# *Original Research Article*

## Standardization of Weed Management Strategy for Chickpea (*Cicerarietinum*L.) under Different Levels of Crop Residue Retention inConservationAgriculture

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**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 ofdifferent levelsofcropresidue retentionandherbicidal weedcontrol measuresonweeddynamics,cropgrowthandyieldcharacteristicsofchickpeacropunderconservatio nagriculture. The experiment consisted of four levels of crop residue (0%, 30%, 60% and 90%)ofprevious crop(maize)andfourherbicidalweedcontroltreatments($H_1$-Imazethapyr@50g a.i. $ha^{-1}$ as pre-emergence (PE) application, $H_2$ - $H_1$ followed by (*fb*) hand weeding (HW) 50days after sowing (DAS), $H_3$ - Imazethapyr @ 25 g a.i. $ha^{-1}$+Clodinafop @60 g a.i. $ha^{-1}$ 30DAS,$H_4$-$H_3$*fb*HW50DAS.Theexperimentwaslaidoutinafactorialrandomizedblockdesignwith16treatment sandreplicatedthrice.Thevariety"JawaharGram-12(JG-12)"wassownwiththe help of happy-seeder. Data were recorded on weed study, crop growth and yield charactersof 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 postemergence treatments which were applied after recording observations on weed density at 30DAS.Ithasbeenobservedthatpostemergenceapplicationofimazethapyr@25ga.i.$ha^{-1}$wasfound to restrict crop growth for a period of 10- 15 days as compared to pre-emergencetreatments. The results on crop growth and yield parameters revealed that higher residueretentionleveltreatment(90%cropresidueretention)recordedsignificantlyhigherplantheig ht(54.81cm), dry matter $plant^{-1}$ (18.39 g $plant^{-1}$), number of pods $plant^{-1}$ (36.46), seeds $plant^{-1}$(47.11),seedyield(1202$kgha^{-1}$)andstrawyield(2916$kgha^{-1}$)ascomparedtonocropresidueretention. Different herbicidal weed control measures could not attain the level of significance;howevertheyieldattributesandyieldweresignificantlyinfluencedasaresultofinteracti onof


Comment [i2]: The summary of the research is long, there is no need to mention the details of the research. It is preferable to rewrite the summary, provided that it does not exceed 150 words.

residue levels and weed control treatments. Thus, we concluded that the retention of 90% cropresidue with pre- emergence application of imazethapyr @ 50 g a.i. $ha^{-1}$ followed by one handweeding at 50 DAS proved to be best from weed control and crop yield point of view underconservationagricultureamongvarioustreatments evaluated.

**Keywords:**ConservationAgriculture,CropResidue,Herbicides,WeedDensity,WeedManagement, Chickpea

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## INTRODUCTION

Conservationagriculture(CA)canberegardedasasustainablesubsetofagriculturalintensification. Concept of CA is based on the improvement, preservation, and prudent use ofnatural resources, such as soil, water and biological resources, besides external inputs. ThepracticeofCAincludingfourfundamentalprinciples*i.e.*,minimalsoildisturbance,cropresiduere tention,cropdiversity,andcontrolledtrafficunderdifferentagro ecosystemshavebeenfoundto improve and sustain agricultural production while also protecting the environment (FAO,2017). The no-till system is a specialized component technology for conservation tillage thatuses a single tractor to operate a specifically built seed cum fertilizer drill (Happy seeder)withoutanylandpreparationactivityexceptsowing&fertilizerapplication.Thepracticeunde rCA system leads to minimal soil disturbance and the crop residues which is retained on thesurface is crucial for the sustainability of soil and water. Herbicides are often used to manageweeds,whilecroprotationisadoptedasanalternatestrategyincertaincircumstances.Thesoil isnottilledexceptopeningofathinstrip(2–3cmwide)inthefieldforseedinsertiontoensureproper seed–soil contact. In the absence of tillage operations, weeds are not controlled throughuprooting and burial as in case of conventional agriculture. Therefore, weed managementremains one of the most important and problematic aspects under CA. In this regard, there isneedforfurtherinvestigationsoastostandardizesuitablepackageforweedmanagementinthepresence of crop residues for successful adoption of CA at a larger scale. Chickpea (*Cicerarietinum*L.) is a legume crop of the Fabaceae family which is grown in rabi season. It is thethird 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 of107lakhtonneatahighestproductivitylevelof1086kg/haintheyear2021-22(Annualreport.2021-22). As usual, Madhya Pradesh (MP) accounted for a significant 28% of the total gramarea and 34% of total gram production in the country, thereby ranking first both in area andproduction followed by Maharashtra, Rajasthanand Karnataka(Annual report. 2021-22).Generally,conventionaltillagetechniquesareusedtogrowchickpeawith2–3pre-sowing

