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Growth analysis of chickpea (*Cicer arietinum* L.) influenced by weed management practices under vertisols of Chhattisgarh plains

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Abstract
A field experiment was laid out during the winter season of 2021-22 and 2022-23 at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh to study the effect of weed management practices on growth of chickpea. The experiment was carried out in randomized block design with fourteen treatments, replicated trice. The experiment comprised and unweeded control. Results revealed that growth parameters like plant height (51.9 cm), number of primary branches plant^{-1} (3.3) and root length (20.4 cm) were recorded maximum in oxyfluorfen 150 g ha^{-1} (PE) *fb* propaquizafop 100 g ha^{-1} (PoE). Growth parameters *viz.*, numerb of secondary branches plant^{-1} (18.9), number of leaves plant^{-1} (95.0), leaf area plant^{-1} (639.0 cm^2), leaf area index (2.13), leaf area duration (53.6 days), dry matter accumulation (26.91 g plant^{-1}) and root dry weight (2.32 g plant^{-1}) were found to be performed best in oxyfluorfen 150 g ha^{-1} (PE) as pre-emergence *fb* topramezone 20.6 g ha^{-1} (PoE). Hand weeding twice however recorded the maximum values of aforesaid parameters while the lowest were recorded in unweeded control. Crop growth rate and relative growth rate were found to be increased upto 60 DAS and decreased thereafter and found to be maximum under oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE). Among herbicidal treatments, seed yield, stover yield and biological yield were significantly higher in combined application of oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) (1746 kg ha^{-1}, 2670 kg ha^{-1} and 4416 kg ha^{-1}, respectively) which was at par with metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE). These treatments were statistically similar with hand weeding twice at 20 and 40 DAS having maximum values of above characters while unweeded control proved inferior.

Keywords: Control, growth, hand weeding, herbicide

Introduction
Chickpea (*Cicer arietinum* L.) is valued for its nutritional quality [high protein content 18-22%, carbohydrate 52-70%, fat 4-10%, minerals (Calcium, Phosphorus and Iron) and Vitamins] in the vegetarian diet. Also, pulse crops are promoted in cropping system intensification and diversification to ensure the sustainable productivity and prevent soil degradation. Specifically, chickpea plays an important role in conservation agriculture systems because of resource saving and biological N_2 fixation (Nath *et al.*, 2021) [6]. Chickpea is a valued crop and provides nutritious food for an expanding world population and will become increasingly important with climate change (Merga and Alemu, 2019) [4]. Two main types of chickpea are recognized *i.e. desi* type with small and brown seed accounts for nearly 90% and *kabuli* type with bold and cream coloured seed is grown in around 10% area (Sah, 2022) [8].
Chickpea is one of the important pulse crops in the world covering 14.6 M ha area with 14.8 Mt of production. The average chickpea grain yield is 1,038 kg ha^{-1} worldwide (FAO, 2021). As per ICMD recommended dose of pulses per capita per day is 75 g but only 36 g is available, for that declining yield as compared to the maximum potential of cultivars is a result of various factors. One of the major obstacle in growing chickpea successfully is their poor ability to compete with weeds. Chickpea is poor competitor to weeds because of slow growth rate and limited leaf development at early stage of crop growth and establishment. The occurrence of invasive and noxious weed species is the main challenges over the world aims for crop production (Merga and Alemu, 2019) [4]. In general, compared with other pulses, chickpea develops relatively slowly when plants are young, it has an open canopy architecture and low stature, reducing its ability to compete with weeds. Therefore, weeds are the major constraint to chickpea production resulting in harvesting difficulties, reduced yield and less economic returns (Taran *et al.*, 2012) [9].

Yield losses due to weed competition vary considerably depending on the level of weed infestation and weed species prevailing (Abbas *et al.*, 2016) [1].

