickpea is rich in nutritionally important unsaturated fatty acids such as linoleic and oleic acids. β -sitosterol, campesterol and stigmasterol are important sterols present in chickpea oil. Ca, Mg, P and, especially, K are also present in chickpea seeds. Chickpea is a good source of important vitamins such as riboflavin, niacin, thiamin, folate and the vitamin A precursor β -carotene. Due to its nitrogen-fixing capacity, chickpea also plays a major role in increasing soil fertility.

In Indian cultivated area, grown over an area of 9.93 million ha with 9.53 million tons of production and an average productivity of 960 kg ha⁻¹ (Anonymous, 2017 A) [1]. The state of Chhattisgarh has better agro-ecological situation for the production of chickpea. It is grown in the state over an area of 349.81 thousand ha with an annual production of 556.31 thousand tons and an average output of 1116 kg ha⁻¹ (Anonymous, 2017B) [2].

Chickpea is a weak competitor for weeds due to slow growth rates and limited leaf production at the early stage of crop growth and establishment if weed control is ignored under these conditions, resulting in yield losses of 40 to 87 per cent (Ratnam, 2013) [12].

2. Materials and Methods

2.1 Study Site Description

The field experiment was conducted at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) during *rabi* season 2019-20. Experimental site was situated at 21° 4'N latitude and 81° 35'E Longitude with an altitude of 290.20 meter above the mean sea level.

2.2 Experimental Details

The experiment was laid out in Randomized Block Design with four replications. The soil of experimental field was clayey (*Vertisols*) in texture, which was low, medium and high in available N (223 kg/ha.), P (12.24 kg/ha.) and K (382.6 kg/ha.), respectively. The treatment of Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 21 DAS (T₂), Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃), Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS (T₄), Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS (T₅), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing at 30 DAS (T₆), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS (T₈), Weed free check (weeding at 20 and 40 DAS) (T₉), Weedy check (T₁₀). Herbicide dissolved thoroughly in water at the rate of 500 liter as ha⁻¹ as carrier and sprayed in their respective plots.

2.3 Cultivation Details

Chickpea (*Cicer arietinum* L.) variety Indira chana-1 was grown as test crop. It was released from IGKV, Raipur. It is a bold seeded variety and having brown seed colour. The crop duration is about 105-110 days. Land preparation was performed when the soil reached working order. The field was prepared with plough drawn by tractor followed by harrowing to get a well-pulverized seed bed. Weed and crop residues have been stripped to get free seed bed for weed and stubble. It was eventually leveled with the help of a tractor-driven leveler. Recommended dose of nutrient 20:50:20 kg N : P₂O₅ : K₂O ha⁻¹ was applied through diammonium phosphate (DAP), and muriate of potash (MOP), respectively as basal at the time of sowing in rows uniformly to each plot. First irrigation was given by controlled flooding method just after sowing in order to ensure proper germination of the crop. Second irrigation was applied at 45 DAS.

The seed was sown mechanically in row on November 29, 2019. The spacing from row to row used a certified seed @ 80 kg ha⁻¹ was 30 cm. The seeds were treated with carbendazim @ 2 g kg⁻¹ of seed followed by seeds inoculated with *Rhizobium* culture @ 5 g kg⁻¹ seeds before sowing to prevent the crop from soil and seed borne diseases. Seeds were manually sown after drying in shade. Weed management practices were adopted as per treatments. Two manual hand weeding were done at 20 and 40 days after sowing in hand weeding treatment and 30 DAS for T₆. The harvesting was done manually with the help of sickle. The produce of each

net plot was tied into bundle and allowed to sun drying in respective plots for two days. The harvested bundles were weighted with the help of spring balance and transported to threshing floor.

2.4 Observation Recorded

The important weed species associated with the chickpea crop in the experimental field were grouped in to two *i.e.* broadleaf and grassy.

2.4.1 Weed density (Total and species wise)

The weed density of different weed species was studied at 30, 60, 90 DAS and at harvest. The weed study in each plot was made at random from five selected spots and for this purpose quadrat (1 m²) was used. Only green weeds samples were noted. Counting of weeds was done according to species and total population of weeds was also worked out. The data were recorded m⁻² for statistical analysis.

