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Bio-efficacy of imazethapyr in chickpea (*Cicer arietinum* L.) under the lateritic belt of West Bengal

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Abstract

A field experiment was conducted during the *rabi* season of 2020-21 in the Agricultural Farm of the Institute of Agriculture (Palli Siksha Bhavana), Visva-Bharati, Sriniketan, Birbhum, West Bengal. The experiment was laid out in randomized block design with nine treatments each were replicated thrice, the treatments are T_1 - Imazethapyr 30 gha^{-1} as PE, T_2 -Imazethapyr 40 gha^{-1} as PE, T_3 - Imazethapyr 50 gha^{-1} as PE, T_4 - Imazethapyr 30 gha^{-1} as POE, T_5- Imazethapyr 40 gha^{-1} as POE, T_6 - Imazethapyr 50 gha^{-1} as POE, T_7 -Pendimetalin 750 gha^{-1} as PE, T_8 – Weed-free, T_9 - Weedy check. The experimental results clearly indicated the need for different weed management practices to reduce the influence of weeds in chickpea cultivation. Among the Imazethapyr treatments, Imazethapyr 50 gha^{-1} as POE recorded the lowest density and dry weight of weeds, higher weed control efficiency (64.42%), which resulted in higher growth parameters, yield attributes, and higher seed and stover yield. Herbicides controlled weeds to a greater extent. Weed infestation caused about a 79.16% reduction in yield in chickpea crops. And among the herbicidal treatments, the pendimethalin 750 gha^{-1} PE (T_7) showed better results and gives good economic values.

Keywords: Bio-efficacy, imazethapyr, weed management, pre and post-emergence

Introduction

Among the grain legumes, Chickpea (*Cicer arietinum* L., Fabaceae) is an important food legume commonly known as Bengal gram and locally as Chana, unique food legume. It leaves a substantial amount of residual nitrogen for subsequent crops and adds plenty of organic matter to maintain and improve soil health and fertility. Because of its deep tap root system, chickpea can withstand drought conditions by extracting water from deeper layers in the soil profile so it has a great role in dryland agriculture. Two types of chickpea are recognized, desi and Kabuli types. The seeds of desi types are small having dark brown in color with a thick seed coat, whereas the seeds of Kabuli types are large having whitish-cream color with a thin seed coat. Chickpea is the largest produced food legume of south Asia and the third-largest produced food legume globally, after common bean and field pea. Chickpea is grown in more than 50 countries. India is the largest chickpea producing country accounting for 64% of the global chickpea production. In India, the chickpea crop ranks first among pulses, occupying about 30% of the total cultivated area of pulses and contributing 40% of total pulse production (Ready *et al*. 2007) [13]. In India, major chickpea growing states are Madhya Pradesh, Rajasthan, Bihar, Maharashtra, Uttar Pradesh, Karnataka and West Bengal. In West Bengal, it covers an area of 0.215 million hectares with a production of 0.21 million tonnes and an average yield of 976.74 kg ha^{-1} (Anonymous, 2017) [1]. India is also the largest chickpea importing country in the world (Anonymous, 2019) [2]. Hence, there is need a to augment the productivity of chickpea to meet the requirement.

The productivity of chickpea is low in spite of high-yielding varieties and new agronomic practices. There are several factors responsible for the low productivity of the crop. The pulses being a poor competitor to weeds, especially during initial growth stages, suffer considerable resulted in yield loss. Crop yield losses due to weeds have been estimated to be 54.7% (Poonia and Pithia 2013) [9]. The degree of yield loss varies from 18-90%, depending on the growing conditions, crop species, and management practices (Prasad, 2014) [10]. The critical period for crop-weed competition is defined as the number of weeks after crop emergence, during which a crop must be weed-free to prevent yield losses greater than 5% (Rathod *et al*., 2017) [11]. Chickpea has a short stature, slow early-season growth rate, and open-canopy growth habit, which make them poor competitors with weeds.