Material and Methods

The experiment was conducted during *Rabi* season of 2021-22 and 2022-23 at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). Climate of the region is sub-humid with hot summer and cold winter with an average annual rainfall 1326 mm. The soil of experimental field was clayey (*Vertisols*), neutral in reaction (pH 7.1), medium in organic carbon (0.61%) and low in available nitrogen (222.7 kg ha^{-1}), medium in available phosphorus (13.8 kg ha^{-1}) and high in available potassium (373.2 kg ha^{-1}). The experiment was carried out in randomized block design with fourteen treatments, replicated trice. Treatment comprised herbicides *viz.*, oxyfluorefen 23.5% EC 150 g/ha (PE), oxyfluorefen 23.5% EC 250 g/ha (PE), metribuzin 70% WP 350 g/ha (PE), quizalofop-p-ethyl 5 % EC 100 g/ha (PoE), propaquizafop 10% EC 100 g/ha (PoE), topramezone 33.6% SC 20.6 g/ha (PoE), oxyfluorefen 23.5% EC 150 g/ha (PE) *fb* quizalofop-p-ethyl 5 % EC 100 g/ha (PoE), oxyfluorefen 23.5% EC 150 g/ha (PE) *fb* propaquizafop 10% EC 100 g/ha (PoE), oxyfluorefen 23.5% EC 150 g/ha (PE) *fb* topramezone 33.6% SC 20.6 g/ha (PoE), metribuzin 70% WP 350 g/ha (PE) *fb* quizalofop-p-ethyl 5% EC 100 g/ha (PoE), metribuzin 70% WP g/ha (PE) *fb* propaquizafop 10% EC 100 g/ha (PoE), metribuzin 70% WP 350 g/ha (PE) *fb* topramezone 33.6% SC 20.6 g ha^{-1} (PoE) including hand weeding twice at 20 and 40 DAS and unweeded control. Sowing was done manually using 80 kg ha^{-1} seeds of Indira chana-1 cultivar in rows of 30 cm apart, with plant-to-plant distance of 10 cm. Nitrogen (20 kg ha^{-1}) and phosphorus (50 kg ha^{-1}) and potassium (20 kg ha^{-1}) were applied in the form of urea single superphosphate (SSP) and muriate of potash (MOP), respectively as starter dose. Influence of above mentioned treatments on chickpea was studied for growth behavior and seed yields of berseem and growth indices were computed and analyzed statistically using *F*- test, the procedure given by Gomez and Gomez (1984) [3]. Critical difference (CD) values at *P*=0.05 were used to determine the significance of mean differences of treatments.

Leaf area index

$$\text{LAI} = \frac{\text{Leaf area (cm}^2\text{ plant}^{-1}\text{)}}{\text{Ground area (cm}^2\text{ plant}^{-1}\text{)}}$$

Leaf area duration

$$\text{LAD (days)} = \frac{L_1 + L_2}{2} \text{ x } (t_2 - t_1)$$

Crop growth rate

$$\text{Crop growth rate (g plant}^{-1}\text{ day}^{-1}\text{)} = \frac{W_2 - W_1}{t_2 - t_1}$$

Relative growth rate

$$\text{RGR (g g}^{-1}\text{ day}^{-1}\text{)} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Net assimilation rate

$$\text{NAR (g cm}^{-2}\text{ day}^{-1}\text{)} = \frac{W_2 - W_1}{t_2 - t_1} \text{ x } \frac{\log_e L_2 - \log_e L_1}{L_2 - L_1}$$

Results and Discussion

Among herbicides, higher plant height was noticed in herbicidal oxyfluorfen 150 g ha^{-1} (PE) *fb* propaquizafop 100 g ha^{-1} (PoE) which was found at par with oxyfluorfen 150 g ha^{-1} (PE) *fb* quizalofop-p-ethyl 100 g ha^{-1} (PoE), metribuzin 350 g ha^{-1} (PE) *fb* propaquizafop 100 g ha^{-1} (PoE) and metribuzin 350 g ha^{-1} (PE) *fb* quizalofop-p-ethyl 100 g ha^{-1} (PoE), but significantly superior over rest of the herbicidal treatments. Further analysis of data also indicated that hand weeding twice at 20 and 40 DAS had maximum plant height and significantly minimum plant height was recorded under unweeded control during both the years of experiment and in mean.

maximum number of primary branches was recorded with oxyfluorfen 150 g ha^{-1} (PE) *fb* propaquizafop 100 g ha^{-1} (PoE), which was found to be at par with oxyfluorfen 150 g ha^{-1} (PE) *fb* quizalofop-p-ethyl 100 g ha^{-1} (PoE), oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE), metribuzin 350 g ha^{-1} (PE) *fb* propaquizafop 100 g ha^{-1} (PoE), metribuzin 350 g ha^{-1} (PE) *fb* quizalofop-p-ethyl 100 g ha^{-1} (PoE) and metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.5 g ha^{-1} (PoE) and significantly higher over rest of the herbicides and their combinations. Further among all treatments hand weeding twice at 20 and 40 DAS produced maximum number of primary branches while unweeded control produced significantly lower number of primary branches during 2021-22, 2022-23 and on mean basis.