2.4.2 Dry matter production of weeds (Total and species wise)

Dry matter production of weeds was recorded at 30, 60, 90 DAS and at harvest. The weeds of 1m² quadrat were uprooted and roots were detached, sun dried and finally oven dried at 60 °C for 48 hours. The dry matter was recorded species wise and as total dry matter.

2.4.3 Weed control efficiency (WCE)

"The weed control efficiency was calculated at 30, 60, 90 DAS and at harvest on the basis of reduction in dry matter production of weeds in treated plots in comparison with weedy check and expressed in percentage as suggested by Mani *et al.* (1973) [10].

$$WCE (\%) = \frac{DWC - DWT}{DWC} \times 100$$

Where,

WCE = Weed control efficiency (%)

DWC = Dry weight of weeds in weedy check plot (g)

DWT = Dry weight of weeds in treated plot (g)

2.4.4 Transformation of data

"Data on weed count and weed dry weight showed high variation. To make the analysis of variance more valid the data on weed count and weed dry weight was subjected to square root transformation by using formula $\sqrt{x} + 0.5$ (Chandel, 1984) [6].

3. Results and Discussion

3.1 Total and species wise weed density (No.m⁻²)

Its total weed density of *Medicago denticulata*, *Echinochloa colona*, *Chenopodium album* and many others were recorded at 30, 60, 90 DAS and mentioned in Table: 1. At harvest and. At all the observing stages the overall weed density was greatly affected by various weed control treatments.

"At 30 DAS, lowest total weed density was observed under the treatment of weed free (hand weeding at 20 and 40 DAS) (T₉), however, it was at par to the treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇),

and Topramezone 33.6 SC formulation(25.7 g a.i./ha) EPoE at 14 DAS (T₃), Comparably, at different observation intervals, i.e. at 60, 90 DAS and at harvest, relatively lower total weed density was reported under hand weeding at 20 and 40 DAS (T₉), which was considerably greater than other treatments, while under” weed control (T₁₀) it was larger than the rest of the treatments.

“Among the herbicidal treatments, significantly lower weed density recorded under the treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), which was at par with Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), and Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha)

EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃), respectively, and significantly superior rest of the treatments. Then it can be reported on the base of the above results that the weed density trend was in ascending order from 30 DAS to harvest point. The use of herbicides and weeding by hand reduced significantly the density of weeds at the early stage of crop yields. In fact, weed infestation increased significantly under control plot (T₁₀) up to harvest, and highest weed density was observed during the crop growth cycle in control plot (T₁₀), as no control measure was adopted. Such results are consistent with the” Butter and Aggarwal (2008) ^[4], Kumar (2010) ^[9] and Singh *et al.* (2014) ^[15] find

Table 1: Total weed population in chickpea as influenced by different weed control measures

Treatment	Weed population (No.m ⁻²)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Topramezone 33.6 SC formulation(20.6 g a.i./ha) EPoE at 14 DAS	5.70 (32.10)	5.87 (34.05)	5.43 (29.10)	5.26 (27.20)
T ₂ Topramezone 33.6 SC formulation(20.6 g a.i./ha) EPoE at 21 DAS	6.17 (37.55)	6.37 (40.05)	6.08 (36.55)	5.82 (33.45)
T ₃ Topramezone 33.6 SC formulation(25.7 g a.i./ha) EPoE at 14 DAS	6.09 (36.60)	6.13 (37.20)	5.70 (32.15)	5.47 (29.55)
T ₄ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS	6.22 (38.25)	6.40 (40.55)	6.24 (38.45)	5.92 (34.60)
T ₅ Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS	6.29 (39.03)	6.48 (40.80)	6.37 (40.20)	5.99 (35.50)
T ₆ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing /hand weeding at 30 DAS	4.93 (23.85)	4.98 (23.50)	4.00 (15.60)	3.79 (13.85)
T ₇ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS	6.01 (35.73)	6.07 (42.20)	5.67 (31.75)	5.06 (25.55)
T ₈ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	6.13 (37.05)	6.26 (39.75)	5.73 (32.50)	5.58 (30.70)
T ₉ Weed free check (hand weeding at 20 and 40 DAS)	4.81 (22.70)	4.71 (21.85)	3.87 (14.63)	3.62 (12.85)
T ₁₀ Weedy check	9.45 (88.90)	10.25 (104.6)	9.32 (86.41)	9.14 (83.15)
SEm±	0.11	0.18	0.17	0.19
CD (P=0.05)	0.34	0.53	0.50	0.55

