International Journal of Plant & Soil Science

Volume 35, Issue 14, Page 175-182, 2023; Article no.IJPSS.100527
ISSN: 2320-7035

Standardization of Management Strategy for Chickpea (*Cicer arietinum* L.) under Different Levels of Crop Residue Retention in Conservation Agriculture

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i143034

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/100527

Original Research Article

Received: 25/03/2023
Accepted: 27/05/2023
Published: 02/06/2023

ABSTRACT

A field experiment was conducted at ICAR- Indian Institute of Soil Science (IISS), Bhopal (Madhya Pradesh) to evaluate the impact of different levels of crop residue retention and herbicidal weed control measures on weed dynamics, crop growth and yield characteristics of chickpea crop under conservation agriculture. Data were recorded on weed study, crop growth and yield characters of

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chickpea. Results indicate that pre-emergence herbicide application treatments (H_1 and H_2) were found to be effective in reducing weed density at 30 DAS (63.56%) as compared to post emergence treatments which were applied after recording observations on weed density at 30 DAS. It has been observed that post emergence application of imazethapyr @ 25 g a.i. ha^{-1} was found to restrict crop growth for a period of 10-15 days as compared to pre-emergence treatments. The results on crop growth and yield parameters revealed that higher residue retention level treatment (90% crop residue retention) recorded significantly higher plant height (54.81cm), dry matter $plant^{-1}$ (18.39 g $plant^{-1}$), number of pods $plant^{-1}$ (36.46), seeds $plant^{-1}$ (47.11), seed yield (1202 kg ha^{-1}) and straw yield (2916 kg ha^{-1}) as compared to no crop residue retention.

Keywords: Conservation agriculture; crop residue; herbicides; weed density; chickpea.

1. INTRODUCTION

Conservation agriculture (CA) can be regarded as a sustainable subset of agricultural intensification. Concept of CA is based on the improvement, preservation, and prudent use of natural resources, such as soil, water and biological resources, besides external inputs. The practice of CA including four fundamental principles *i.e.,* minimal soil disturbance, crop residue retention, crop diversity, and controlled traffic under different agro ecosystems have been found to improve and sustain agricultural production while also protecting the environment [1]. The no-till system is a specialized component technology for conservation tillage that employs a single tractor to drive a specially designed seed cum fertilizer drill (Happy seeder), with the exception of sowing and fertilizer application, without engaging in any other land preparation activities. The practice under CA system leads to minimal soil disturbance and the crop residues which is retained on the surface is crucial for the sustainability of soil and water. Herbicides are often used to manage weeds, while crop rotation is adopted as an alternate strategy in certain circumstances. The soilis not tilled except opening of a thin strip (2–3 cm wide) in the field for seed insertion to ensure proper seed–soil contact. In the absence of tillage operations, weeds are not controlled through uprooting and burial as in case of conventional agriculture. Therefore, weed management remains one of the most important and problematic aspects under CA. In this regard, there is need for further investigation so as to standardize suitable package for weed management in the presence of crop residues for successful adoption of CA at a larger scale. Chickpea (*Cicer arietinum* L.) is a legume crop of the Fabaceae family which is grown in rabi season. It is the third most important pulse crop in the world after dry bean and pea [2]. Chickpea is cultivated in about 99 lakh hectares. The country harvested a record production of 107 lakh tonne at a highest productivity level of 1086 kg/ha in the year 2021-22 [3]. As usual, Madhya Pradesh (MP) accounted for a significant 28% of the total gram area and 34% of total gram production in the country, thereby ranking first both in area and production followed by Maharashtra, Rajasthan and Karnataka [3]. Generally, conventional tillage techniques are used to grow chickpea with 2–3 pre- sowing cultivation. However, considering the shifting trends of resource base in the current farming environment, it is becoming increasingly important to switch from traditional crop management practices to resource conserving technologies under maize-chickpea cropping system. One of the main biological factors limiting the production of the majority of crops in India is the prevalence of weeds in the fields which not only compete with crops for natural and applied resources but also reduce the quantity and quality of agricultural produce. Poor weed management practice is the most important yield-limiting factor in chickpea. Due to the crop's slow early growth and tiny height, it is extremely susceptible to crop-weed competition and can suffer yield losses of up to 75% as a result of weeds [4]. Weeds such as *Chenopodium album*, *Cynodon dactylon*, *Medicago hispida*, *Anagalis arvensis*, *Melilotus indica*, *Melilotus alba*, *Cyperus rotundus*, *Argemone mexicana* and *Solanumnigrum* have been predominantly reported by many research workers to infest the chickpea fields and thus reduce crop yield [5]. According to Singh and Singh [6], the first 60 days are crucial for crop-weed competition in chickpea. There are now several promising herbicides that can aid in controlling weeds in chickpea crops. A number of promising herbicides are now available which can help in weed management in chickpea crop. Therefore, it is important to develop effective weed control strategies that can be adapted to the CA situation. Maintaining this view, the herbicides, namely imazethapyr and clodinafop propargyl, were tested alone as pre-emergence herbicides or in combination with post-emergence herbicides to test their efficacy against weeds, effect on crop growth and yield parameters under CA.