Comment [i4]: 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.

cultivation. However, considering the shifting trends of resource base in the current farmingenvironment,itisbecomingincreasinglyimportanttoswitchfromtraditionalcropmanagement practices to resource conserving technologies under maize-chickpea cropping system. One ofthe main biological factors limiting the production of the majority of crops in India is theprevalence of weeds in the fields which not only compete with crops for natural and appliedresourcesbutalsoreducethequantityandqualityofagriculturalproduce.Poorweedmanagement practice is the most important yield-limiting factor in chickpea. The crop beingslowinearlyphaseofgrowthandsmallinheight,ishighlyvulnerabletocrop-weedcompetitionatearlystagesofcropgrowthandcausesupto75%lossesinyieldduetoweeds(Chaudhary*etal*.,2005).Weedssuchas*Chenopodiumalbum,Cynodondactylon,Medicagohispida,Anagalisarvensis,Melilotusindica,Melilotusalba,Cyperusrotundus,Argemonemexicana*and*Solanumnigrum*have been predominantly reported by many research workers to infest the chickpeafieldsandthusreducecropyield(Gupta*etal*.,2012).Thefirst60daysareconsideredtobethe most critical for crop-weed competition in chickpea (Singh and Singh, 2000). A number ofpromisingherbicidesarenowavailablewhichcanhelpinweedmanagementinchickpeacrop.Thus, it is critical to develop an effective weed management strategy which can adapt to theCA situation. Keeping this is view, an experiment has been planned with a view to testherbicides, *viz*., imazethapyr and clodinafop-propargyl either alone as pre-emergence or incombinationwithpost-emergenceherbicides,totesttheirefficacyagainstweeds,effectoncropgrowthand yield parametersunder CA.

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## MATERIAL ANDMETHODS

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 (ConsortiumResearchPlatformonConservationAgriculture)experiment,tostandardizetheweedmanagementstrategyforchickpeaunderdifferentlevelsofcropresidueretentionunderconservation agriculture in Vertisols of central India. Geographically, the experimental site islocatedbetween23°18'28.26"Nand77°24'26.00"Eatanaltitudeof485mabovesealevel.The10-yearaveragerainfallintheexperimentalareais1,146mm,ofwhichmorethan80%occursduring June to September. The experimental area has a mean annual air temperature of 25 °C. Theclimate of the region is generally humid subtropical, with hot and dry summers and warm andhumidmonsoonsbeginninginlateJuneandendinginlateSeptember.Thesummerseasonbeginsin the second half of March and ends in mid-June. The winter peaks in January, when

**Comment [i5]:** 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.

**Comment [i6]:** According to Singh and Singh (2000), 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.

**Comment [i7]:** 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 clodinafoppropargyl, were tested alone as preemergence herbicides or in combination with postemergence herbicides to test their efficacy against weeds, effect on crop growth and yield parameters under CA.