Among herbicidal treatments, significantly maximum number of secondary branches plant^{-1} was noted under oxyfluorfen 150 g ha^{-1} (PE) as pre-emergence *fb* topramezone 20.6 g ha^{-1} (PoE) which remained at par to metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE). Hand weeding twice at 20 and 40 DAS produced maximum number of secondary branches among all applied treatments whereas unweeded control failed to produce comparable number of secondary branches plant^{-1} to any of herbicidal treatment or their combination during both the years of experiment and in mean.

Higher number of leaves plant^{-1} was noticed under oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE), among herbicides, which was found at par with metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) but significantly superior over rest of the herbicides and their combinations. Data also shown that, hand weeding twice at 20 and 40 DAS had maximum number of leaves plant^{-1} but significantly minimum number of leaves plant^{-1} was recorded under unweeded control, during both the years and on mean basis.

Among herbicidal treatments, the highest leaf area plant^{-1}, leaf area index (LAI) and leaf area duration (LAD) were recorded for oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) which was found to be on par with metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE), oxyfluorfen 150 g ha^{-1} (PE) *fb* propaquizafop 100 g ha^{-1} (PoE), oxyfluorfen 150 g ha^{-1} (PE) *fb* quizalofop-p-ethyl 100 g ha^{-1} (PoE), metribuzin 350 g ha^{-1} (PE) *fb* propaquizafop 100 g ha^{-1} (PoE) and metribuzin 350 g ha^{-1} (PE) *fb* quizalofop-p-ethyl 100 g ha^{-1} (PoE) but was significantly higher to all other herbicides as well as their combinations. Furthermore, treatment hand weeding twice at 20 and 40 DAS resulted in maximum leaf

area plant^{-1}, leaf area index and leaf area duration while unweeded control recorded the minimum during two years of investigation *i.e.*, 2021-22 and 2022-23 and mean basis.

Significantly higher total dry matter accumulation plant^{-1} was recorded in herbicidal combinations of oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) which was found at par with metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) but significantly superior over rest of the herbicides and their combinations. Further analysis of data also revealed that hand weeding twice accumulated significantly maximum dry matter which was found at par with herbicidal combinations *viz.,* oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) and metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) but significantly superior over rest of treatments while unweeded control recorded the lowest dry matter accumulation plant^{-1}, during both the years and on pooled mean basis.

Crop growth rate (CGR) was increased with the advancement of crop age upto 90 DAS and it was decreased thereafter. Among herbicidal treatments, oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) was proved to be best in increasing crop growth rate throughout the period of investigation followed by metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE). The increasing trend of CGR from 60-90 DAS was presented by these two treatments while in all remaining treatments CGR was found to be increased upto 60 DAS and decreased thereafter from 60-90 DAS. Among weed management practices, throughout the crop growth period, hand weeding twice at 20 and 40 DAS was proved to be best in increasing CGR while, unweeded control showed the minimum crop growth rate of chickpea than rest of the treatments, during both the years and on pooled mean basis.

Relative growth rate (RGR) was found to be maximum between 30-60 DAS and a decreasing trend was observed after 60 DAS in all the treatments. Among herbicidal treatments, oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) was proved best regarding RGR followed by metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) throughout the growth period of crop during both the years of investigation. Further, hand weeding twice at 20 and 40 DAS has proved to be best with regards to relative growth rate whereas, unweeded control resulted in the poorest RGR at all stages of crop growth. during two years of investigation *i.e.* 2021-22 and 2022-23 and mean basis.

Net assimilation rate (NAR) was computed for 30-60 DAS and 60-90 DAS and observed that it was increased maximum between 30-60 DAS and thereafter from 60-90 DAS decreased in all the treatments during 2021-22, 2022-23 and on mean basis.