2. MATERIALS AND METHODS

Field experiments were conducted during the *Rabi* season of 2020 and 2021 at ICAR- Indian Institute of Soil Science (IISS), Bhopal (MP) under an ongoing CRP-CA (Consortium Research Platform on Conservation Agriculture) experiment, to standardize the weed management strategy for chickpea under different levels of crop residue retention under conservation agriculture in Vertisols of central India.

Geographically, the experimental site is located between 23°18'28.26"N and 77°24'26.00"E at an altitude of 485 metre above sea level. The10-year average rainfall in the experimental area is 1,146 mm, of which more than 80% occurs during June to September. The experimental area has a mean annual air temperature of 25 °C. The climate in the region is generally humid subtropical, with hot, dry summers and a warm, wet monsoon that begins in late June and ends in late September. The summer season he starts in late March and ends in mid-June. Winter peaks in January, when temperatures can drop to near freezing at night. The soil of the experimental site was deep heavy clay (Typic Haplustert) in texture (24.5% sand, 23.5% silt and 47.4 % clay) having swelling and shrinking characteristics upon wetting and drying.

The experiment consisted of four levels of crop residue retention CR_0 (without residue), CR_{30} (30% residue), CR_{60} (60% residue), and CR_{90} (90% residue of the previous crop (maize)), and four herbicidal weed control treatments (H_1- Imazethapyr @ 50 g a.i. ha^{-1} as pre-emergence (PE) application, H_2- H_1 followed by (fb) hand weeding (HW) 50 days after sowing (DAS), H_3- Imazethapyr @ 25 g a.i. ha^{-1}+Clodinafop @60 g a.i. ha^{-1} 30 DAS, H_4 - H_3 fb HW 50 DAS. A uniform application of paraquat@1 kg a.i. ha^{-1} was applied for control of existing weeds in the field. The experiment was laid out in a factorial randomized block design with 16 treatments and replicated thrice. The crop variety"Jawahar Gram-12 (JG-12)" was sown in second fortnight of October each year with a seed rate(80 kg ha^{-1}) at 27.5 cm x 10 cm row to row and plant to plant spacing, respectively. A uniform fertilizer dose of 20:50:40 kg N: P_2O_5:K_2O ha^{-1} was applied in all the treatments. Irrigation was applied at 30 days after sowing and at pod filling stage. The pre and post emergence herbicidal weed control treatments were applied as per treatments with the help of a knapsack sprayer using 500 liters of water ha^{-1}. Data on weed flora were recorded with the help of quadrant measuring 0.25 m^{-2} by randomly placing it at four places in each plot in the experimental fields.

The data on weed density and crop growth parameters were recorded at 30 days after sowing (DAS) and at harvest. Three plants were selected randomly from each plot for the measurements of growth and yield attributes (the samples were air-dried and oven dried at 65 °C for three days until a constant weight was achieved). After harvesting, threshing, cleaning and drying, the seed yield was recorded. Straw yield was obtained by subtracting the seed yield from the total biomass yield. The Standard method of “Analysis of variance” was used for analyzing the data [7]. Standard error of the means (S. Em±) was worked out for each factor and interactions. The least significant difference test was used to interpret the treatment effect at the 5% level of significance ($p < 0.05$). The data were suitably illustrated with graphs and figures at appropriate place.