**Comment [i8]:** The researcher did not mention the purpose of the study

**Comment [i9]:** MATERIALS

**Comment [i10]:** Its not clear , is it 2020-2021 and also 2021-2022

**Comment [i11]:** In new section

thetemperaturemayoccasionallydropclosetofreezingonsomenights.Thesoiloftheexperimental

**Comment [i12]:** Theclimate**in**theregionisgenerall yhumidsubtropical,with**hot,**drysummersand**awarm, wetmonsoonthatbegins**inlateJuneand**ends**inlateSept ember.Thesummerseason**hestarts**in**late**Marchanden dsinmid-June.**Winter**peaksinJanuary,when**temperaturescan** dropto**near**freezing**atnight.**

sitewasdeepheavyclay(TypicHaplustert)intexture(24.5%sand,23.5%siltand47.4%clay)havingswellingandshrinkingcharacteristicsuponwettinganddrying.Theexperimentconsistedof four levels of crop residue retention $CR_0$(without residue), $CR_{30}$(30% residue), $CR_{60}$(60%residue),and$CR_{90}$(90%residueofthepreviouscrop(maize)),andfourherbicidalweedcontroltreatments($H_1$-Imazethapyr@50ga.i.ha$^{-1}$aspre-emergence(PE)application,$H_2$-$H_1$followedby (fb) hand weeding (HW) 50 days after sowing (DAS), $H_3$-Imazethapyr @ 25 g a.i. ha$^{-1}$+Clodinafop@60ga.i.ha$^{-1}$30DAS,$H_4$-H3fbHW50DAS.Auniformapplicationofparaquat@1kga.i.ha$^{-1}$wasappliedforcontrolofexistingweedsinthefield.Theexperimentwaslaidoutinafactorialrandomizedblockdesignwith16treatmentsandreplicatedthrice.Thecropvariety"JawaharGram-12(JG-12)"wassowninsecondfortnightofOctobereachyearwithaseedrate(80 kg ha $^{-1}$) at 27.5 cm x 10 cm row to row and plant to plant spacing, respectively.A uniformfertilizer dose of 20:50:40 kg N: $P_2O_5$:$K_2O$ ha$^{-1}$ was applied in all the treatments. Irrigation wasapplied at 30 days after sowing and at pod filling stage. The pre and post emergence herbicidalweedcontroltreatmentswereappliedaspertreatmentswiththehelpofaknapsacksprayerusing500litresofwaterha$^{-1}$.Dataonweedflorawererecordedwiththehelpofquadrantmeasuring 0.25m$^{-2}$byrandomlyplacingitatfourplacesineachplotintheexperimentalfields.Thedataonweeddensityand cropgrowthparameterswererecordedat30daysaftersowing(DAS)andatharvest.Threeplantswereselectedrandomlyfromeachplotforthemeasurementsofgrowthandyieldattributes(thesampleswereair-driedandovendriedat65°Cuntilaconstantweightwasachieved).Afterharvesting,threshing,cleaning anddrying,theseedyieldwasrecorded.Thestrawyieldwasobtainedbysubtractingtheseedyieldfromthetotalbiomassyield.Thestandardmethodof“Analysisofvariance”wasusedforanalysingthedata(PanseandSukhatme1995).Standarderrorofthemeans(S.Em±)wasworkedoutforeachfactorandinteractions.Theleastsignificantdifferencetestwasusedtointerpretthetreatmenteffectatthe5%levelofsignificance($p < 0.05$). The data were suitably illustrated with graphs and figures at appropriate place.**RESULTSANDDISCUSSION**

**Comment [i13]:** In new section

**Comment [i14]:** In new section

**Comment [i15]:** of growth

**Comment [i16]:** How many days has it been put in the oven ?

**Comment [i17]:** Delete

**Comment [i18]:** In reference 1985

**WeedfloraandTotal weed density**

Weed flora present in the experiment at field was recorded during both the years. The weeds aregroupedasmonocot,dicotgrassesandsedgesweeds.Theresultsrevealedthatthedominantweedflora in the experimental field weeds comprised of *Dichanthiumannulatum*and *Asphodelustenuifolius*among monocots and *Anagallisarvensis*, *Launaeaprocumbens*, *Cichoriumintybus*,*Euphorbia hirta*, *Convolvulus arvensis*, *Alternanthera sessile*,

**Comment [i19]:** Weed flora present in field trials was recorded in both years. Weeds are divided into monocotyledonous plants, dicotyledonous plants, and sedge weeds.