3.2. Species wise weed density (No. m⁻²)

3.2.1. *Medicago denticulata* (No. m⁻²)

“The slightly lowest density of *Medicago denticulata* in weed-free treatment was reported at 30 DAS (hand weeding at 20 and 40 DAS) (T₉), however, it was at par to the treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE” *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇),and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) (Table 2. depicted).

“At 60, 90 DAS and at harvest, significantly lowest density was noted under weed free (hand weeding at 20 and 40 DAS

(T₉) which was significantly superior over other treatments. Among the herbicidal treatments, significantly lower density was observed in Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆),Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇),and Topramezone 33.6 SC formulation(25.7 g a.i./ha) EPoE at 14 DAS (T₃) Under weedy check (T₁₀) the maximum density of *Medicago denticulata* (T₁₀) was reported.Similar results was reported” by Singh *et al.* (2014) ^[15].

Table 2: Density of *Medicago denticulata* in chickpea as influenced by different weed control measures

Treatment	Weed population (No.m ⁻²)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Topramezone 33.6 SC formulation (20.6 g a.i./ha) PoE at 14 DAS	4.06 (16.05)	4.18 (17.00)	3.88 (14.60)	3.76 (13.65)
T ₂ Topramezone 33.6 SC formulation (20.6 g a.i./ha) PoE at 21 DAS	4.37 (18.65)	4.47 (19.50)	4.33 (18.30)	4.14 (16.70)
T ₃ Topramezone 33.6 SC formulation (25.7 g a.i./ha) PoE at 14 DAS	4.33 (18.30)	4.34 (18.45)	4.06 (16.10)	3.89 (14.70)
T ₄ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS	4.43 (19.15)	4.50 (19.85)	4.45 (19.35)	4.22 (17.30)
T ₅ Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS	4.47 (19.53)	4.57 (20.40)	4.53 (20.10)	4.27 (17.75)
T ₆ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing /hand weeding at 30 DAS	3.59 (12.40)	3.50 (11.75)	2.90 (7.95)	2.74 (7.00)
T ₇ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS	4.32 (18.18)	4.32 (18.35)	4.05 (15.90)	3.21 (10.90)
T ₈ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	4.34 (18.35)	4.40 (18.90)	4.08 (16.25)	3.97 (15.30)
T ₉ Weed free check (hand weeding at 20 and 40 DAS)	3.45 (11.40)	3.37 (10.85)	2.78 (7.33)	2.61 (6.45)
T ₁₀ Weedy check	6.64 (43.65)	7.26 (52.30)	6.61 (43.20)	6.48 (41.55)
SEm±	0.09	0.14	0.12	0.22
CD (P=0.05)	0.27	0.41	0.36	0.63

3.2.2 *Echinochloa colona* (No. m⁻²)

At 30 DAS, the density of *Echinochloa colona* was minimum under the treatment of weed free (hand weeding at 20 and 40 DAS) (T₉), however, it was at par to the treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇), and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) (Table 3).

“At 60, 90 DAS and at harvest, the weed free (hand weeding at 20 and 40 DAS) (T₉) recorded significantly lowest

Echinochloa colona density. Under weedy check (T₁₀) the maximum density was recorded. Among the herbicidal treatments, at 60, 90 DAS and at harvest, treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆) Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇), and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) were at par to the weed free (hand weeding at 20 and 40 DAS) (T₉).