Significantly higher root length was noticed in herbicidal combinations of oxyfluorfen 150 g ha^{-1} (PE) *fb* propaquizafop 100 g ha^{-1} (PoE) which was found at par with oxyfluorfen 150 g ha^{-1} (PE) *fb* quizalofop-p-ethyl 100 g ha^{-1} (PoE), metribuzin 350 g ha^{-1} (PE) *fb* propaquizafop 100 g ha^{-1} (PoE) and metribuzin 350 g ha^{-1} (PE) *fb* quizalofop-p-ethyl 100 g ha^{-1} (PoE) but significantly superior over rest of the treatments. Further analysis indicated that hand weeding twice resulted in maximum root length while unweeded control recorded the minimum during 2021-22, 2022-23 and on mean data basis, respectively.

Significantly higher root dry weight recorded in combined application of oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) which was found at par with metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) but significantly superior over others. Further analysis of data also revealed that hand weeding twice recorded significantly higher root dry weight whereas, unweeded control produced significantly lower, during 2021-22, 2022-23 and mean.

Hand weeding twice was found to be the best with respect to all growth attributes followed by chemical treatments of oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) and metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE). In agreement with present results, Merga and Alemu, 2019 [4] found differences in plant height due to various intensities of weed competition with crop plants. The lower plant height in topramezone treated plots was might be due to the fact that herbicides greatly reduced the weed infestation, but affect the plant by reducing the plant height and other growth parameters. Marwat *et al.,* 2011 also reported that weed control significantly increased the plant height of crop due to less weed-crop competition. These findings were in agreement with Rupareliya *et al.*, 2017 [7]. Increased branches with reduced weed produced more number of branches, might be owing to the fact that treatments which have better weed control efficiency caused more horizontal crop growth as a result produced more number of branches plant^{-1}. These results are supported by the findings of Muhammad, 2011 [5].

Crop dry matter is a net result of photosynthesis which remains in balanced after respiration process. At the same time, growth attributes *e.g.* plant height, number of branches and plant population have the direct bearing in contributing the dry matter accumulation, while density and the dry weight of the weeds have a strongly negative correlation. This is very true here also that the treatments, reduced the density and dry weight of the weeds more effectively, provided a more favourable micro-environment to enhance the crop growth and ultimately having more crop dry weight in the respective treatments. Similar findings have been reported by Tiwari and Meena, 2014. The crop growth rate showed increased trend upto 60 DAS and decreased thereafter. The increase in CGR upto 60 DAS due to the fact that after 60 DAS source sink relationship was occurred and translocation of photosynthates from vegetative to reproductive parts took place which lead to decrease in vegetative growth and increase in reproductive growth. The positive correlation between growth parameters and yield, negative correlation between dry matter of crop and weeds confirms the benefitial effect of growth parameters on yield and detrimental effect of dry matter of weeds on dry matter of crop.