*Sonchusarvensis*, *Chenopodiumalbum*,*Viciahirsuta*,*Medicagopolymorpha*amongdicotweeds andsedges.Snehaetal.(2019)

andDewangan*et al*. (2016) reported similar findings in terms of weed flora in chickpea field.Amongdifferentlevelsofcropresidueretention,itwasobservedthatthealllevelsofcropresidueret ention had significantly lower total weed density as compared to no/nil crop residue retention**(Table1)**.However,thelowesttotalweeddensitywasrecordedat30and50DAS(50.42and 32.51 no.$m^{-2}$ respectively) under 90% crop residue retention. It might be due to the smotheringeffectofcrop residueson theweed densityand totalweed population.

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

| **Cropresiduelevels** | **At30 DAS pooled** | **At50 DAS pooled** |
|---|---|---|
| 90%cropresidueretention ($CR_{90\%}$) | 7.07 (50.42) | 5.63 (32.51) |
| 60%cropresidueretention ($CR_{60\%}$) | 7.34 (54.25) | 5.92 (35.82) |
| 30%cropresidueretention ($CR_{30\%}$) | 7.64 (58.74) | 6.25 (39.76) |
| No/nilcrop residue retention ($CR_{0\%}$) | 8.65 (75.04) | 7.30 (54.75) |
| **Weedmanagement** | | |
| $H_1$(Imazethapyr @50ga.i.$ha^{-1}$asPE) | 6.79 (46.21) | 7.46 (55.79) |
| $H_2$($H_1$*fb*HWat50 DAS) | 6.82 (46.46) | 7.49 (55.90) |
| $H_3$(Imazethapyr@25ga.i.$ha^{-1}$+Clodinafop@60ga.i.$ha^{-1}$30DAS) | 8.56 (73.18) | 5.07 (25.56) |
| $H_4$($H_3$*fb*HW at50DAS) | 8.53 (72.60) | 5.09 (25.60) |
| S.Em.± | 0.04 | 0.034 |
| CD(P=0.05) | 0.14 | 0.098 |
| **Interaction(Cropresidue ×Herbicide)** | | |
| S.Em.± | 0.09 | 0.06 |
| CD(P=0.05) | NS | 0.19 |

**Figures inparenthesisindicatestheoriginalvalue,Datatransformedto(√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)wasrecordedinnocropresidueretentiontreatmentbecauseitmightbeduetono/nilcropresidueret ention soil surface resulting in more weed germination, rapid weed growth, and higher cropcompetition. Similar findings were reported by Sushа*et al*. (2014). 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 intotalweeddensityat30DAS(46.21and46.46no.$m^{-2}$,respectively)ascomparedtopost

