***Original Research Article***

# Effect of herbicide on root nodules, phytotoxicityand economicsof chickpea


## ABSTRACT

Theexperimentwasconducteddur*ing**Rabi*season2011-12 atAgronomyResearchFarmof N.D.U.A.&T.~~)~~, Kumarganj, Faizabad, Uttar Pradesh.To find suitable weedmanagement practice for controlling ~~of~~ weeds in chickpea ~~for~~ and increase the yield, net returnand benefit cost ratio. The significantly highest ~~values of~~ fresh and dry weight of nodules perplant (mg) at 45 DAS and 60 DAS (day after sowing) was recorded in weed free plot at each growth stage except dry weightof nodules per plant (mg) at 45 DAS was maximum (392.0mg) in oxyfluorfen 200 g pre-emergence (PE) *fb*quizalofop 60gha$^{-1}$post emergence (PoE) plot and number of branches at 60 and 90 DAS was found highest in weed free plot (11.2122.50) respectively and found statically at par with pendimethalin 1000 gha$^{-1}$PE, pendimethalin 1000gPE *fb*quizalofop 60 gha$^{-1}$PoE and pendimethalin 1000 gPE *fb*clodinafop 60 gha$^{-1}$PoE plot at 60DAS and at 90 DAS significantly lowest value of number of branches (11.10) in pendimethalin750 gPEfbquizalafop 60g + oxyfluorfen 200 gha$^{-1}$ PoE plot. In p~~P~~endimethalin750 g PE*fb*quizalafop 60 g +oxyfluorfen 200 gha$^{-1}$PoE and oxyfluorfen200 g + quizalofop 60 gha$^{-1}$PoE treatments ~~where~~ very severe toxicity (about 80 %) was observed and was followed by oxyfluorfen 200 g + *fb*clodinafop 60 gha$^{-1}$PoEandpendimethalin1000gPE*fb*imazethapyr75g+quizalofop60gha$^{-1}$PoE,respectively.Themaximumreductioninseedyieldofchickpeawererecordedinpre-emergenceapplicationofpendimethalin750gfollowedbycombinedPoEapplicationofquizalofop-ethyl60g+oxyfluorfen200gha$^{-1}$at35DAS. T~~t~~hiswascausedduetophyto-toxicityamongtheherbicidesundertreatment.Maximum net monetary returns (₹ 53588.05ha$^{-1}$) and B-C ratio (2.24) were recorded in PE applicationof pendimethalin1000gandPoE application of clodinafop60gha$^{-1}$ and(2.05)obtainedin PE application of pendimethalin1000g and PoE application of quizalofop-ethyl 60gha$^{-1}$at35DAS. andPEapplicationofpendimethalin750gfollowedby combinedPoE application of quizalofop-ethyl 60g + oxyfluorfen 200gha$^{-1}$at 35 DAS and PoEapplication of oxyfluorfen200g + quizalofop-ethyl 60gha$^{-1}$ PoE the net monetary returns and B:C ratiowereinnegative.



Keywords:Economics, Herbicides,Phytotoxicity, Root nodulations andWeedcontrol


**Comment [a1]:** Too long sentence. Split into 2 or 3 sentences

**Comment [a2]:** Revise. not clear

**Comment [a3]:** Needs revision.

## INTRODUCTION

Chickpea (*Cicerarietinum*) is the topmost pulse crop and it cover around 92 percent areaand 89 percent production in semiarid tropical countries (Rathore 2000).In India thea Area,productionandproductivityofchickpeaarethe8.17millionhectares,7.48milliontonnes and 915 kgha$^{-1}$, respectively. The areaunder chickpea crop has reduced to 0.60 million hectaresin 2012-13 from 1.06 million hectarein1966-67(Anonymous2013)duetoslowinitialgrowth,itsuffersbadlybyseverecompetition with weeds for nutrients, light, water and space result into heavy reduction inyieldabout40-45 percentduetosevereinfestationofweeds(Singh and Singh 1992). It is a rich source ofproteinandtherefore,agronomistsdesiretomaximizeitsproductionwhilereducingorminimizetheuseofherbicides.However, ifherbicidesareapplied in chickpea field nitrogen fixation and subsequentlyreduced the yield(Pahwa and Prakash 1992). Weed causes a reduction in chickpea production about 40-90 percent so herbicides are widely used(Ahlawat2000).Sinceearlierstudieshavedemonstratedthe adverse effects of herbicides on Rhizobium growth and itssymbiosiswithotherlegumecrops,andinsufficientinformationisavailableontheeffectofherbicideson Meso-rhizobium with chickpea symbiosis, as a results the fresh anddryweightofnodulesplant$^{-1}$(mg)decreases.Weedinfestation in chickpea offer serious competition and causeyield reduction to the extent of 75 percent (Chaudhary *et al*. 2005). The initial 60 days period considered being the critical forweed crop competition in chickpea (Singh and Singh 1992)but with the increase in labour cost and scarcity of labour,manual weed control has become a difficult task in chickpea.The herbicide application is an effective control of mixed weed flora isrequired forbetteradoptioninthiscropbythe farmers.Hence, present study was carried out under fieldconditions in order to evaluate the effects of soil applicationsofdifferentherbicidesonthephytotoxiceffect*viz.*cropdiscoloration, chlorosis, stunting and wilting of crop plantswere taken into account, fresh and dry weight of nodule andyield and economics ofchickpea.