The short plants and open canopy allow early emerging weeds to compete with chickpea from emergence until late in the season and later emerging weeds to grow without much foliar competition. Most weeds will exceed the chickpea canopy height a few weeks after emergence. The weed height can be several times that of the chickpea crop. If the weeds are not controlled at the right stages, there is a significant loss in yield occurred. Depending upon the intensity of weed flora and duration of weed infestation, weed management is neglected under these conditions, resulting in yield loss of 40 to 87% in Andhra Pradesh (Ratnam *et al*., 2011) [12]. Physical method or manual weeding is a traditional method of weed management in chickpea cultivation. Although hand weeding in chickpea crops is very easy and environment friendly but it is tedious and highly labour intensive and drudgery. Hand wedding can control the weeds efficiently but unavailability of labour during peak periods and high wages of labour needs for alternative methods of weed control. Chemical weed control with the help of herbicides by pre-plant incorporation (PPI), pre-emergence, post-emergence, and a combination of all of them is very effective for weed control. Herbicidal weed management becomes a competitive and promising way to control weed in chickpea because of its short stature and slow initial growth, at least in the early stages of the chemical method of weeding is very easy, flexible and cheaper than using costly labors for weeding purposes. Furthermore, this method is very useful in different climatic and edaphic conditions and shows effective results compared to tedious manual weeding. Both by increasing herbicide use efficiency and reducing injury to crop by applying recommended doses, crop yield can be improved by chemical method.

Materials and Methods

A field experiment was conducted in chickpea to know the effect of Imazethapyr on population and dry weight of weeds and growth and productivity of chickpea (*Cicer arietinum* L.) at the Agricultural Farm, Block-D, Plot no. 04 of the (PalliSiksha Bhavana) Institute of Agriculture, Visva-Bharati, Sriniketan, Birbhum, West Bengal during *rabi* season of 2020-21. The field is situated at 23°40’9” North latitude and 87°39’27” east longitude at an average altitude of 58.90m above the mean sea level (MSL) sub-humid, semi-arid region of West Bengal.

The soil of the experimental plot was sandy loam (*Ultisol*) in texture and the soil was acidic in reaction, low level of organic carbon (0.49%), available nitrogen (157.8 mg kg^{-1}) and potassium content (13.67 mg kg^{-1}), and medium in available phosphorus (167.85 mg kg^{-1}). The experimental site (Sriniketan) is located under the sub-humid red and lateritic agro-ecological zone of the tropics region of West Bengal. The average maximum and minimum temperature varied from 15.11-18.82 ºC and 27.96-34.17 ºC, respectively. The total rainfall and humidity recorded during the cropping period were 0.03 mm, and 86-94.28%, respectively. The experiment was laid out in randomized block design, replicated thrice within a plot, and involved nine treatment combinations (Table 1). The chickpea variety used for the experiment was Anuradha (WBG-39), which is a wilt-resistant high yielding (25 Qt./ha) variety suitable to be grown in West Bengal. The crop was fertilized at the rate of 30 kg N, 60 kg P_2O_5, and 60 kg K_2O ha^{-1} in all the treatments. Nitrogen was applied through urea at the time of sowing; P_2O_5 and K_2O were applied as a single basal dose in the form of diammonium phosphate (SSP) and muriate of potash (MOP). Chickpea is a deep-rooted as well as drought-resistant crop. The crop is grown without irrigation. Herbicides were applied through a knap-sac sprayer fitted with a flat fan nozzle. Weed density or count was taken from each plot at a randomly selected place with the help of a quadrate of 0.5m x 0.5m at 30, 60, 90 DAS, and at harvest. The number of weeds was counted and data were presented per m^2 and subjected to statistical analysis after square root transformation with the following formula -$\sqrt{(X + 0.5)}$. The weed samples used for the recording of weed density were uprooted from the area under each quadrant placed in each plot on the same dates 30, 60, 90 DAS, and at harvest. The weeds were cleaned thoroughly by washing with water, kept in sunlight for drying, and were placed in a hot air oven for drying at 65 °C for 72 hours or more till constant weights were recorded. Weed control efficiency was computed using the dry weight of weeds. The total weed control efficiency was determined by using the total dry weight of weeds irrespective of species. It can be worked out from a reduction in weed dry weight due to the o weed control method over the weedy check. To determine the WCE of individual treatment, the following formula was used and expressed in percentage.

$$\text{WCE (\%)} = \frac{\text{DMC} - \text{DMT}}{DMC} x100$$

Where WCE=Weed control efficiency; DMC= Dry matter of weed in control plot; DMT= Dry matter of weed in the treated plot. Growth attributes taken for estimation were e.g. number of branches per plant, the height of the plant, LAI, and CGR. Yield attributes taken for yield estimation were the number of pods per plant, number of seeds per pod, number of seeds per plant, test weight, and seed yield. The harvest index was calculated by biological and economic yield as described by Donald (1962). Seed and stover yield was determined from the net plot area and were weighed in kg and converted into q ha^{-1}. The Economics of different treatments was calculated by taking into account the prevailing market price of inputs and produce. Gross returns were worked out for each treatment based on the quality and market prices of the produce. The net returns were worked out by deducting the cost incurred from the gross returns of the particular treatment. Returns per rupee invested were calculated on basis of the gross return to the cost of cultivation. The benefit-cost (B: C) ratio was incurred by dividing the net return by the cost of cultivation. Statistical analysis was performed using the SPSS statistical software package.