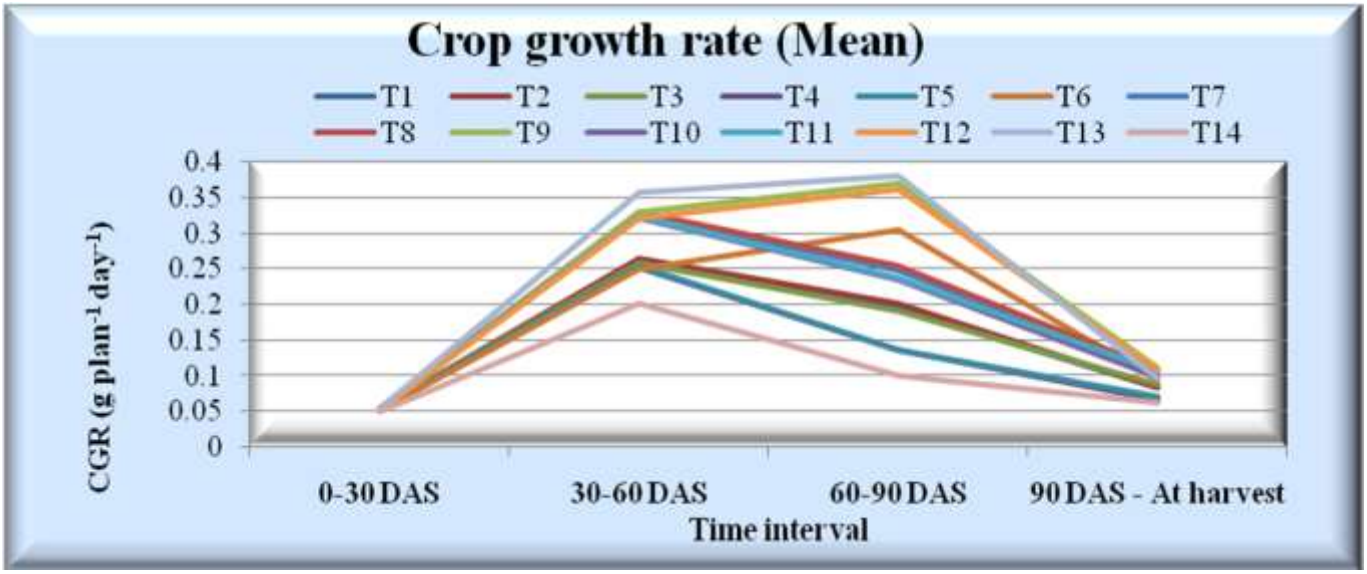

Fig 1: Effect of different herbicides on crop growth rate of chickpea

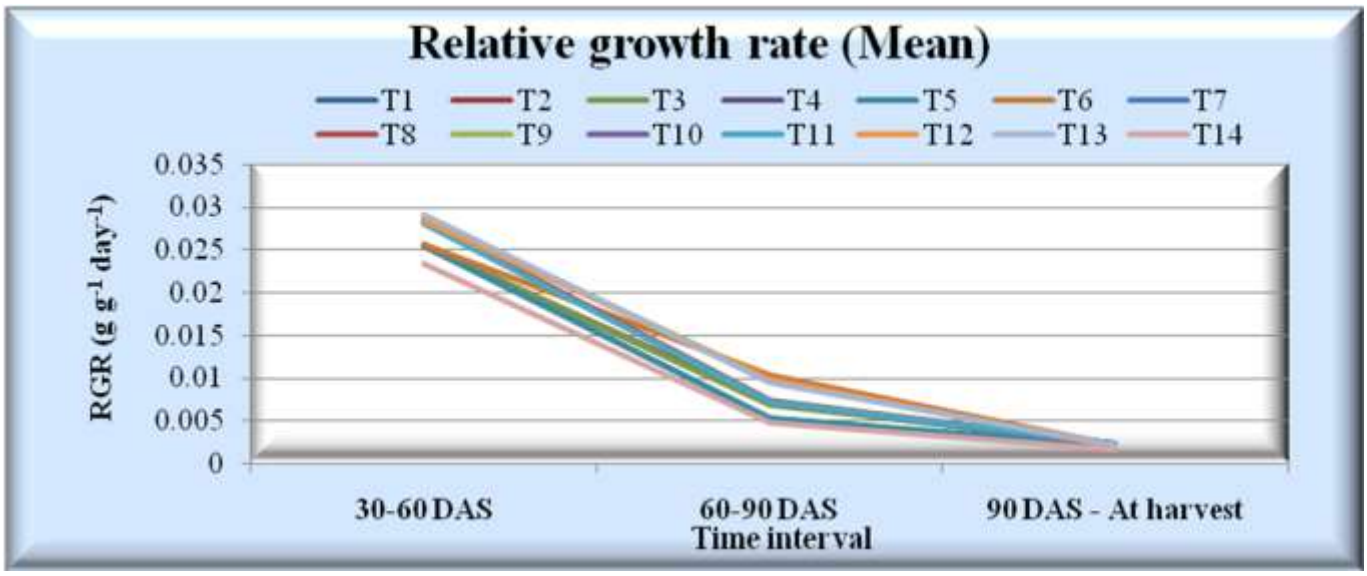

Fig 2: Effect of different herbicides on relative growth rate of chickpea

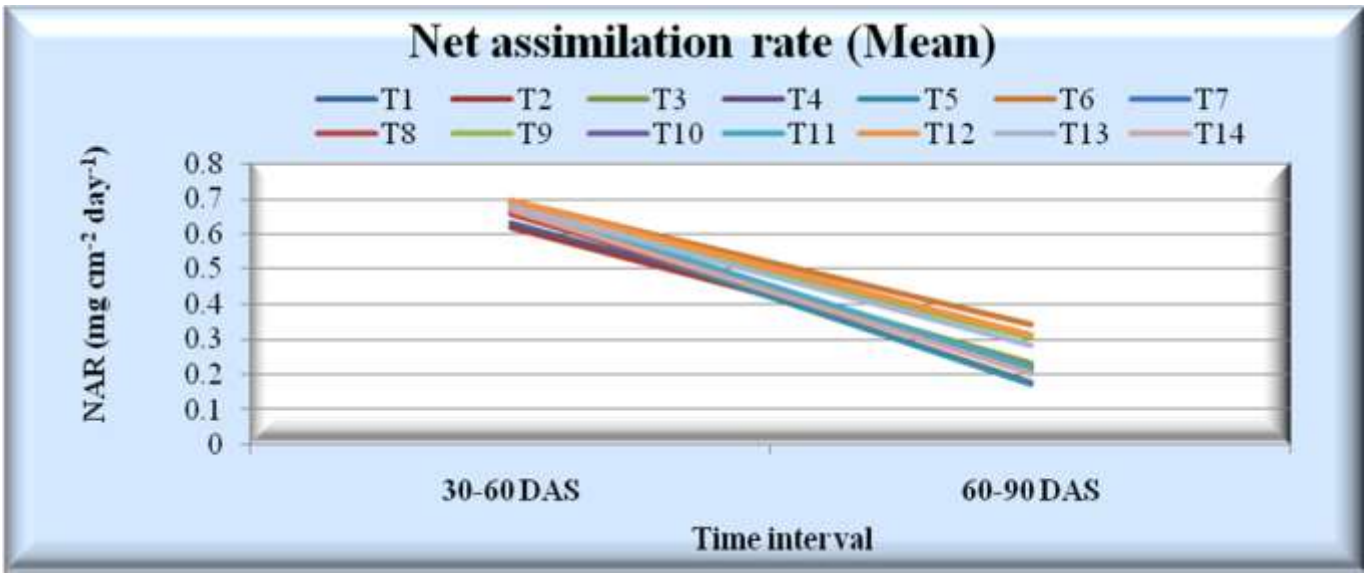

Fig 3: Effect of different herbicides on net assimilation rate of chickpea

Table 1: Effect of different herbicides on growth attributes of chickpea

Treatments			Plant height (cm)			Number of primary branches plant^{-1}			Number of secondary branches plant^{-1}			Number of leaves plant^{-1}			Leaf area plant^{-1} (cm^2)		
	Herbicide	Dose (g ai. ha^{-1})	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean
T_1	Oxyfluorfen (PE)	150	40.3	49.5	44.9	2.7	2.5	2.6	13.7	12.6	13.2	74.5	66.1	70.3	438.2	389.7	414.0
T_2	Oxyfluorfen (PE)	250	40.6	50.0	45.3	2.8	2.5	2.7	14.1	13.0	13.5	75.2	66.5	70.9	442.8	395.4	419.1
T_3	Metribuzin (PE)	350	40.1	49.1	44.6	2.7	2.5	2.6	13.7	12.5	13.1	72.2	64.1	68.2	417.8	371.9	394.8
T_4	Quizalofop-p-ethyl (PoE)	100	37.9	47.2	42.5	2.6	2.3	2.5	13.3	12.1	12.7	68.3	61.9	65.1	384.7	354.1	369.4
T_5	Propaquizafop (PoE)	100	38.1	47.3	42.7	2.6	2.4	2.5	13.3	12.2	12.8	69.5	61.9	65.7	401.2	353.7	377.5
T_6	Topramezone (PoE)	20.6	40.9	50.2	45.5	2.9	2.6	2.7	16.2	15.1	15.7	87.5	76.7	82.1	532.0	460.3	496.2
T_7	Oxyfluorfen (PE) *fb* Quizalofop-p-ethyl (PoE)	150+100	46.8	56.8	51.8	3.3	3.1	3.2	17.1	16.0	16.6	91.6	80.9	86.2	592.0	519.7	555.8
T_8	Oxyfluorfen (PE) *fb* Propaquizafop (PoE)	150+100	47.1	56.7	51.9	3.3	3.2	3.3	17.5	16.5	17.0	92.3	81.3	86.8	605.5	533.1	569.3