MATERIALSANDMETHODS

The experiment was conducted during*Rabi* season ofthe year 2011-12 at Agronomy Research Farm of N.D.U.A&T Kumarganj,Faizabad U.P. India. The soil of the experimental field wasclay-

loam,lowinorganiccarbonavailablenitrogenandphosphorus,mediuminpotashandalkalineinreaction.Chickpea variety "*PG-186*" was sown in early second fortnight of November, 2011 at 40 cm row spacingand 4-5 cm deep by using the *Kudali*. Theexperimentwaslaid outinrandomizedblockdesignwithfourteen treatments combinations *viz.*$T_1$: Pendimethalin 1000 g $ha^{-1}$ (PE), $T_2$: Pendimethalin 1000 g (PE) fb quizalofop 60 g $ha^{-1}$ ( PoE), T3: Pendimethalin 1000 g (PE) fb clodinafop 60 g $ha^{-1}$ (PoE), T4: Pendimethalin 750 g (PE) fb quizalofop 60 g + oxyfluorfen 200 g $ha^{-1}$ (PoE), $T_5$: Oxyfluorfen 200 g $ha^{-1}$ (PE), $T_6$: Oxyfluorfen 200 g (PE) fb quizalofop 60 g $ha^{-1}$ (PoE), $T_7$:Oxyfluorfen 200 g (PE)fb clodinafop 60 g $ha^{-1}$ (PoE), $T_8$: Oxyfluorfen 200 g + quizalofop 60 g $ha^{-1}$ (PoE), $T_9$: Oxyfluorfen 200 g + fb clodinafop 60 g $ha^{-1}$ (PoE), $T_{10}$: Imazethapyr 75 g $ha^{-1}$ (PoE), $T_{11}$: Pendimethalin 1000 g (PE) fb imazethapyr 75 g $ha^{-1}$ (PoE), $T_{12}$: Pendimethalin 1000 g (PE) fb imazethapyr 75 g + quizalofop 60 g $ha^{-1}$ (PoE), $T_{13}$: Weed free, and $T_{14}$: Weedy check and all the treatments were replicated in thrice. Two hands weedings was done in weed free plot exceptall treatments.Auniformdoseoffertilizers20-40-40,N-$P_2O_5$-$K_2O$kgha$^{-1}$wasappliedatthetimeofsowing in furrows. Pre-plant incorporation and PE herbicide wereappliedonedaybeforeandaftersowing,respectivelyusingaknapsacksprayerfittedwithflatfannozzle with a spray volume of 600 litres of water per hectare.Hand weeding was done with the help of *khurpi* as whenrequiredinweedfreetreatment.Weeddryweightwasrecorded by placing a quadrate of 0.25 m at three randomplaces in each plot and then weighed for all weeds separatelyafterovendrying45 daysaftersowingand harvesting.