Table 3: Density of *Echinochloa colona* in chickpea as influenced by different weed control measures

Treatment	Weed population (No.m ⁻²)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS	2.92 (8.05)	3.00 (8.50)	2.79 (7.30)	2.69 (6.75)
T ₂ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 21 DAS	3.12 (9.25)	3.29 (10.35)	3.10 (9.15)	2.98 (8.40)
T ₃ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS	3.10 (9.15)	3.15 (9.45)	2.92 (8.05)	2.81 (7.40)
T ₄ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS	3.15 (9.45)	3.30 (10.40)	3.18 (9.65)	3.04 (8.75)
T ₅ Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS	3.17 (9.55)	3.33 (10.60)	3.24 (10.05)	3.06 (8.90)
T ₆ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing /hand weeding at 30 DAS	2.47 (5.60)	2.67 (6.65)	2.10 (3.95)	1.99 (3.45)
T ₇ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS	3.06 (8.90)	3.09 (9.15)	2.91 (8.00)	2.80 (7.35)
T ₈ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	3.11 (9.20)	3.24 (10.00)	2.94 (8.15)	2.86 (7.70)
T ₉ Weed free check (hand weeding at 20 and 40 DAS)	2.49 (5.70)	2.44 (5.45)	2.03 (3.65)	1.91 (3.20)
T ₁₀ Weedy check	4.80 (22.60)	5.16 (26.20)	4.70 (21.61)	4.61 (20.80)
SEm±	0.07	0.09	0.08	0.07
CD (P=0.05)	0.20	0.27	0.25	0.23

3.2.3 *Chenopodium album* (No. m⁻²)

At 30 DAS, the minimum density of *Chenopodium album* was observed in the treatment of weed free (hand weeding at 20

and 40 DAS) (T₉), however, it was at par to the treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6

SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE” *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇), and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) (Table 4).

Significantly lowest density “was recorded under 60, 90 DAS and at harvest weed free (hand weeding at 20 and 40 DAS) (T₉). The maximum *Chenopodium album* density was recorded under weedy check (T₁₀). Among herbicidal treatments, at 60 DAS, 90 DAS and at harvest, treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0

kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇), and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) were at par to the weed free (hand weeding at 20 and 40 DAS)” (T₉), in descending order. However, density of *Chenopodium album* under all the herbicidal treatments was significantly lower than control plot and other treatments.

Table 4: Density of *Chenopodium album* in chickpea as influenced by different weed control measures

Treatment	Weed population (No./m ²)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS	2.30 (4.80)	2.37 (5.15)	2.20 (4.35)	2.13 (4.05)
T ₂ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 21 DAS	2.51 (5.80)	2.58 (6.15)	2.45 (5.50)	2.34 (5.00)
T ₃ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS	2.45 (5.50)	2.45 (5.55)	2.30 (4.80)	2.22 (4.45)
T ₄ Topramezone formulation 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	2.52 (5.85)	2.59 (6.20)	2.51 (5.80)	2.38 (5.15)
T ₅ Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS	2.55 (6.00)	2.61 (6.35)	2.55 (6.00)	2.41 (5.30)
T ₆ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing /hand weeding at 30 DAS	1.99 (3.47)	2.02 (3.60)	1.63 (2.15)	1.60 (2.05)
T ₇ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS	2.43 (5.40)	2.46 (5.60)	2.29 (4.75)	2.20 (4.35)
T ₈ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	2.50 (5.75)	2.54 (5.95)	2.31 (4.85)	2.25 (4.60)
T ₉ Weed free check (hand weeding at 20 and 40 DAS)	1.96 (3.35)	1.94 (3.25)	1.64 (2.20)	1.56 (1.95)
T ₁₀ Weedy check	3.73 (13.40)	4.01 (15.60)	3.66 (12.95)	3.60 (12.45)
SEm±	0.04	0.08	0.06	0.06
CD (P=0.05)	0.14	0.023	0.18	0.18

3.2.4 Other weed species (No. m⁻²)

“At 30 DAS, however, the substantially lower density of other weed species was reported for weed-free treatment (hand weeding at 20 and 40 DAS) (T₉) but was equivalent to the treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE” *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇), and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃), respectively.

With respect to subsequent observation intervals “at 60, 90 DAS and at harvest, the lower density of other weed species was reported under weed-free (hand weeding at 20 and 40 DAS) (T₉), which, was statistically at par with the treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE” *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇), and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) The highest density was recorded under weedy check (T₁₀) (Table 5.).