T_9	Oxyfluorfen (PE) *fb* Topramezone (PoE)	150+20.6	41.4	50.7	46.0	3.2	3.1	3.1	19.7	18.1	18.9	100.5	89.5	95.0	676.2	601.7	639.0
T_{10}	Metribuzin (PE) *fb* Quizalofop-p-ethyl (PoE)	350+100	46.5	55.3	50.9	3.1	3.0	3.1	16.3	15.2	15.7	88.6	79.7	84.1	553.8	493.9	523.9
T_{11}	Metribuzin (PE) *fb* Propaquizafop (PoE)	350+100	46.7	56.1	51.4	3.1	3.1	3.1	16.4	15.3	15.9	89.3	79.9	84.6	559.0	500.9	530.0
T_{12}	Metribuzin (PE) *fb* Topramezone (PoE)	350+20.6	41.2	50.2	45.7	3.1	3.0	3.0	19.7	18.0	18.8	98.6	87.7	93.1	653.5	578.2	615.8
T_{13}	Hand weeding twice		47.8	57.7	52.8	3.5	3.3	3.4	20.8	18.7	19.7	102.5	92.3	96.9	715.7	649.9	682.8
T_{14}	Unweeded control		32.3	40.6	36.4	2.2	1.9	2.1	11.2	10.1	10.7	56.9	50.7	53.8	248.9	223.1	236.0
SEm±			1.67	2.30	1.47	0.13	0.10	0.09	0.66	0.66	0.48	3.3	3.0	2.3	43.8	39.6	39.7
CD (P=0.05)			4.86	6.68	4.29	0.39	0.30	0.27	1.91	1.92	1.39	9.6	8.7	6.8	127.3	115.1	115.4

Table 2: Effect of different herbicides on growth attributes of chickpea

Treatments			Leaf area index			Leaf area duration (days)			Dry matter accumulation (g plant^{-1})			Root length (cm)			Root dry weight (g plant^{-1})		
	Herbicide	Dose (g ai. ha^{-1})	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean
T_1	Oxyfluorfen (PE)	150	1.46	1.30	1.38	39.9	35.3	37.6	20.10	17.29	18.70	15.1	13.3	14.2	1.78	1.61	1.70
T_2	Oxyfluorfen (PE)	250	1.48	1.32	1.40	40.6	36.2	38.4	20.13	17.75	18.94	15.7	14.0	14.9	1.82	1.64	1.73
T_3	Metribuzin (PE)	350	1.39	1.24	1.32	38.5	33.9	36.2	20.03	17.05	18.54	14.9	13.0	14.0	1.77	1.58	1.68