3. RESULTS AND DISCUSSION

3.1 Weed Flora and Total Weed Density

Weed flora present in field trials was recorded in both years. Weeds are divided into monocotyledonous plants, dicotyledonous plants, and sedge weeds. The results revealed that the dominant weed flora in the experimental field weeds comprised of *Dichanthium annulatum* and *Asphodelus tenuifolius* among monocots and *Anagallis arvensis*, *Launaea procumbens*, *Cichorium intybus*, *Euphorbia hirta*, *Convolvulus arvensis*, *Alternanthera sessile*, *Sonchus arvensis*, *Chenopodium album*, *Vicia hirsuta*, *Medicago polymorpha* among dicot weeds and sedges. Sneha et al. [8] and Dewangan et al. [9] reported similar findings in terms of weed flora in chickpea field. Among different levels of crop residue retention, it was observed that the all levels of crop residue retention had significantly lower total weed density as compared to no/nil crop residue retention (Table 1).

Table 1. Effect of crop residue retention and herbicidal weed control treatments on total weed density (no. m^{-2})

Crop residue levels	At 30 DAS pooled	At 50 DAS pooled
90% crop residue retention ($CR_{90\%}$)	7.07 (50.42)	5.63 (32.51)
60% crop residue retention ($CR_{60\%}$)	7.34 (54.25)	5.92 (35.82)
30% crop residue retention ($CR_{30\%}$)	7.64 (58.74)	6.25 (39.76)
No/nil crop residue retention ($CR_{0\%}$)	8.65 (75.04)	7.30 (54.75)
Weed management		
H_1 (Imazethapyr @ 50 g a.i. ha^{-1} as PE)	6.79 (46.21)	7.46 (55.79)
H_2 (H_1 *fb* HW at 50 DAS)	6.82 (46.46)	7.49 (55.90)
H_3 (Imazethapyr @ 25 g a.i. ha^{-1}+Clodinafop @ 60 g a.i. ha^{-1} 30 DAS)	8.56 (73.18)	5.07 (25.56)
H_4 (H_3 *fb* HW at 50 DAS)	8.53 (72.60)	5.09 (25.60)
S. Em. ±	0.04	0.034
CD (P=0.05)	0.14	0.098
Interaction (Crop residue × Herbicide)		
S. Em. ±	0.09	0.06
CD (P=0.05)	NS	0.19

Figures in parenthesis indicates the original value, Data transformed to ($\sqrt{x+.5}$)

However, the lowest total weed density was recorded at 30 and 50 DAS (50.42 and 32.51no. m^{-2} respectively) under 90% crop residue retention. It might be due to the smothering effect of crop residues on the weed density and total weed population. The greater amount of residues prevents weeds to grow through the mulch [10]. The maximum total weed density (75.04 no.m^{-2} at 30 DAS and 54.75 no. m^{-2} at 50 DAS) was recorded in no crop residue retention treatment because it might be due to no/nil crop residue retention soil surface resulting in more weed germination, rapid weed growth, and higher crop competition. Similar findings were reported by Susha et al. [11]. Pre emergence herbicide (Imazethapyr @ 50 g a.i. ha^{-1}) application treatments *viz*., H_1 (Imazethapyr @ 50 g a.i. ha^{-1}) and H_2 (Imazethapyr @ 50 g a.i. ha^{-1} *fb* one HW at 50 DAS) were found to be significantly lower in total weed density at 30 DAS (46.21 and 46.46 no.m^{-2}, respectively) as compared to post emergence application of herbicides in treatments *i.e*., H_2 (Imazethapyr @ 25 g a.i. ha^{-1}+Clodinafop @ 60 g a.i. ha^{-1} 30 DAS) and H_4 (Imazethapyr @ 25 g a.i. ha^{-1}+Clodinafop @ 60 g a.i. ha^{-1} 30 DAS *fb* HW at 50 DAS) (73.18 and 72.60 no.m^{-2}) which were applied after recording observations on weed density at 30 DAS. The reduced overall weed density in treatments H_1 and H_2 may be attributable to imazethapyr's pre-emergence effect on weed germination. Barla and Upasani [12] also noted results in a comparable manner. At 50 DAS, significantly lower total weed density was recorded in treatments H_3 and H_4 (25.56 and 25.60 no.m^{-2}), respectively as compared to H_1 and H_2 treatments (55.78 and 55.9 no.m^{-2}). Low total weed density might be dueto effect of post emergence application of herbicide (Imazethapyr @ 25 g a.i. ha^{-1}+Clodinafop @60 g a.i. ha^{-1} 30 DAS) in both treatments H_3 and H_4. Similar results were reported by Dubey et al. [13], Kaushik et al. [14] and Rupareliya et al. [15].