emergenceapplicationofherbicidesintreatments*i.e.*,$H_2$(Imazethapyr@25ga.i.ha$^{-1}$+Clodinafop @ 60 g a.i. ha$^{-1}$ 30 DAS) and $H_4$ (Imazethapyr @ 25 g a.i. ha$^{-1}$+Clodinafop @ 60ga.i.ha$^{-1}$30DAS*fb*HWat50DAS)(73.18and72.60no.m$^{-2}$)whichwereappliedafterrecordingobservations on weed density at 30 DAS. The lower total weed density in treatments $H_1$ and $H_2$might be due pre-emergence application of imazethapyr affected on weed germination. Similarresults were also observed by Barla and Upasani (2021). At 50 DAS, significantly lower totalweed density was recorded in treatments $H_3$ and $H_4$ (25.56 and 25.60 no.m$^{-2}$), respectively ascompared to $H_1$ and $H_2$ treatments (55.78 and 55.9 no.m$^{-2}$). Low total weed density might be duetoeffectofpostemergenceapplicationofherbicide(Imazethapyr@25ga.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*etal.* (2018), Kaushik*et al.* (2014) and Rupareliya*et al.* (2018). Interaction effect of crop residueretention and herbicidal weed control treatments was found significant on total weed density at50 DAS. The minimum mean total density (19.33 no. m$^{-2}$) was observed under the interaction of90%cropresidueretentionand$H_4$.While,maximumtotaldensitywasrecorded(74.67and74.94no.m$^{-2}$)incombinationofno/nilcrop residuewithtreatments$H_1$and$H_2$ respectively. **(Table2)**

**Comment [i21]:** The reduced overall weed density in treatments H1 and H2 may be attributable to imazethapyr's pre-emergence effect on weed germination. Barla and Upasani (2021) also noted results in a comparable manner.

**Comment [i22]:** methods

**Comment [i23]:** Lowest mean total density

**Comment [i24]:** The highest total density was recorded

**Table 2.**Interaction of crop residue retention and herbicidal weed control treatments on totalweeddensity (no. m$^{-2}$) at50 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-Cropresidue, H-Herbicide treatments**

## Cropgrowthandyieldcharacteristics

**Comment [i25]:** features of crop yield and growth

Thedataoncropgrowth(plantheightanddryweightplant$^{-1}$,atharvest)andyieldcharacteristics(numberofpodsplant$^{-1}$,seedsplant$^{-1}$,seedandstrawyield(kgha$^{-1}$)weresignificantlyinfluencedbycropresidueretentionandherbicidalweedcontrolpractice.Amongt

**Comment [i26]:** its not clear

hecropresidueretention,

**Comment [i27]:** Among other things, for retaining crop residues

plantheight(54.81cm)anddryweight(18.39gplant$^{-1}$)wererecordedwiththe90%cropresidueretentionwhichwasatparwith60%cropresidueretentionandsignificantlyhigherascomparedto30%andnocropresidueretention,whileminimum(49.71and14.07gplant$^{-1}$)wererecordedunder no/nil crop residue retention. Higher growth of crop might be due to higher crop residueretention which improves soil moisture, nutrient uptake by crop and also soil health *i.e.*, soilorganiccarbon,soilstructureandsoilporosity(Yadav*etal*.,2019;Kumawat*etal*.,2020).Theseresultswereinclose conformitywiththoseofJakhar*etal*.(2017).Withrespecttoweedcontroltreatments,plantheightandplantdryweight(55.82cmand19.60gplant$^{-1}$)wereobservedwithtreatment$H_2$ whichwassignificantlysuperiortotherestoftheherbicidetreatmentsandminimumplantheightanddryweight(50.46cmand15.03gplant$^{-1}$)werenotedundertreatment$H_3$.

Comment [i28]: The lowest

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**Table 3.**Effect of crop residue retention and herbicidal weed control treatments on plant height,dryweight, podsandseedsplant$^{-1}$