Table 5: Density of *Other weeds* in chickpea as influenced by different weed control measures

Treatment	Weed population (No.m ⁻²)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS	1.92 (3.20)	1.97 (3.40)	1.83 (2.85)	1.80 (2.75)
T ₂ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 21 DAS	2.09 (3.85)	2.13 (4.05)	2.02 (3.60)	1.96 (3.35)
T ₃ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS	2.04 (3.65)	2.06 (3.75)	1.92 (3.20)	1.87 (3.00)
T ₄ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS	2.07 (3.80)	2.14 (4.10)	2.04 (3.65)	1.97 (3.40)
T ₅ Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS	2.11 (3.95)	2.18 (4.25)	2.13 (4.05)	2.01 (3.55)
T ₆ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing /hand weeding at 30 DAS	1.70 (2.40)	1.69 (2.35)	1.43 (1.55)	1.36 (1.35)
T ₇ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by	1.92	2.01	1.90	1.85

Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS	(3.25)	(3.55)	(3.10)	(2.95)
T ₈ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	2.06	2.11	1.93	1.89
	(3.75)	(3.95)	(3.25)	(3.10)
T ₉ Weed free check (hand weeding at 20 and 40 DAS)	1.66	1.63	1.39	1.32
	(2.25)	(2.15)	(1.45)	(1.25)
T ₁₀ Weedy check	3.12	3.34	3.02	2.97
	(9.25)	(10.70)	(8.65)	(8.35)
SEm±	0.06	0.06	0.05	0.04
CD (P=0.05)	0.17	0.18	0.14	0.12

3.3 Total and species wise dry matter production of weeds (g m⁻²)

Different weed control treatments at 30, 60, 90 DAS have greatly affected the overall weed dry matter, and at harvest and data are provided in Table 6. Present us. Substantially higher dry matter was observed for weed species, namely *Medicago denticulata*, *Chenopodium album* *Echinochloa colona* and others under weed control (T₁₀) relative to the rest of the trees.

“At 30 DAS, significantly lower total dry matter of weed species was recorded under the treatment of weed free (hand weeding at 20 and 40 DAS) (T₉), however, lower total weed dry matter was recorded under of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation(25.7 g a.i./ha) EPoE at 14 DAS (T₃) as compared to weedy check (T₁₀) and rest of the

treatments. At later time interval of observed *i.e.* at 60, 90 DAS and at harvest, weed free (hand weeding at 20 and 40 DAS) (T₉) resulted in significant reduction in total dry matter production of weeds which, was significantly superior over other treatments. However, among the herbicidal weed management treatments, significantly lower total weed dry matter was recorded under Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE” *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) which were at par to each other at all the later stages of observation *i.e.* 60, 90 DAS and at harvest, and were superior over rest of the treatments. While highest dry matter production was noted under weedy check (T₁₀). These result are in accordance with the finding of Sharma (2009) ^[13], Bhutada and Bhale (2013) ^[5] and Chandrakar *et al.* (2015) ^[7]

Table 6: Total weeds dry weight of chickpea as influenced by different weed control measures

Treatment	Weeds dry weight (g m ⁻²)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Topramezone 33.6 SC formulation(20.6 g a.i./ha) EPoE at 14 DAS	3.95 (15.17)	3.71 (13.37)	4.57 (20.41)	4.88 (23.36)
T ₂ Topramezone 33.6 SC formulation(20.6 g a.i./ha) EPoE at 21 DAS	4.13 (16.57)	4.67 (21.37)	4.95 (24.10)	5.26 (27.26)
T ₃ Topramezone 33.6 SC formulation(25.7 g a.i./ha) EPoE at 14 DAS	4.02 (15.72)	4.14 (16.70)	4.63 (20.93)	4.91 (23.69)
T ₄ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS	4.25 (17.55)	4.71 (21.70)	5.04 (24.93)	5.30 (27.65)
T ₅ Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS	4.27 (17.80)	4.78 (22.52)	5.08 (25.41)	5.31 (27.72)
T ₆ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing /hand weeding at 30 DAS	3.57 (12.25)	3.14 (9.14)	3.48 (11.64)	3.75 (13.61)
T ₇ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS	4.00 (15.56)	4.08 (16.31)	4.60 (20.70)	4.90 (23.57)
T ₈ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	4.12 (16.45)	4.23 (17.54)	4.67 (21.41)	5.00 (24.62)
T ₉ Weed free check (hand weeding at 20 and 40 DAS)	3.26 (10.15)	2.92 (8.06)	3.23 (9.97)	3.50 (11.81)
T ₁₀ Weedy check	5.25 (27.12)	6.57 (42.78)	7.08 (49.80)	7.33 (53.33)
SEm±	0.10	0.16	0.14	0.13
CD (P=0.05)	0.29	0.48	0.43	0.39