Results and Discussion

The experiment was laid out in Randomized Block Design (RBD) with nine treatments and three replications. The treatments consisted of T_1 - Imazethapyr 30gha^{-1} as PE, T_2 - Imazethapyr 40gha^{-1} as PE, T_3 - Imazethapyr 50gha^{-1} as PE, T_4 - Imazethapyr 30gha^{-1} as POE, T_5- Imazethapyr 40gha^{-1} as POE, T_6 - Imazethapyr 50gha^{-1} as POE, T_7 -Pendimetalin 750 gha^{-1} as PE, T_8 – Weed-free, T_9 - Weedy check. The variety used for the experiment was Anuradha (WBG-39) which matured in 110 days. The predominant weed flora present in the experimental field were *Digitaria sanguinalis*, *Echinochloa colonum* and *Cynodon dactylon* among grasses, *Polygonum plebeian*, *Euphorbia hirta*, *Chenopodium album* L., *Malvastrum coromandelianum*, and *Amaranthus Viridis* among broadleaved weeds. and no sedges were found in the experimental field. The highest density of grasses and broadleaved weeds was observed in the weedy check (T_9) and lowest in weed-free plots in all the observations. (Table-1). Imazethapyr 30, 40, and 50 g ha^{-1} as POE reduced weed density and dry weight than its PE application. Among the post-emergence application of imazethapyr, imazethapyr 50 g ha^{-1} as POE recorded lower density and dry weight of all categories weeds. (Kaushik *et al*. 2014; Bhutada and Bhale 2013; Lyon and Wilson 2005) [6, 13, 8]. Among all the chemical treatments pendimethalin 750 gha^{-1} PE (T_7) recorded the lowest density and dry weight of weeds. (Table-2) (Yadav *et al*. (2019) [15].

Next to weed-free (T_8), pendimethalin 750 gha^{-1} PE (T_7) and imazethapyr 50 g ha^{-1} as POE resulted higher growth parameters such as plant height, number of branches, aerial dry matter accumulation, LAI, and CGR in most of the observations. The lowest growth parameters were observed under weedy check. Imazethapyr pre-emergence application recorded lower growth parameters than its post-emergence application and pendimethalin. (Table-3). The no. of pods $plant^{-1}$ and the no. of seeds pod^{-1} were observed maximum in weed-free plot followed by T_7 (pendimethalin 750 gha^{-1} PE) and imazethapyr 50 g ha^{-1} as POE (T_6). (Table-4 & 5) (Kakade *et al*., 2020); (Kumar and Sarkar 2020) [1, 7].

The highest seed and stover yield was recorded in weed free (T_8) recorded the highest seed yield (1485.57 kg ha^{-1}) of chickpea which was significantly higher thanT_1 to T_7. (Gore *et al*., 2018). Significantly lower seed yield (303.70 kg ha^{-1}) was obtained under T_9 (weedy check) than T_4 to T_8. T_1, T_2 and T_3 were statistically at par among them and recorded significantly lower seed yield than T_4, T_5, T_6, T_7 and T_8. Among all the imazethapyr treatment T_6 (imazethapyr 50 g ha^{-1} POE) recorded the highest seed yield and was at par with T_5. (Gupta *et al*., 2012) [4]. (Table-6).

Pendimethalin 750 gha^{-1} PE recorded higher net return (Rs. 70505.00 ha^{-1}) among all the chemical treatments and among imazethapyr treatments, T_6 (imazethapyr 50 g ha^{-1} as POE) recorded higher net return (Rs.41388.50 ha^{-1}) and returns per invested was highest in T_7 (3.41) followed by T_8 and T_6 which were statistically at par with each other and significantly higher than.T_1 to T_5. Yield loss due to uncontrolled weed growth in chickpea is 79.16%. Pendimethalin 750 gha^{-1}as PE and imazethapyr 50 g ha^{-1} as POE controlled the weeds effectively and recorded higher growth parameters, yield attributes and yield of chickpea. (Table-7).