| **Cropresidue** | **Plant height(cm)** | **Dry weightplant$^{-1}$** | **Pods plant$^{-1}$** | **Seeds plant$^{-1}$** |
|---|---|---|---|---|
| 90%crop residueretention ($CR_{90\%}$) | 54.81 | 18.39 | 36.46 | 47.11 |
| 60%cropresidueretention ($CR_{60\%}$) | 54.24 | 18.05 | 35.50 | 46.11 |
| 30%cropresidueretention ($CR_{30\%}$) | 53.61 | 17.65 | 33.79 | 44.75 |
| No/nilcrop residue retention ($CR_{0\%}$) | 49.71 | 14.07 | 26.17 | 34.86 |
| **Weedmanagement** | | | | |
| $H_1$(Imazethapyr @50ga.i.ha$^{-1}$asPE) | 54.58 | 17.60 | 34.53 | 46.29 |
| $H_2$($H_1$*fb*HWat50 DAS) | 55.82 | 19.60 | 37.67 | 49.88 |
| $H_3$(Imazethapyr@25ga.i.ha$^{-1}$+Clodinafop@60ga.i.ha$^{-1}$30DAS) | 50.46 | 15.03 | 28.71 | 37.39 |
| $H_4$($H_3$*fb*HW at50DAS) | 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(Cropresidue ×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 andstraw yield (36.46, 47.11, 1202 kg ha$^{-1}$ and 2916 kg ha$^{-1}$, respectively) were achieved under the90%cropresidueretentionwhichwasstatisticallyatparwiththe60%cropresidueretentionand

significantly higher than 30% and no/nil crop residue retention. While, the lowest values wererecorded in the no crop residue retention treatment (26.17, 34.86, 950 kg ha$^{-1}$ and 2623 kg ha$^{-1}$).Cropresidueretentiontreatmentshadhigheryieldsthanthatofcropresidueremovals,suggesting that field mulching with crop residue promotes soil health, crop productivity andreduced the weed density. This is because residues and their decomposition improves the soilstructure through enhancing soil aggregate stability and soil properties while limiting soil waterevaporation 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 yieldcharacteristics (37.67, 49.88, 1305 kg ha$^{-1}$ and 3077 kg ha$^{-1}$) were recorded in $H_2$ which wasremarkably higher in comparison to rest of the herbicidal weed control treatments. The highervalueofyieldcharacteristicsmightbeduetotheeffectofpre-emergenceapplicationofimazethapyr and hand weeding, resulting in reduced weed germination, weed density and lowerweedcompetitionfornutrientandmoisture.RelatedresultswerereportedbyRathod*etal*.(2017)andBarlaandUpasani(2021).Whereas,theminimumvaluesofyieldcharacteristicswerefoundunderthetreatment$H_3$(28.71, 37.39, 979kg ha$^{-1}$and2596kg ha$^{-1}$) (**Table3 andFigure1**).

Comment [i31]: However,minimalvalues ofyield-relatedtraitswerefoundintreatmentH3

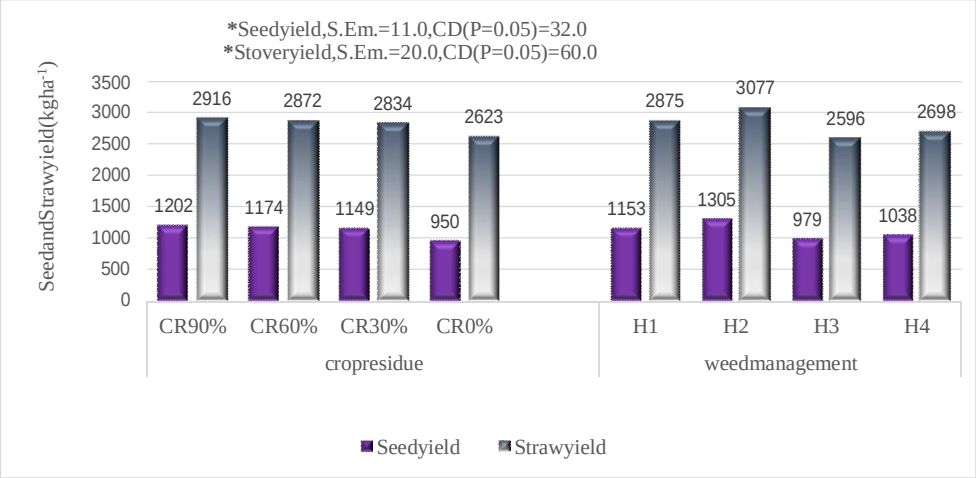


**Figure 1.**Effect of crop residue retention and herbicidal weed control treatments on seed andstraw yield

The lower yield characteristics in treatments $H_3$ and $H_4$ might be due to phytotoxic effect ofimazethapyronchickpea.Theresultsimpliedthatahigherconcentrationofimazethapyrresultedindecline ingrowth,yieldattributesandyieldofchickpea(Goud*et al*.,2013)andimazethapyr