T_4	Quizalofop-p-ethyl (PoE)	100	1.28	1.18	1.23	35.9	32.2	34.0	17.17	14.52	15.84	14.2	12.0	13.1	1.71	1.51	1.61
T_5	Propaquizafop (PoE)	100	1.34	1.18	1.26	36.8	32.2	34.5	17.30	14.85	16.08	14.3	12.4	13.4	1.72	1.52	1.62
T_6	Topramezone (PoE)	20.6	1.77	1.53	1.65	43.0	37.0	40.0	22.97	20.79	21.88	18.2	16.3	17.3	2.06	1.88	1.97
T_7	Oxyfluorfen (PE) *fb* Quizalofop-p-ethyl (PoE)	150+100	1.97	1.73	1.85	53.7	47.3	50.5	24.20	22.29	23.25	21.2	19.4	20.3	2.14	1.96	2.05
T_8	Oxyfluorfen (PE) *fb* Propaquizafop (PoE)	150+100	2.02	1.78	1.90	54.7	48.3	51.4	24.53	22.65	23.59	21.3	19.5	20.4	2.15	1.97	2.06
T_9	Oxyfluorfen (PE) *fb* Topramezone (PoE)	150+20.6	2.25	2.01	2.13	56.7	50.5	53.6	28.07	25.75	26.91	18.7	17.2	17.9	2.40	2.23	2.32
T_{10}	Metribuzin (PE) *fb* Quizalofop-p-ethyl (PoE)	350+100	1.82	1.65	1.73	49.4	44.6	47.0	23.33	21.21	22.27	21.0	19.2	20.1	2.09	1.91	2.00
T_{11}	Metribuzin (PE) *fb* Propaquizafop (PoE)	350+100	1.86	1.67	1.77	50.5	45.1	47.8	23.67	21.67	22.67	21.2	19.3	20.2	2.11	1.92	2.02
T_{12}	Metribuzin (PE) *fb* Topramezone (PoE)	350+20.6	2.18	1.93	2.05	54.1	48.7	51.3	27.47	25.33	26.40	18.6	16.8	17.7	2.39	2.21	2.30
T_{13}	Hand weeding twice		2.39	2.17	2.28	61.9	55.8	58.9	28.57	26.54	27.55	22.3	20.0	21.1	2.42	2.27	2.35
T_{14}	Unweeded control		0.76	0.68	0.72	23.0	19.8	21.4	14.37	11.78	13.07	11.9	10.3	11.1	1.47	1.29	1.38
SEm±			0.15	0.13	0.13	2.85	2.62	2.54	0.95	0.92	0.63	0.79	0.58	0.52	0.08	0.07	0.07
CD (P=0.05)			0.42	0.38	0.38	8.29	7.60	7.40	2.77	2.66	1.83	2.30	1.70	1.50	0.23	0.20	0.21