Imazethapyr as post-emergence was found more effective than its pre-emergence application in lowering density and dry weight of weeds of chickpea and recording higher growth parameters, yield attributes, and yield of chickpea. (Singh *et al*., 2014) [14]. The use of imazethapyr with 50 g ha^{-1} as post-emergence provides not only effective control of all categories of weeds (grasses and broadleaf weeds in the experiment) but also provides better crop growth, productivity, and profitability of chickpea crop. Therefore, imazethapyr with the dose of 50 g ha^{-1}as post-emergence may be considered as promising weed management in chickpea crops under the lateritic belt of West Bengal.

Table 1: Effect of treatments on the density of weeds at intervals of 30, 60, 90 DAS and at harvest.

Different treatments	Density of weeds (No. m^{-2}) at 30 DAS			Density of weeds (No. m^{-2}) at 60 DAS			Density of weeds (No. m^{-2}) at 90 DAS			Density of weeds (No. m^{-2}) at harvest		
	Grasses	BLW	Total	Grasses	BLW	Total	Grasses	BLW	Total	Grasses	BLW	Total
T_1 Imazethapyr 30 g ha^{-1} PE	10.84 (118.8)	10.25 (104.67)	21.09 (223.47)	11.38 (132.94)	13.16 (178.36)	24.54 (311.3)	11.45 (132.92)	12.25 (150.99)	23.70 (283.91)	11.70 (138.51)	12.21 (152.10)	23.91 (290.61)
T_2 Imazethapyr 40 g ha^{-1} PE	10.25 (108.27)	9.60 (101.33)	19.85 (209.60)	11.23 (128.90)	12.61 (162.59)	23.84 (291.49)	11.08 (124.11)	11.98 (146.34)	23.06 (270.45)	11.46 (134.45)	11.99 (146.05)	23.45 (280.5)
T_3 Imazethapyr 50 g ha^{-1} PE	10.10 (106.16)	9.17 (84.00)	19.27 (190.16)	10.78 (118.21)	12.35 (155.39)	23.13 (273.6)	10.97 (122.63)	11.62 (138.07)	22.59 (260.70)	11.24 (131.54)	11.36 (132.83)	22.60 (264.37)
T_4 Imazethapyr 30 g ha^{-1} POE	9.95 (99.65)	7.73 (61.33)	17.68 (160.98)	10.47 (110.67)	12.06 (146.05)	22.53 (256.72)	10.63 (116.44)	11.57 (137.13)	22.20 (253.57)	10.96 (121.35)	11.13 (124.82)	22.09 (246.17)
T_5 Imazethapyr 40 g ha^{-1} POE	8.67 (75.29)	6.50 (45.00)	15.17 (120.29)	9.02 (81.97)	10.63 (113.20)	19.65 (195.17)	9.17 (85.37)	9.91 (98.31)	19.08 (183.68)	10.63 (115.75)	9.25 (85.62)	19.88 (201.37)
T_6 Imazethapyr 50 g ha^{-1} POE	7.21 (52.50)	5.36 (29.00)	12.57 (81.50)	8.11 (66.30)	9.43 (89.51)	17.54 (155.81)	7.74 (60.08)	8.15 (67.40)	15.89 (127.48)	9.75 (94.67)	8.34 (70.07)	18.09 (164.74)
T_7 Pendimethalin 750 g ha^{-1} PE	5.14 (26.80)	2.40 (5.33)	7.54 (32.13)	6.67 (44.68)	3.87 (15.14)	10.54 (59.82)	5.76 (36.58)	3.94 (15.53)	9.70 (52.11)	7.94 (62.67)	4.60 (21.19)	12.54 (83.86)
T_8 Weed free	0.71 (0.00)	0.71 (0.00)	1.42 (0.00)	0.71 (0.00)	0.71 (0.00)	1.42 (0.00)	0.71 (0.00)	0.71 (0.00)	1.42 (0.00)	0.71 (0.00)	0.71 (0.00)	1.42 (0.00)
T_9 Weedy check	11.99 (143.82)	11.39 (133.33)	23.38 (277.15)	11.78 (142.99)	13.55 (185.25)	25.33 (328.24)	12.18 (153.81)	12.45 (158.52)	24.63 (312.33)	11.84 (140.00)	12.56 (157.33)	24.40 (297.33)
SEm (±)	0.15	0.18	0.33	0.14	0.16	0.3	0.17	0.19	0.36	0.14	0.13	0.27
CD at 5%	0.45	0.52	0.97	0.41	0.46	0.87	0.48	0.55	1.03	0.42	0.38	0.80
CV (%)	9.06	11.74	20.80	8.12	8.85	16.97	9.46	10.58	20.04	8.13	7.48	15.61