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

**Table4.**Interactionofcropresidueretentionandherbicidalweedcontroltreatmentsonpodsandseeds plant$^{-1}$

| | Podsplant$^{-1}$ | | | | Seedsplant$^{-1}$ | | | |
|---|---|---|---|---|---|---|---|---|
| **CR/H** | **$CR_{90\%}$** | **$CR_{60\%}$** | **$CR_{30\%}$** | **$CR_{0\%}$** | **$CR_{90\%}$** | **$CR_{60\%}$** | **$CR_{30\%}$** | **$CR_{0\%}$** |
| **$H_1$** | 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 herbicidalweed controltreatmentshad significantlyaffected pods plant$^{-1}$, seeds plant$^{-1}$, seed and straw yield (**Table 4 and 5**). Maximum values ofpods plant$^{-1}$, seeds plant$^{-1}$, seed and straw yield (42.22, 55.57, 1430 kg ha$^{-1}$ and 3252 kg ha$^{-1}$)wererecordedundertheinteractionof90%cropresidueretentionand$H_2$whileminimumvalues(24.33, 32.39, 870 kg ha$^{-1}$ and 2513 kg ha$^{-1}$) were observed the interaction of no/nil crop residueretentionand $H_3$.

**Table5.**Interactionofcropresidueretentionandherbicidalweedcontroltreatmentsonseedandstraw yield

| | Seedyield | | | | Strawyield | | | |
|---|---|---|---|---|---|---|---|---|
| **CR/H** | **$CR_{90\%}$** | **$CR_{60\%}$** | **$CR_{30\%}$** | **$CR_{0\%}$** | **$CR_{90\%}$** | **$CR_{60\%}$** | **$CR_{30\%}$** | **$CR_{0\%}$** |
| **$H_1$** | 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 retentionand$H_2$-Imazethapyr@50ga.i.ha$^{-1}$aspre-emergenceapplicationfollowedbyonehandweedingat 50 days after sowing proved to be best in terms of crop growth and yield characteristics ofchickpea and more remunerative among all the levels of residue retention and herbicidal weedcontrol treatments. Also, higher level of residue retention ($CR_{90}$ - 90% of crop residue retentionlevel)incombinationwith$H_2$(Imazethapyr@50ga.i.ha$^{-1}$asPE*fb*HW50DAS)provedtobethebesttreatmentintermofweedcontrolandrecordedlowestweed density andmaximum cropyield.

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

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**Comment [i32]:** The results obtained from the present study proved that $CR_{90\%}$ with 90 % crop residue retentionand$H_2$-Imazethapyr@50ga.i.ha$^{-1}$aspre-emergenceapplicationfollowedbyonehandweedingat 50 days after sowing proved to be best in terms of crop growth and yield characteristics ofchickpea and more remunerative among all the levels of residue retention and herbicidal weedcontrol treatments. Also, higher level of residue retention ($CR_{90}$ - 90% of crop residue retentionlevel)incombinationwith$H_2$(Imazethapyr@50ga.i.ha$^{-1}$asPE*fb*HW50DAS)provedtobethebesttreatmentintermofweedcontrolandrecordedlowestweed density andmaximum cropyield.
Thus, we concluded that the retention of 90% crop residue with pre-emergence application ofimazethapyr @ 50 g a.i. ha$^{-1}$ followed by one hand weeding at 50 DAS proved to be best fromweed control and crop yield point of view under conservation agriculture among the varioustreatments evaluated.

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**Comment [i33]:** A.

**Comment [i34]:** In the text 2020

**Comment [i35]:** In the text 1995

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