3.4. Species wise dry matter production of weeds (g m⁻²)

3.4.1 *Medicago denticulata* (g m⁻²)

At 30 DAS, *Medicago denticulata* substantially lowest dry matter production was reported in weed-free care (hand weeding at 20 and 40 DAS) (T₉), but it was on a par with care of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha)

EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation(25.7 g a.i./ha) EPoE at 14 DAS (T₃). (Table 7).

At 60, 90 DAS as well as at harvest, the minimum production of dry weeds was recorded under weed-free (hand weeding at 20 and 40 DAS) (T₉), which was substantially superior to other treatments. Among the herbicides, significantly lower dry matter production was observed in Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC

formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at

14 DAS (T₃). The maximum dry weight of *Medicago denticulata* was recorded weedy check (T₁₀).

Table 7: Dry matter of *Medicago denticulata* in chickpea as influenced by different weed control measures

Treatment	Dry matter (g m ⁻²)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS	2.84 (7.64)	2.67 (6.68)	3.27 (10.21)	3.49 (11.68)
T ₂ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 21 DAS	2.96 (8.28)	3.34 (10.69)	3.54 (12.06)	3.76 (13.63)
T ₃ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS	2.89 (7.87)	2.97 (8.36)	3.31 (10.47)	3.51 (11.85)
T ₄ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS	3.05 (8.78)	3.37 (10.86)	3.60 (12.47)	3.78 (13.82)
T ₅ Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS	3.06 (8.91)	3.42 (11.28)	3.63 (12.71)	3.78 (13.85)
T ₆ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing /hand weeding at 30 DAS	2.57 (6.13)	2.27 (4.68)	2.51 (5.82)	2.70 (6.81)
T ₇ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS	2.87 (7.77)	2.93 (8.16)	3.29 (10.35)	3.50 (11.79)
T ₈ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	2.95 (8.23)	3.03 (8.78)	3.34 (10.71)	3.57 (12.25)
T ₉ Weed free check (hand weeding at 20 and 40 DAS)	2.36 (5.08)	2.13 (4.03)	2.34 (4.98)	2.52 (5.90)
T ₁₀ Weedy check	4.06 (16.04)	4.67 (21.39)	5.03 (24.90)	5.21 (26.67)
SEm±	0.08	0.11	0.10	0.10
CD (P=0.05)	0.23	0.33	0.30	0.29

3.4.2 *Echinochloa colona* (g m⁻²)

At 30 DAS, the dry matter development of *Echinochloa colona* was substantially lowest under weed-free treatment (hand weeding at 20 and 40 DAS) (T₉), but was on par with treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) respectively (Table 8).

Substantially lowest “dry weight was noted under weed free (hand weeding at 20 and 40 DAS) (T₉) at 60, 90 DAS and at

harvest, which was clearly better over other treatments. The maximum dry weight of *Echinochloa colona* was recorded under weedy check (T₁₀). Among the herbicidal weed management, significantly lowest dry weight was observed in Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) and both were at par to each other and significantly superior over rest of the treatments.

Table 8: Dry matter of *Echinochloa colona* in chickpea as influenced by different weed control measures

Treatment	Dry matter (g m ⁻²)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS	2.07 (3.82)	1.96 (3.34)	2.36 (5.10)	2.52 (5.84)
T ₂ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 21 DAS	2.15 (4.14)	2.42 (5.34)	2.55 (6.03)	2.70 (6.82)
T ₃ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS	2.11 (3.95)	2.16 (4.18)	2.39 (5.23)	2.53 (5.92)
T ₄ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS	2.21 (4.39)	2.43 (5.43)	2.59 (6.23)	2.72 (6.92)
T ₅ Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS	2.22 (4.45)	2.47 (5.64)	2.61 (6.35)	2.72 (6.94)
T ₆ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing /hand weeding at 30 DAS	1.89 (3.06)	1.68 (2.34)	1.84 (2.91)	1.97 (3.40)
T ₇ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS	2.10 (3.93)	2.13 (4.08)	2.38 (5.17)	2.53 (5.89)
T ₈ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	2.15 (4.11)	2.20 (4.39)	2.41 (5.35)	2.58 (6.19)
T ₉ Weed free check (hand weeding at 20 and 40 DAS)	1.74 (2.54)	1.58 (2.01)	1.73 (2.49)	1.85 (2.95)
T ₁₀ Weedy check	1.89	3.34	3.59	3.72

