

Original Research Article

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

ABSTRACT

A field experiment was conducted during the *Rabi* season of 2020-21 and 2021-22 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. The experiment consisted of four levels of crop residue (0%, 30%, 60% and 90%) of previous crop (maize) and four herbicidal weed control treatments (H₁- Imazethapyr @ 50 g a.i. ha⁻¹ as pre-emergence (PE) application, H₂ - H₁ followed by (*fb*) hand weeding (HW) 50 days after sowing (DAS), H₃ - Imazethapyr @ 25 g a.i. ha⁻¹+Clodinafop @60 g a.i. ha⁻¹ 30 DAS, H₄- H₃*fb* HW 50 DAS. The experiment was laidout in a factorial randomized block design with 16 treatments and replicated thrice. The variety “Jawahar Gram-12 (JG-12)” was sown with the help of happy-seeder. Data were recorded on weed study, crop growth and yield characters of chickpea. Results indicate that pre-emergence herbicide application treatments (H₁ and H₂) 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. Different herbicidal weed control measures could not attain the level of significance; however the yield attributes and yield were significantly influenced as a result of interaction of

residue levels and weed control treatments. 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 various treatments evaluated.

Key words: Conservation Agriculture, Crop Residue, Herbicides, Weed Density, Weed Management, Chickpea

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 (FAO, 2017). The no-till system is a specialized component technology for conservation tillage that uses a single tractor to operate a specifically built seed cum fertilizer drill (Happy seeder) without any land preparation activity except sowing & fertilizer application. 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 soil is 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 (FAOSTAT, 2017). Chickpea is cultivated in about 99 lakh hectare. The country harvested a record production of 107 lakh tonne at a highest productivity level of 1086 kg/ha in the year 2021-22 (Annual report. 2021-22). 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 (Annual report. 2021-22). 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. The crop being slow in early phase of growth and small in height, is highly vulnerable to crop-weed competition at early stages of crop growth and causes up to 75% losses in yield due to weeds (Chaudhary *et al.*, 2005). Weeds such as *Chenopodium album*, *Cynodon dactylon*, *Medicago hispida*, *Anagalis arvensis*, *Melilotus indica*, *Melilotus alba*, *Cyperus rotundus*, *Argemone mexicana* and *Solanum nigrum* have been predominantly reported by many research workers to infest the chickpea fields and thus reduce crop yield (Gupta *et al.*, 2012). The first 60 days are considered to be the most critical for crop-weed competition in chickpea (Singh and Singh, 2000). A number of promising herbicides are now available which can help in weed management in chickpea crop. Thus, it is critical to develop an effective weed management strategy which can adapt to the CA situation. Keeping this in view, an experiment has been planned with a view to test herbicides, *viz.*, imazethapyr and clodinafop-propargyl either alone as pre-emergence or in combination with post-emergence herbicides, to test their efficacy against weeds, effect on crop growth and yield parameters under CA.

MATERIAL AND METHODS

Field experiments were conducted during the *Rabi* season of 2020-21 and 2021-22 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 m above sea level. The 10-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 of the region is generally humid subtropical, with hot and dry summers and warm and humid monsoons beginning in late June and ending in late September. The summer season begins in the second half of March and ends in mid-June. The winter peaks in January, when the temperature may occasionally drop close to freezing on some nights. 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 CR₀ (without residue), CR₃₀ (30% residue), CR₆₀ (60% residue), and CR₉₀ (90% residue of the previous crop (maize)), and four herbicidal weed control treatments (H₁-Imazethapyr @ 50 g a.i. ha⁻¹ as pre-emergence (PE) application, H₂- H₁ followed by (fb) hand weeding (HW) 50 days after sowing (DAS), H₃-Imazethapyr @ 25 g a.i. ha⁻¹+Clodinafop @60 g a.i. ha⁻¹ 30 DAS, H₄ - H₃ 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: P₂O₅:K₂O 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 litres of water ha⁻¹. Data on weed flora were recorded with the help of quadrant measuring 0.25 m² 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 until a constant weight was achieved). After harvesting, threshing, cleaning and drying, the seed yield was recorded. The straw yield was obtained by subtracting the seed yield from the total biomass yield. The standard method of "Analysis of variance" was used for analysing the data (Panse and Sukhatme 1995). 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.

RESULTS AND DISCUSSION

Weed flora and Total weed density

Weed flora present in the experiment at field was recorded during both the years. The weeds are grouped as monocot, dicot grasses and sedges 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.* (2019)

and Dewangan *et al.* (2016) 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**). However, the lowest total weed density was recorded at 30 and 50 DAS (50.42 and 32.51 no.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.

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 ($\sqrt{x+5}$)

The greater amount of residues prevents weeds to grow through the mulch (Vishwakarma *et al.*, 2017). 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.* (2014). Pre emergence herbicide (Imazethapyr @ 50 g a.i. ha⁻¹) application treatments *viz.*, H₁ (Imazethapyr @ 50 g a.i. ha⁻¹) and H₂ (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.*, H₂ (Imazethapyr @ 25 g a.i. ha⁻¹+Clodinafop @ 60 g a.i. ha⁻¹ 30 DAS) and H₄ (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 lower total weed density in treatments H₁ and H₂ might be due pre-emergence application of imazethapyr affected on weed germination. Similar results were also observed by Barla and Upasani (2021). At 50 DAS, significantly lower total weed density was recorded in treatments H₃ and H₄ (25.56 and 25.60 no.m⁻²), respectively as compared to H₁ and H₂ treatments (55.78 and 55.9 no.m⁻²). Low total weed density might be due to 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 H₃ and H₄. Similar results were reported by Dubey *et al.* (2018), Kaushik *et al.* (2014) and Rupareliya *et al.* (2018). Interaction effect of crop residue retention and herbicidal weed control treatments was found significant on total weed density at 50 DAS. The minimum mean total density (19.33 no. m⁻²) was observed under the interaction of 90% crop residue retention and H₄. While, maximum total density was recorded (74.67 and 74.94 no. m⁻²) in combination of no/nil crop residue with treatments H₁ and H₂ 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	CR _{90%}	CR _{60%}	CR _{30%}	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