**RESULTSANDDISCUSSION**

**Growth parameters**

**Freshanddryweight:** Theevident of presented in Figure1 theboth 45 and 60 DAS,post-emergenceapplicationofeitherclodinafop or quizalofop 60 gha$^{-1}$ each in the plots and pre-emergence application of either pendimethalin 1000 gha$^{-1}$recordedsignificantlyhigher fresh and dry weight of nodulesplant$^{-1}$ as compared tothesingleappliedherbicidetreatmentlikependimethalin1000gha$^{-1}$PEandoxyfluorfen200gha$^{-1}$PE.Whileimazethapyr 75 gha$^{-1}$as PoE and pendimethalin 1000 g PE*fb*imazethapyr75gha$^{-1}$recordedatpartoeachotherwithrespecttofreshanddryweightofnodules.However,pendimethalin1000g*fb*quizalofop60g+oxyfluorfen 200 g,oxyfluorfen 200 g + quizalofop 60 gha$^{-1}$,oxyfluorfen 200 g + clodinafop 60 gha$^{-1}$and pendimethalin1000g as PE*fb*imazethapyr75g + quizalofop60

**Comment [a4]:** ??? translate in english

**Comment [a5]:** ? it is normally used for soil collection. check

**Comment [a6]:** Poor sentence . Meaning not conveyed. Revised

gha$^{-1}$asPoErecorded lower values of fresh and dry weight of noduleswhich were at partoeachother.These findings are in the conformity ~~as~~to the report~~ed by~~ of Nandan *et al*. (2011) and Singh *et al*. (2011).

**Phytotoxicity:** Thedatarelatingtophytotoxiceffectofweedcontroltreatments on chickpea have been given in Table 1. The tank mixedapplication of oxyfluorfen 200 g with either quizalofop orclodinafopat60gha$^{-1}$eachorimazethapyr75g+quizalofop60gha$^{-1}$appliedasonlypost-emergencetreatmentsorasfollow up with pendimethalin 1000 g or oxyfluorfen 200 gha$^{-1}$applied as PE showed phytotoxicity symptom oncrop plants within 1-15 DAHA. The phytotoxic symptomsobserved from 3$^{rd}$ DAHA incaseofPoEherbicidesandmaximumtoxicityobservedat7-10daysofapplicationincaseofpendimethalin750 g PE *fb*quizalafop 60 g + oxyfluorfen 200gha$^{-1}$PoEandoxyfluorfen200g+quizalofop60gha$^{-1}$PoE.

treatmentswhereveryseveretoxicityabout80percentwasobserved followed by oxyfluorfen 200 g + *fb*clodinafop 60gha$^{-1}$ PoE and pendimethalin 1000 g PE*fb*imazethapyr 75g+quizalofop60gha$^{-1}$PoE,respectively.However,incaseoftreatments*viz*.imazethapyr75gha$^{-1}$PoE,pendimethalin1000gPE*fb*imazethapyr75gha$^{-1}$PoEandpendimethalin1000gPE*fb*imazethapyr75g+quizalofop 60 gha$^{-1}$ PoE, slightly rejuvenation of crop plants(20-30%)wasrecordedthrough visualobservations.Thisrecovery took place within fortnight period of crop growthafter the appearance oftoxicity.The tank mixed application of quizalofop 60 g + oxyfluorfen200g as PoE caused ~~the~~ very severe phytotoxicity (upto80 %) to the crop and showed the discoloration, chlorosis ofleaves and finally wilting of the chickpea plant and symptomsobservedfrom 3 DAHA andfinallywilting was recorded at 10DAHA. Almost similar degree ofphytotoxicitywasrecordedincaseofoxyfluorfen200gfollowed by oxyfluorfen 200 g + clodinafop 60 gha$^{-1}$ having(about 70 %) toxicity. Ratnam *et al.* (2011) also reported thetypephytotoxicsymptomsofherbicidesonchickpeacrop.

Comment [a7]: Need to be discussed in detail

**Numberofbranches:** The data pertaining to number of branchesplant$^{-1}$ recorded at60 and 90 DAS stages of crop growth have been presented infigure 2. Pre-emergence of pendimethalin 1000 gha$^{-1}$ alone andincombinationwithquizalofoporclodinafop60g ha$^{-1}$asa PoE eachseparatelybeingatparandrecordedsignificantlyhigherbranchesplant$^{-1}$thanweedycheck.Likewise, oxyfluorfen 200 g PE alone and in combination withquizalofopandclodinafop60g ha$^{-1}$PoEeachseparatelyaswellastreatmentimazethapyr75g ha$^{-1}$PoEand pendimethalin1000gPE*fb*imazethapyr75g ha$^{-1}$