	(3.06)	(10.70)	(12.45)	(13.33)
SEm±	0.05	0.08	0.07	0.07
CD (P=0.05)	0.15	0.23	0.20	0.20

3.4.3 *Chenopodium album* (g m⁻²)

At 30 DAS, significantly lower dry matter production of *Chenopodium album* was observed in the treatment of weed free (hand weeding at 20 and 40 DAS) (T₉), however, it was at par to the treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) respectively (Table 9).

“At 60, 90 DAS and at harvest, significantly lower dry matter production was recorded under weed free (hand weeding at 20 and 40 DAS) (T₉), than weedy check (T₁₀). The significantly

maximum dry matter production of *Chenopodium album* was under weedy check (T₁₀). Among the herbicidal treatments, at At 60, 90 DAS and at harvest, treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) were at par to the weed free (hand weeding at 20 and 40 DAS) (T₉), respectively, but, superior over rest of the treatments and were” significantly effective in reducing the dry matter production of *Chenopodium album* than rest of the herbicidal treatments including weedy check (T₁₀).

Table 9: Dry matter of *Chenopodium album* in chickpea as influenced by different weed control measures

Treatment	Dry matter (g m ⁻²)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS	1.64 (2.19)	1.58 (2.01)	1.89 (3.06)	2.00 (3.50)
T ₂ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 21 DAS	1.73 (2.48)	1.92 (3.20)	2.03 (3.61)	2.14 (4.09)
T ₃ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS	1.68 (2.33)	1.73 (2.50)	1.91 (3.14)	2.01 (3.55)
T ₄ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS	1.77 (2.63)	1.94 (3.25)	2.06 (3.74)	2.16 (4.15)
T ₅ Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS	1.78 (2.67)	1.96 (3.36)	2.07 (3.81)	2.16 (4.16)
T ₆ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing /hand weeding at 30 DAS	1.53 (1.84)	1.40 (1.45)	1.50 (1.75)	1.59 (2.04)
T ₇ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS	1.66 (2.29)	1.71 (2.44)	1.90 (3.10)	2.01 (3.53)
T ₈ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	1.72 (2.47)	1.76 (2.63)	1.92 (3.21)	2.05 (3.71)
T ₉ Weed free check (hand weeding at 20 and 40 DAS)	1.42 (1.52)	1.31 (1.21)	1.41 (1.50)	1.50 (1.77)
T ₁₀ Weedy check	2.30 (4.81)	2.63 (6.42)	2.82 (7.47)	2.91 (8.00)
SEm±	0.04	0.05	0.05	0.05
CD (P=0.05)	0.11	0.17	0.15	0.15

3.4.4 Other weed species (gm⁻²)

“At 30 DAS, weed free (hand weeding at 20 and 40 DAS) (T₉), produced lower dry matter of other weed species, however, it was at par to the treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE” *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) respectively.

With respect to later observation intervals, i.e. “at 60, 90 DAS and at harvest, the amount of minimum dry matter of other

weed species was reported under weed-free (hand weeding at 20 and 40 DAS) (T₉), which was statistically equivalent to treatment of Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @ 1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE *fb* Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 14 DAS (T₃) as compared to weedy check (T₁₀) and other treatments. The low dry matter production was recorded under weedy check (T₁₀) (Table 10).