Crop growth and yield characteristics

The data on crop growth (plant height and dry weight plant⁻¹, at harvest) 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 the crop residue retention,

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 minimum (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 (Yadav *et al.*, 2019; Kumawat *et al.*, 2020). These results were in close conformity with those of Jakhar *et al.* (2017). 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 H₂ which was significantly superior to the rest of the herbicide treatments and minimum plant height and dry weight (50.46 cm and 15.03 g plant⁻¹) were noted under treatment H₃.

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

Maximum 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 improves the soil structure through enhancing soil aggregate stability and soil properties while limiting soil water evaporation and soil crusting (Jordan *et al.*, 2010). Similar results were reported by Singh *et al.* (2022) and Parihar *et al.* (2019). Among herbicidal weed control treatments, maximum yield characteristics (37.67, 49.88, 1305 kg ha⁻¹ and 3077 kg ha⁻¹) were recorded in H₂ 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, weed density and lower weed competition for nutrient and moisture. Related results were reported by Rathod *et al.* (2017) and Barla and Upasani (2021). Whereas, the minimum values of yield characteristics were found under the treatment H₃ (28.71, 37.39, 979 kg ha⁻¹ and 2596 kg ha⁻¹) (Table 3 and Figure 1).

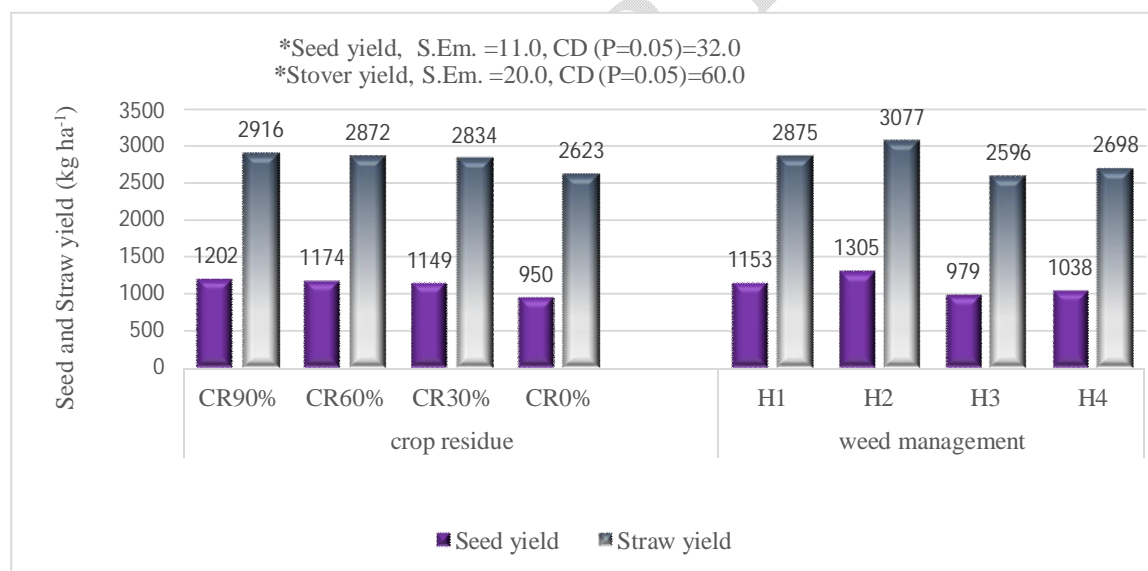


Figure 1. Effect of crop residue retention and herbicidal weed control treatments on seed and straw yield

The lower yield characteristics in treatments H₃ and H₄ might be due to phytotoxic 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 (Goud *et al.*, 2013) and imazethapyr

makes the stems and leaves long and narrow (Veisi *et al.*, 2019). Similar results were reported by Goud *et al.* (2013).

Table 4. Interaction of crop residue retention and herbicidal weed control treatments on pods and seeds plant⁻¹

CR/H	Pods plant ⁻¹				Seeds plant ⁻¹			
	CR _{90%}	CR _{60%}	CR _{30%}	CR _{0%}	CR _{90%}	CR _{60%}	CR _{30%}	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			

Interaction effect of crop residue and herbicidal weed control treatments had significantly affected pods plant⁻¹, seeds plant⁻¹, seed and straw yield (**Table 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 H₂ 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 H₃.

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

CR/H	Seed yield				Straw yield			
	CR _{90%}	CR _{60%}	CR _{30%}	CR _{0%}	CR _{90%}	CR _{60%}	CR _{30%}	CR _{0%}
H ₁	1240	1208	1185	979	2988	2934	2896	2682
H ₂	1430	1394	1348	1048	3252	3208	3124	2726
H ₃	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			

CONCLUSIONS

The results obtained from the present study proved that CR_{90%} with 90 % crop residue retention and H₂- 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 H₂ (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.

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UNDER PEER REVIEW