Table 2: Effect of treatments on the dry weight of weeds at intervals of 30, 60, 90 DAS and at harvest.

Different treatments	dry weight of weeds (No. m^{-2}) at 30 DAS			dry weight of weeds (No. m^{-2}) at 60 DAS			dry weight of weeds (No. m^{-2}) at 90 DAS			dry weight of weeds (No. m^{-2}) at harvest		
	Grasses	BLW	Total	Grasses	BLW	Total	Grasses	BLW	Total	Grasses	BLW	Total
T_1 Imazethapyr 30 g ha^{-1} PE	5.27 (28.17)	2.41 (5.35)	7.68 (33.52)	8.43 (72.11)	6.16 (39.42)	14.59 (111.53)	8.90 (80.49)	7.65 (62.34)	16.55 (142.83)	9.28 (86.94)	6.67 (44.40)	15.95 (131.34)
T_2 Imazethapyr 40 g ha^{-1} PE	4.92 (24.16)	2.38 (5.17)	7.30 (29.33)	8.30 (69.11)	5.90 (35.90)	14.20 (105.01)	8.69 (76.37)	7.49 (57.05)	16.15 (133.42)	8.94 (83.90)	6.36 (40.07)	15.30 (123.97)
T_3 Imazethapyr 50 g ha^{-1} PE	4.59 (20.80)	2.27 (4.73)	6.86 (25.53)	8.18 (68.02)	5.76 (33.16)	13.94 (101.18)	8.34 (70.26)	7.32 (53.82)	15.66 (124.08)	8.77 (77.46)	6.34 (39.73)	15.11 (117.37)
T_4 Imazethapyr 30 g ha^{-1} POE	4.40 (19.35)	2.21 (4.47)	6.61 (23.82)	8.10 (67.23)	5.22 (27.13)	13.32 (94.36)	8.17 (67.57)	7.28 (53.56)	15.45 (121.13)	8.54 (74.05)	6.24 (38.40)	14.78 (112.45)
T_5 Imazethapyr 40 g ha^{-1} POE	4.02 (16.10)	1.94 (3.27)	5.96 (19.37)	7.98 (65.35)	3.99 (15.91)	11.97 (81.26)	7.27 (56.05)	6.07 (37.99)	13.34 (94.04)	7.36 (55.37)	5.10 (27.87)	12.46 (83.24)
T_6 Imazethapyr 50 g ha^{-1} POE	3.35 (10.93)	1.69 (2.53)	5.04 (13.46)	6.60 (44.13)	3.03 (9.87)	9.63 (54)	6.38 (41.15)	5.25 (28.86)	11.63 (70.01)	6.81 (46.94)	4.32 (19.27)	11.13 (66.21)
T_7 Pendimethalin 750 g ha^{-1} PE	3.00 (9.04)	0.99 (0.53)	3.99 (9.57)	5.34 (29.58)	1.56 (1.95)	6.90 (31.53)	5.67 (32.64)	3.48 (12.30)	9.15 (44.94)	6.33 (40.23)	2.51 (6.43)	8.84 (46.66)
T_8 Weed free	0.71 (0.00)	0.71 (0.00)	1.42 (0.00)	0.71 (0.00)	0.71 (0.00)	1.42 (0.00)	0.71 (0.00)	0.71 (0.00)	1.42 (0.00)	0.71 (0.00)	0.71 (0.00)	1.42 (0.00)
T_9 Weedy check	5.81 (33.97)	2.51 (5.93)	8.32 (39.9)	10.10 (102.80)	6.60 (43.30)	16.70 (146.10)	10.70 (105.66)	7.91 (64.22)	18.61 (169.88)	9.67 (94.84)	6.95 (47.80)	16.62 (142.64)
SEm (±)	0.1	0.05	0.15	0.14	0.12	0.26	0.13	0.16	0.29	0.14	0.11	0.25
CD at 5%	0.29	0.16	0.45	0.42	0.34	0.76	0.37	0.48	0.85	0.41	0.31	0.72
CV (%)	8.33	6.08	14.41	9.04	9.17	18.21	8.02	11.52	19.54	8.66	7.69	16.35

Table 3: Effect of treatments on weed control efficiency (%) in chickpea at intervals of 30, 60, 90 DAS and at harvest.