[1]PoErecordedsignificantlyhighernumberofbranchesplant[-]
[1]overtreatmentpendimethalin750gPE*fb*quizalafop 60 g + oxyfluorfen 200 g ha[-1]PoE, oxyfluorfen200 g + quizalofop 60 g ha[-1]PoE and oxyfluorfen 200 g +*fb*clodinafop 60g ha[-1]PoE.At60 and 90 DASofcropgrowth,weedfreetreatmentdidnotshowmuchdifferenceascomparedtopendimethalin 1000 g PE along with clodinafop 60 g PoE,pendimethalin 1000 gha[-1] along with quizalofop 60 g PoE,pendimethalin1000gPE,pendimethalin1000gPE*fb*imazethapyr 75 g PoE and oxyfluorfen 200 g PE alongwithclodinafop60g ha[-1]PoEbeingatparrecordedsignificantly higher number of branchesplant[-1] as compared toweedycheck.The similar trend was observed at 90th day stage also**(**Pahwa and Prakash, 1992**)**. Thismay be because of the fact that treatments which have betterweed control efficiency caused more horizontalcrop growthasaresultproduceda greaternumber ofbranchesplant[-1].

**YIELD**

Alltheweed-controlmeasureshadsignificant~~ly~~ positiveimpact on grain yield of chickpea over weedy check (Figure ~~no.~~ 2).The significantly highestvalues of m~~M~~aximum reductioninseed yield (tha[-1]) were recorded in pre-emergence applicationofpendimethalin750g*fb*withcombinedpost-emergenceapplicationofquizalofop-ethyl60g+oxyfluorfen200gha[-1]PoE (0.47tha[-1]) at 35 DAS over weedy check (0.92tha[-1]) andsignificantlyatparwithpostemergenceapplicationofoxyfluorfen 200g + quizalofop-ethyl 60gha[-1] (0.48 tha[-1]) at 35DAS, and post-emergence application of oxyfluorfen 200g +clodinafop 60gha[-1] PoE (0.52 tha[-1]) treatment this is might bedue to less reduction of weed and phyto-toxicity of herbicideinpendimethalinaspre-emergencefollowedbymixpost-emergence of quizalofop-ethyl 60g + oxyfluorfen were lesseffective,andhinderedduringcriticalperiodofgrowth.(Ratnam. *et al* 2011).

**ECONOMICS**

The data is evident from figure ~~no.~~ 2 maximum net monetary returns (₹ 53588.05ha[-1]) and B:C ratio(2.24)wererecordedinpre-emergenceapplicationofpendimethalin 1000g (PE) *fb* post emergence application ofclodinafop60gha[-1]at35DASbyregisteringnetmonetaryreturns ₹ 50448.05ha[-1] and B:C ratio (2.05) in pre-emergenceapplicationofpendimethalin1000g*fb*byPoE applicationof quizalofop-ethyl60gha[-1]at35DAS,foundtobe thenextbesttreatmentandpre-emergenceapplicationofPendimethalin 750 g followed by combined post-

**Comment [a8]:** Incomplete. discuss properly

**Comment [a9]:** poor sentence

emergenceapplicationofquizalofop-ethyl60g+oxyfluorfen200 gha$^{-1}$ at 35DASandpostemergencecombinedapplicationofoxyfluorfen 200g + quizalofop-ethyl 60gha$^{-1}$at 35DAS, thenetmonetaryreturnsandB:Cratiowereinnegativebecause of high cost of cultivation (Pedde *et al*. 2013).

## CONCLUSION

The PE application of pendimethalin 1000 g ha$^{-1}$ along with PoE application of either clodinafop propargyl 60 g ha$^{-1}$ or quizalofop ethyl 60 g ha$^{-1}$ proved superior over rest of the treatments with respect to fresh weight, dry weight, number of branches, grain yield, B-C ratio, net returns and economics of chickpea followed by oxyfluorfen 200 g ha$^{-1}$ as PE along with PoE application of clodinafop propargyl or quizalofop ethyl 60 g ha$^{-1}$ each. However, PoE application of tank mixed herbicides caused the phytotoxicity to the chickpea.with