Table 10: Dry matter of other weed species in chickpea as influenced by different weed control measures

Treatment	Dry matter (g m ⁻²)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS	1.42 (1.53)	1.35 (1.34)	1.59 (2.04)	1.68 (2.34)
T ₂ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 21 DAS	1.47 (1.66)	1.62 (2.14)	1.70 (2.41)	1.79 (2.72)

T ₃ Topramezone 33.6 SC formulation(25.7 g a.i./ha) EPoE at 14 DAS	1.44 (1.58)	1.47 (1.67)	1.61 (2.09)	1.69 (2.37)
T ₄ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS	1.50 (1.75)	1.63 (2.17)	1.73 (2.49)	1.81 (2.77)
T ₅ Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS	1.51 (1.78)	1.65 (2.25)	1.74 (2.54)	1.81 (2.77)
T ₆ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing /hand weeding at 30 DAS	1.31 (1.23)	1.20 (0.94)	1.29 (1.16)	1.36 (1.36)
T ₇ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS	1.44 (1.57)	1.45 (1.63)	1.60 (2.07)	1.69 (2.35)
T ₈ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	1.46 (1.64)	1.50 (1.75)	1.62 (2.14)	1.72 (2.47)
T ₉ Weed free check (hand weeding at 20 and 40 DAS)	1.23 (1.02)	1.14 (0.81)	1.22 (1.00)	1.29 (1.18)
T ₁₀ Weedy check	1.92 (3.21)	2.18 (4.28)	2.34 (4.98)	2.41 (5.33)
SEm±	0.03	0.04	0.04	0.04
CD (P=0.05)	0.09	0.13	0.12	0.12

4.2.4 Weed control efficiency (WCE)

“Weed control efficiency of different weed at 30, 60, 90 DAS and at harvest are Table 11. The data reflect the highest weed control efficiency was recorded under weed free (hand weeding at 20 and 40 DAS) (T₉) *fb* Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @1.0 kg ha⁻¹ PE + one hoeing at 30 DAS (T₆), Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS (T₁), Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE” *fb*

Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS (T₇) and Topramezone 33.6 SC formulation(25.7 g a.i./ha) EPoE at 14 DAS (T₃). This May well be attributed to decreased weed density and dry weight with a pre-emergence and PoE application to some degree of Pendimethali + Imazethapyr and Topramezone. These result are in accordance with the finding of Ali *et al.* (2013), Bhutada and Bhale (2013), Kour *et al.* (2014) [8] and Rathod *et al.* (2017).

Table 11: Weed control efficiency of chickpea as influenced by different weed control measures

Treatment	Weed control efficiency (%)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS	44.20	68.16	58.46	55.75
T ₂ Topramezone 33.6 SC formulation (20.6 g a.i./ha)E PoE at 21 DAS	38.51	48.81	50.60	48.05
T ₃ Topramezone 33.6 SC formulation(25.7 g a.i./ha)E PoE at 14 DAS	41.82	60.05	57.37	54.95
T ₄ Topramezone 33.6 SC formulation (25.7 g a.i./ha) EPoE at 21 DAS	34.85	48.18	49.25	47.70
T ₅ Quizalofop-p-ethyl 5 EC (100 g a.i./ha) PoE at 25 DAS	34.07	47.02	48.76	47.55
T ₆ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE + one Hoeing /hand weeding at 30 DAS	54.30	77.94	76.68	74.34
T ₇ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE <i>fb</i> Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS	42.48	62.20	58.43	55.84
T ₈ Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (25.7 g a.i./ha) EPoE at 21 DAS	39.15	58.84	56.89	53.64
T ₉ Weed free check (hand weeding at 20 and 40 DAS)	62.38	80.98	79.79	77.63
T ₁₀ Weedy check	0.00	0.00	0.00	0.00
SEm±	2.97	3.42	2.84	2.47
CD (P=0.05)	8.64	9.94	8.25	7.17

5. Conclusions

Significantly lower total and species wise “weed density and dry matter of weed species and total weed index were recorded under weed free” (hand weeding at 20 and 40 DAS). However, it was at par to the treatment of “Pendimethalin 30 EC + Imazethapyr 2% (Ready mix) @1.0 kg ha⁻¹ PE + one hoeing at 30 DAS”, Topramezone 33.6 SC formulation (20.6 g a.i./ha) EPoE at 14 DAS, Pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix @ 1kg/ha) PE followed by Topramezone 33.6 SC (20.6 g a.i./ha) EPoE at 21 DAS.

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