Interaction effect of crop residue retention and herbicidal weed control methods was found significant on total weed density at 50 DAS. Lowest mean total density (19.33 no. m^{-2}) was observed under the interaction of 90% crop residue retention and H_4. While, the highest total density was recorded (74.67 and 74.94no. m^{-2}) in combination of no/nil crop residue with treatments H_1 and H_2 respectively. (Table 2).

Table 2. Interaction of crop residue retention and herbicidal weed control treatments on total weed density (no. m^{-2}) at 50 DAS

CR/H	CR90%	CR60%	CR30%	$CR_{0\%}$
H_1	6.76 (45.28)	6.76 (49.78)	6.76 (53.45)	6.76 (74.67)
H_2	7.09 (45.89)	7.09 (48.78)	7.09 (54.00)	7.09 (74.94)
H_3	7.34 (19.56)	7.34 (22.44)	7.34 (25.72)	7.34 (34.50)
H_4	8.67 (19.33)	8.67 (22.28)	8.67 (25.89)	8.67 (34.89)
S. Em. ±		0.06		
CD (P=0.05)		0.19		

CR- Crop residue, H- Herbicide treatments

3.2 Features of Crop Yield and Growth

The data on crop growth (plant height and dry weight plant) and yield characteristics (number of pods plant^{-1}, seeds plant^{-1}, seed and straw yield (kg ha^{-1}) were significantly influenced by crop residue retention and herbicidal weed control practice. Among other things, for retaining crop residues plant height (54.81 cm) and dry weight (18.39 g plant^{-1}) were recorded with the 90% crop residue retention which was at par with 60% crop residue retention and significantly higher as compared to 30% and no crop residue retention, while the lowest (49.71 and 14.07 g plant^{-1}) were recorded under no/nil crop residue retention. Higher growth of crop might be due to higher crop residue retention which improves soil moisture, nutrient uptake by crop and also soil health *i.e.*, soil organic carbon, soil structure and soil porosity [16,17]. These results were in close conformity with those of Jakhar et al. [18]. With respect to weed control treatments, plant height and plant dry weight (55.82 cm and 19.60 g plant^{-1}) were observed with treatment H_2 which was significantly superior to the rest of the herbicide treatments and the lowest plant height and dry weight (50.46 cm and 15.03 g plant^{-1}) were noted under treatment H_3. Highest values of yield characteristics *i.e.*, number of pods plant^{-1}, seeds plant^{-1}, seed and straw yield (36.46, 47.11, 1202 kg ha^{-1} and 2916 kg ha^{-1}, respectively) were achieved under the 90% crop residue retention which was statistically at par with the 60% crop residue retention and significantly higher than 30% and no/nil crop residue retention. While, the lowest values were recorded in the no crop residue retention treatment (26.17, 34.86, 950 kg ha^{-1} and 2623 kg ha^{-1}).Crop residue retention treatments had higher yields than that of crop residue removals, suggesting that field mulching with crop residue promotes soil health, crop productivity and reduced the weed density. This is because residues and their decomposition improve the soil structure through enhancing soil aggregate stability and soil properties while limiting soil water evaporation and soil crusting [19]. Similar results were reported by Singh et al. [20] and Parihar et al. [21]. Among herbicidal weed control treatments, maximum yield characteristics (37.67, 49.88, 1305 kg ha^{-1} and 3077 kg ha^{-1}) were recorded in H_2 which was remarkably higher in comparison to rest of the herbicidal weed control treatments. The higher value of yield characteristics might be due to the effect of pre-emergence application of imazethapyr and hand weeding, resulting in reduced weed germination, weeds density and lower weed competition for nutrient and moisture. Related results were reported by Rathod et al. [22] and Barla and Upasani [12]. However, lowest values of yield-related traits were found in treatment (28.71, 37.39, 979 kg ha^{-1} and 2596 kg ha^{-1}) (Table 3 and Fig. 1).