Table 3: Effect of different herbicides on Yield of chickpea

Treatments			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Biological yield (kg ha^{-1})		
	Herbicide	Dose (g ai. ha^{-1})	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean
T_1	Oxyfluorfen (PE)	150	1297	1111	1204	2057	1900	1979	3354	3011	3183
T_2	Oxyfluorfen (PE)	250	1387	1213	1300	2090	1952	2021	3477	3166	3321
T_3	Metribuzin (PE)	350	1249	1091	1170	1984	1861	1922	3232	2952	3092
T_4	Quizalofop-p-ethyl (PoE)	100	1000	862	931	1757	1589	1673	2757	2451	2604
T_5	Propaquizafop (PoE)	100	1034	867	950	1764	1640	1702	2798	2507	2652
T_6	Topramezone (PoE)	20.6	1540	1438	1489	2332	2181	2257	3873	3619	3746
T_7	Oxyfluorfen (PE) *fb* Quizalofop-p-ethyl (PoE)	150+100	1627	1530	1579	2462	2329	2396	4089	3859	3974
T_8	Oxyfluorfen (PE) *fb* Propaquizafop (PoE)	150+100	1630	1556	1593	2474	2347	2410	4104	3902	4003
T_9	Oxyfluorfen (PE) *fb* Topramezone (PoE)	150+20.6	1780	1771	1776	2690	2718	2704	4471	4489	4480
T_{10}	Metribuzin (PE) *fb* Quizalofop-p-ethyl (PoE)	350+100	1544	1471	1507	2357	2249	2303	3901	3720	3810
T_{11}	Metribuzin (PE) *fb* Propaquizafop (PoE)	350+100	1577	1488	1532	2386	2309	2347	3963	3797	3880
T_{12}	Metribuzin (PE) *fb* Topramezone (PoE)	350+20.6	1770	1722	1746	2674	2667	2670	4444	4389	4416
T_{13}	Hand weeding twice		1812	1802	1807	2721	2784	2752	4533	4587	4560
T_{14}	Unweeded control		527	475	501	1539	1384	1462	2066	1859	1963
SEm±			49.2	45.3	30.0	73.8	81.1	53.6	86.5	93.1	61.2
CD (P=0.05)			143.0	131.6	87.1	214.6	235.8	155.7	251.3	270.8	177.9

Figures rounded up to nearest value

Conclusion

Herbicidal combination of oxyfluorfen 150 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE) recorded significantly lower density of weed, dry matter production of weed and thus, increased growth and yield of chickpea over rest of the other herbicidal treatments except metribuzin 350 g ha^{-1} (PE) *fb* topramezone 20.6 g ha^{-1} (PoE). Hand weeding twice at 20 and 40 DAS however, proved to be best regarding these parameters.

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