Treatment	Weed control efficiency (%)			
	30 DAS	60DAS	90DAS	At harvest
T_1 Imazethapyr 30 g ha^{-1} PE	13.63	23.54	16.38	9.04
T_2 Imazethapyr 40 g ha^{-1} PE	19.94	26.92	20.65	12.40
T_3 Imazethapyr 50 g ha^{-1} PE	32.89	30.88	22.22	15.17
T_4 Imazethapyr 30 g ha^{-1} POE	36.75	34.09	24.11	19.77
T_5 Imazethapyr 40 g ha^{-1} POE	52.03	34.70	31.72	23.28
T_6 Imazethapyr 50 g ha^{-1} POE	64.42	46.54	44.44	35.66
T_7 Pendimethalin 750 g ha^{-1} PE	77.10	59.43	63.25	51.50
T_8 Weed free	100.00	100.00	100.00	100.00
T_9 Weedy check	0.00	0.00	0.00	0.00
SEm (±)	0.35	0.47	0.3	0.37
CD at 5%	1.01	1.38	1.1	1.07
CV (%)	10.01	14.2	11.93	13.3

Table 4: Effect of treatments on plant height, Number of branches plant^{-1} and Leaf Area Index (LAI) at intervals of 30, 60, 90 DAS and at harvest.

Different treatments	Plant height (cm)				Number of branches plant^{-1}				Leaf Area Index (LAI)		
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS
T_1 Imazethapyr 30 g ha^{-1} PE	12.77	19.97	26.30	27.57	11.47	33.93	47.00	64.13	0.35	0.74	0.66
T_2 Imazethapyr 40 g ha^{-1} PE	12.80	20.37	26.47	28.53	12.43	34.20	58.40	66.73	0.36	0.77	0.70
T_3 Imazethapyr 50 g ha^{-1} PE	13.57	21.40	29.97	31.00	15.00	34.60	60.67	71.07	0.40	0.82	0.74
T_4 Imazethapyr 30 g ha^{-1} POE	13.87	22.63	30.37	31.70	15.93	37.00	65.70	72.37	0.41	0.95	0.77
T_5 Imazethapyr 40 g ha^{-1} POE	14.10	23.30	31.00	32.13	16.40	37.53	68.47	75.13	0.43	0.98	0.83
T_6 Imazethapyr 50 g ha^{-1} POE	14.47	23.70	32.53	33.17	17.13	44.07	71.53	83.47	0.45	1.01	0.89
T_7 Pendimethalin 750 g ha^{-1} PE	14.85	24.83	34.67	35.97	17.60	47.00	90.47	88.53	0.49	1.06	1.07
T_8 Weed free	15.13	26.20	35.70	38.07	18.47	49.27	108.53	92.80	0.49	1.15	1.26
T_9 Weedy check	12.55	19.17	25.23	26.50	9.83	30.27	44.30	62.00	0.29	0.61	0.60
SEm (±)	0.59	1.25	1.32	1.41	1.11	1.93	4.05	2.21	0.04	0.08	0.06
CD at 5%	1.7	3.75	3.97	4.24	3.33	5.78	12.13	6.63	0.11	0.24	0.18
CV (%)	7.36	9.66	7.58	7.74	12.89	8.64	10.25	5.1	15.81	15.23	13.59

Table 5: Effect of treatments on Aerial dry matter accumulation (g m^{-2}), Crop Growth Rate (CGR) g m^{-2} day^{-1}, No. of pods $plant^{-1}$ and No. of seeds $pods^{-1}$ at intervals of 30, 60, 90 DAS and at harvest.