The lower yield characteristics in treatments H_3 and H_4 might be due to phototoxic effect of imazethapyr on chickpea. The results implied that a higher concentration of imazethapyr resulted in decline in growth, yield attributes and yield of chickpea [23] and imazethapyr makes the stems and leaves long and narrow [24]. Similar results were reported by Goud et al. [23].

Interaction effect of crop residue and herbicidal weed control treatments had significantly affected pods plant^{-1}, seeds plant^{-1}, seed and straw yield (Tables 4 and 5). Maximum values of pods plant^{-1}, seeds plant^{-1}, seed and straw yield (42.22, 55.57, 1430 kg ha^{-1} and 3252 kg ha^{-1}) were recorded under the interaction of 90% crop residue retention and H_2 while minimum values (24.33, 32.39, 870 kg ha^{-1} and 2513 kg ha^{-1}) were observed the interaction of no/nil crop residue retention and H_3.

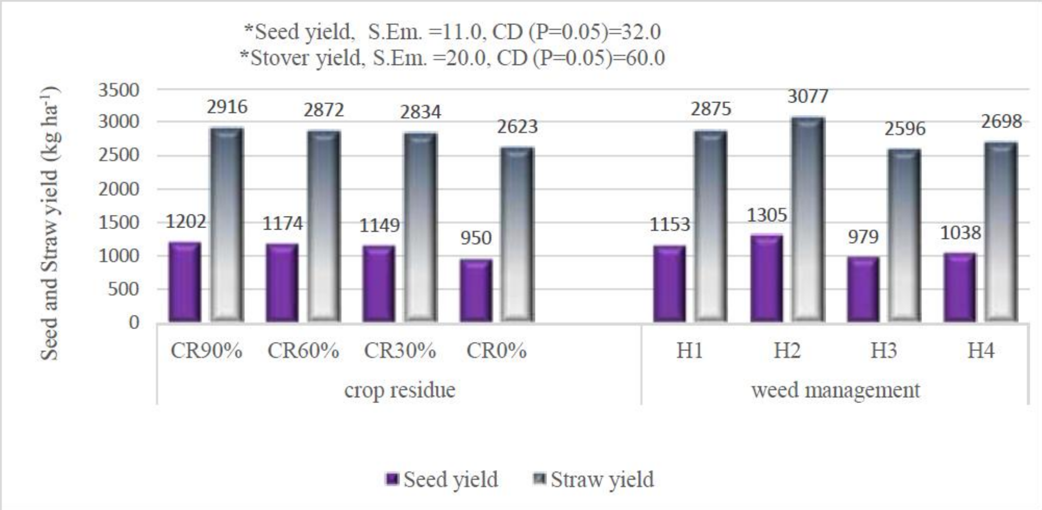

Fig. 1. Effect of crop residue retention and herbicidal weed control treatments on seed and straw yield

Table 3. Effect of crop residue retention and herbicidal weed control treatments on plant height, dry weight, pods and seeds plant^{-1}

Crop residue	**Plant height (cm)**	**Dry weight plant^{-1}**	**Pods plant^{-1}**	**Seeds plant^{-1}**
90% crop residue retention ($CR_{90\%}$)	54.81	18.39	36.46	47.11
60% crop residue retention ($CR_{60\%}$)	54.24	18.05	35.50	46.11
30% crop residue retention ($CR_{30\%}$)	53.61	17.65	33.79	44.75
No/nil crop residue retention ($CR_{0\%}$)	49.71	14.07	26.17	34.86
Weed management				
H_1 (Imazethapyr @ 50 g a.i. ha^{-1} as PE)	54.58	17.60	34.53	46.29
H_2 (H_1 *fb* HW at 50 DAS)	55.82	19.60	37.67	49.88
H_3 (Imazethapyr @ 25 g a.i. ha^{-1}+Clodinafop @ 60 g a.i. ha^{-1} 30 DAS)	50.46	15.03	28.71	37.39
H_4 (H_3 *fb* HW at 50 DAS)	51.50	15.93	31.01	39.28
S. Em. ±	0.25	0.19	0.50	0.37
CD (P=0.05)	0.73	0.55	1.43	1.08
Interaction (Crop residue × Herbicide)				
S. Em. ±	0.51	0.38	0.99	0.75
CD (P=0.05)	NS	NS	2.86	2.16

Table 4. Interaction of crop residue retention and herbicidal weed control treatments on pods and seeds plant^{-1}

	Pods plant^{-1}				**Seeds plant^{-1}**			
CR/H	**CR90%**	**CR60%**	**CR30%**	**$CR_{0\%}$**	**CR90%**	**CR60%**	**CR30%**	**$CR_{0\%}$**
H_1	38.50	36.50	36.44	26.67	51.00	49.72	49.11	35.33
H_2	42.22	41.22	40.00	27.22	55.57	54.78	51.72	37.44
H_3	31.94	30.33	28.22	24.33	40.39	38.72	38.06	32.39
H_4	33.17	33.94	30.50	26.44	41.50	41.22	40.11	34.28
S. Em. ±			0.99			0.75		
CD (P=0.05)			2.86			2.16		

Table 5. Interaction of crop residue retention and herbicidal weed control treatments on seed and straw yield

CR/H	Seed yield				Straw yield			
	CR90%	CR60%	CR30%	$CR_{0\%}$	CR90%	CR60%	CR30%	$CR_{0\%}$
H_1	1240	1208	1185	979	2988	2934	2896	2682
H2	1430	1394	1348	1048	3252	3208	3124	2726
H3	1028	1014	1002	870	2645	2619	2607	2513
H_4	1109	1082	1060	902	2781	2729	2710	2574
S. Em. ±			17.79			37.42		
CD (P=0.05)			51			108		

4. CONCLUSIONS

The results obtained from the present study proved that with 90 % crop residue retention and H_2- Imazethapyr @ 50 g a.i. ha^{-1} as pre-emergence application followed by one hand weeding at 50 days after sowing proved to be best in terms of crop growth and yield characteristics of chickpea and more remunerative among all the levels of residue retention and herbicidal weed control treatments. Also, higher level of residue retention (CR90 - 90% of crop residue retention level) in combination with H_2 (Imazethapyr @ 50 g a.i. ha^{-1} as PE fb HW 50 DAS) proved to be the best treatment in term of weed control and recorded lowest weed density and maximum crop yield.

Thus, we concluded that the retention of 90% crop residue with pre-emergence application of imazethapyr @ 50 g a.i. ha^{-1} followed by one hand weeding at 50 DAS proved to be best from weed control and crop yield point of view under conservation agriculture among the various treatments evaluated.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAO Produce with Inputs; Memories of the International Expert Consultation on Conservation Agriculture for Sustainable Development, Havana Cuba: FAO, Cuba; 2017.
2. The Food and Agriculture Organization Corporate Statistical Database [FAOSTAT]; 2017. Agriculture Data. Available:http://www.faostat.fao.org.
3. Annual report, Government of India Ministry of agriculture and Farmers Welfare (Department of Agriculture & Farmers Welfare) Directorate of Pulses Development; 2021-22.
4. Chaudhary BM, Patel JJ, Delvadia DR. Effect of weed management practices and seed rateson weeds and yield of chickpea. Indian Journal of Weed Sciences. 2005;37(3&4):271- 272.
5. Gupta V, Singh BN, Kumar JM, Singh and Jamwal BS. Effect of imazethapyr on weed control and yield in chickpea under kandi belt of low altitude sub-tropical zone of Jammu. Madras Agricultural Journal. 2012;99:81-86.
6. Singh KP, Meena V, Somasundaram J, Singh S, Dotaniya ML, Das H. Interactive effect of tillage and crop residue management on weed dynamics, root characteristics, crop productivity, profitability and nutrient uptake in chickpea (*Cicer arietinum* L.) under Vertisol of Central India. PLoS ONE Journal. Pone. 2022;17(12):0279831.
7. Panse VG, Sukhatme PV. Statistical methods for agricultural workers, ICAR publication, New Delhi, India; 1985.
8. Sneha G. Bio-efficacy of pendimethalin as PPI against complex weed flora in Chickpea. Thesis M.Sc. (Ag)., JNKVV Jabalpur, (MP); 2019.
9. Dewangan M, Singh AP, Chowdhury T, Kumar, D, Kumar B. Management of complex weed flora in chickpea. Indian Journal of Weed Science. 2016;48(1):79-82.
10. Vishwakarma AK, Wanjari RH, Brajendra and Gopal Ram. Weed management in conservation agriculture: A brief review. Journal of Pharmacognosy and Phytochemistry. 2017;1:502- 506.
11. Susha VS, Das TK, Sharma AR, Nath CP. Carry-over effect of weed management practices of maize (*Zea mays*) on weed dynamics and productivity of succeeding zero and conventional till wheat (*Triticum*