Different treatments	Aerial dry matter accumulation (g m^{-2})				Crop Growth Rate (CGR) g m^{-2} day^{-1}				Yield attributes		
	30 DAS	60 DAS	90 DAS	At harvest	0 to 30 DAS	30 to 60 DAS	60 to 90 DAS	90 to harvest	No. of pods $plant^{-1}$	No. of seeds $pods^{-1}$	100 seed weight
T_1 Imazethapyr 30 g ha^{-1} PE	21.9	44.3	73.5	119.9	0.73	0.80	0.96	2.35	9.80	1.03	12.37
T_2 Imazethapyr 40 g ha^{-1} PE	22.4	46.3	77.4	128.1	0.75	0.81	1.04	2.57	10.17	1.07	12.27
T_3 Imazethapyr 50 g ha^{-1} PE	23.4	49.2	80.7	139.1	0.78	0.87	1.05	2.90	10.53	1.13	12.20
T_4 Imazethapyr 30 g ha^{-1} POE	25.6	54.8	85.7	156.0	0.86	0.98	1.09	3.53	11.93	1.17	12.40
T_5 Imazethapyr 40 g ha^{-1} POE	33.2	76.7	121.3	203.9	1.10	1.40	1.50	3.73	13.63	1.20	12.60
T_6 Imazethapyr 50 g ha^{-1} POE	37.5	80.0	129.3	212.2	1.25	1.44	1.63	4.17	15.87	1.23	13.30
T_7 Pendimethalin 750 g ha^{-1} PE	47.0	107.9	198.8	297.8	1.57	2.02	2.70	4.93	21.40	1.27	13.67
T_8 Weed free	58.2	120.0	226.5	334.6	1.94	2.06	3.55	5.43	23.67	1.30	14.50
T_9 Weedy check	19.7	43.6	71.4	87.0	0.66	0.73	0.93	0.79	7.60	1.00	12.00
SEm (±)	2.58	3.51	6.44	9.59	0.09	0.12	0.14	0.23	1.07	0.5	0.55
CD at 5%	7.51	10.21	18.73	27.85	0.27	0.34	0.43	0.69	3.21	0.16	1.65
CV (%)	13.93	8.79	9.44	8.63	14.78	16.18	15.47	11.81	13.38	8.09	7.46

Table 6: Effect of treatments on seed yield, stover yield, harvest index and weed index.

Treatment	Yield (kg ha^{-1})		Harvest Index	Weed index (%)
	Seed Yield	Stover Yield		
T_1 Imazethapyr 30 g ha^{-1} PE	417.03	865.00	32.38	72.03
T_2 Imazethapyr 40 g ha^{-1} PE	443.13	904.00	32.90	69.61
T_3 Imazethapyr 50 g ha^{-1} PE	484.97	983.33	32.98	66.70
T_4 Imazethapyr 30 g ha^{-1} POE	574.87	1155.00	32.75	61.81
T_5 Imazethapyr 40 g ha^{-1} POE	686.43	1367.33	33.34	53.62
T_6 Imazethapyr 50 g ha^{-1} POE	866.67	1600.33	35.15	40.37
T_7 Pendimethalin 750 g ha^{-1} PE	1233.67	2013.33	37.94	16.59
T_8 Weed free	1485.57	2343.00	38.68	0.00
T_9 Weedy check	303.70	639.67	32.23	79.16
SEm (±)	64.93	76.22	1.58	3.57
CD at 5%	188.74	221.58	4.73	10.71
CV (%)	15.58	10.01	7.98	12.11

Table 7: Effect of treatments on economics of chickpea cultivation.

Treatment	Economics of chickpea cultivation			
	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Return per rupee invested
T_1 Imazethapyr 30 g ha^{-1} PE	28425	33795.17	5370.17	1.19
T_2 Imazethapyr 40 g ha^{-1} PE	28585	35902.67	7317.67	1.26
T_3 Imazethapyr 50 g ha^{-1} PE	28745	39289.00	10544.00	1.37
T_4 Imazethapyr 30 g ha^{-1} POE	28425	46566.83	18141.83	1.64
T_5 Imazethapyr 40 g ha^{-1} POE	28585	55598.33	27013.33	1.95
T_6 Imazethapyr 50 g ha^{-1} POE	28745	70133.50	41388.50	2.44
T_7 Pendimethalin 750 g ha^{-1} PE	29195	99700.00	70505.00	3.41
T_8 Weed free	48405	120016.83	71611.83	2.48
T_9 Weedy check	27505	24615.83	-2889.17	0.89
SEm (±)		5204.5	5204.5	0.16
CD at 5%		15601.4	15601.4	0.48
CV (%)		15.44	32.58	15.21

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