aestivum). Indian Journal of Agronomy. 2014;59(1):41-47.

12. Barla Sheela, Upasani Ravikant. Efficacy of pre and post emergence application of imazethapyr and its ready-mix herbicides on growth, weed dynamics and productivity of chickpea (*Cicer arietinum* L.). Legume Research - An International Journal. 2021;10.18805/lr-4719.
13. Dubey SK, Kumar A, Singh D, Partap T, Chauarsiya A. Effect of different weed control measures on performance of chickpea under irrigated condition. International Journalof Current Microbiology and Applied Sciences. 2018;705.362.
14. Kaushik SS, Rai AK, Sirothia P, Sharma AK, Shukla AK. Growth, yield and economics of rain-fed chickpea (*Cicer arietinum* L.) as influenced by integrated weed management. Indian Journal of Natural Products and Resources. 2014;5(3):282-285.
15. Rupareliya VV, Chovatia PK, Vekariya SJ, Javiya PP. Evaluation of pre and post emergence herbicides in chickpea (*Cicer arietinum* L.). International Journal of Chemical Studies. 2018; 6(1):1662-1665.
16. Yadav Devideen and Kumawat, Anita and Shivay, Yash bir, Vishwakarma Anand, Sharma N, Sharma VK, Biswas Ashis. Consequence of divergent crop residue and green manuring practices on soil nutrient balance: A review. 2019;903-908.
17. Kumawat A, Vishwakarma, AK, Wanjari, RH, Sharma NK, Yadav Devideen, Dineshkumar and Biswas, AK. Impact of levels of residue retention on soil properties under conservation agriculture in Vertisols of central India. Archives of Agronomy and Soil Science. 2020; 68:3:368-382.
18. Jakhar P, Rana KS, Dass A, Choudhary AK, Choudhary M. Influence of moisture management practices on productivity, profitability and energy dynamics of rainfed maize (*Zea mays*) in semi-arid sub-tropical climate. Indian Journal of Agronomy. 2017;62 (2):191-196.
19. Jordán A, Zavala LM, and Gil J. Effects of mulching on soil physical properties and runoff under semi-arid conditions in southern Spain. Catena. 2010;81(1):77-85.
20. Singh S, Singh NA. Crop- weed competition in chickpea: Challenges and strategies for the New Millennium. In National Symposium on Agronomy. 2000; 199.
21. Parihar M, Parihar C, Nanwal R, Singh A, Jat S, Nayak H, Jat ML. Effect of different tillageand residue management practices on crop and water productivity and economics in maize (*Zea mays*) based rotations. Indian Journal of Agricultural Sciences, 2019;89(2):360-366.
22. Rathod PS, Patil DH, Dodamani BM. Integrated weed management in chickpea (*Cicer arietinum* L.) under rainfed conditions of Karnataka, India. Legume Research. 2017;40(3):580-585.
23. Goud VV, Murade NB, Khakre MS, and Patil AN. Efficacy of imazethapyr and quizalofop-ethyl herbicides on growth and yield of chickpea. The Bioscan. 2013;8(3):1015-1018.
24. Veisi M, Mansouri MS, Ghiasvand M. Chemical control of broadleaf weeds in autumn-sown rainfed chickpea. Journal of Plant Protection Research. 2019;59(4): 552–560.

Peer-review history:
The peer review history for this paper can be accessed here:
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