**Comment [a10]:** Is it needed? Conclude with the composition of mix

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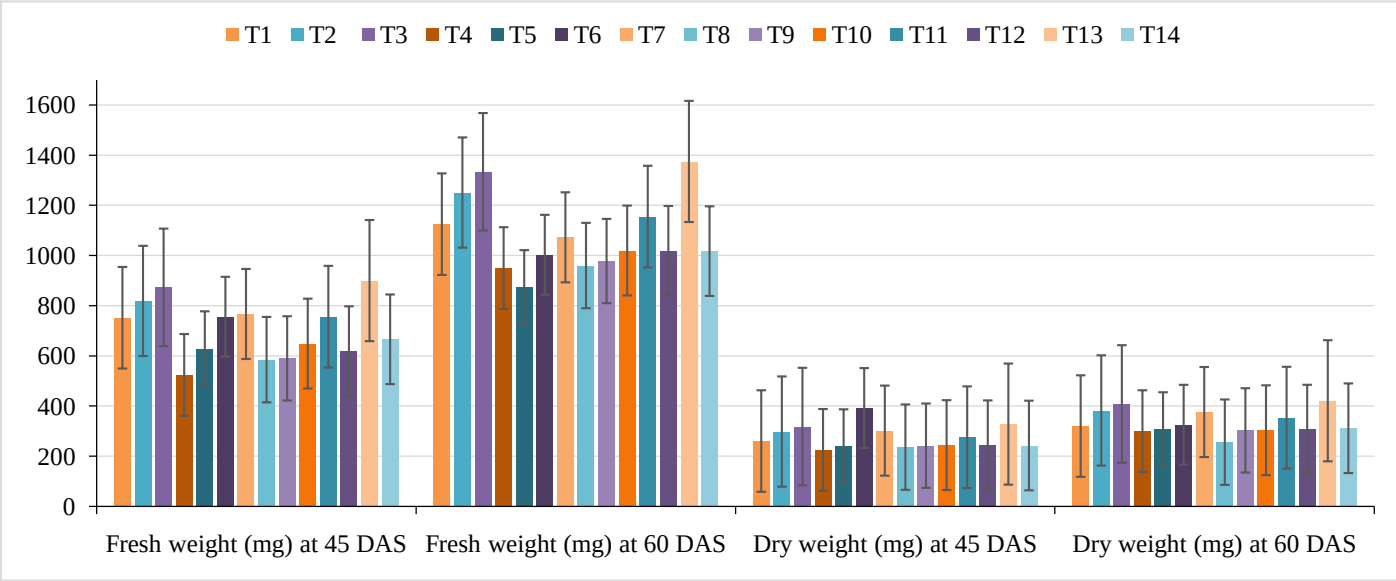


**Figure no.1:**Effectofweed controltreatmentsonfreshanddryweightofnodulesperplantat45 and 60 DAS ofchickpea

$T_1$: Pendimethalin 1000 g $ha^{-1}$ (PE), $T_2$: Pendimethalin 1000 g (PE) fb quizalofop 60 g $ha^{-1}$ ( PoE), T3: Pendimethalin 1000 g (PE) fb clodinafop 60 g $ha^{-1}$ (PoE), T4: Pendimethalin 750 g (PE) fb quizalofop 60 g + oxyfluorfen 200 g $ha^{-1}$ (PoE), $T_5$: Oxyfluorfen 200 g $ha^{-1}$ (PE), $T_6$: Oxyfluorfen 200 g (PE) fb quizalofop 60 g $ha^{-1}$ (PoE), $T_7$: Oxyfluorfen 200 g (PE) fb clodinafop 60 g $ha^{-1}$ (PoE), $T_8$: Oxyfluorfen 200 g + quizalofop 60 g $ha^{-1}$ (PoE), $T_9$: Oxyfluorfen 200 g + fb clodinafop 60 g $ha^{-1}$ (PoE), $T_{10}$: Imazethapyr 75 g $ha^{-1}$ (PoE), $T_{11}$: Pendimethalin 1000 g (PE) fb imazethapyr 75 g $ha^{-1}$ (PoE), $T_{12}$: Pendimethalin 1000 g (PE) fb imazethapyr 75 g + quizalofop 60 g $ha^{-1}$ (PoE), $T_{13}$: Weed free, and $T_{14}$: Weedy check.

**Table1:** Visualobservationonphytotoxicityon chickpeaduetodifferent herbicides(Score0-10)

| Treatments | CropdiscolourationonDAHA | | | | | | ChlorosisonDAHA | | | | | | StuntingonDAHA | | | | | | WiltingonDAHA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 01 | 03 | 05 | 07 | 10 | 15 | 01 | 03 | 05 | 07 | 10 | 15 | 01 | 03 | 05 | 07 | 10 | 15 | 01 | 03 | 05 | 07 | 10 | 15 |
| Pendimethalin 1000 g $ha^{-1}$ (PE) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pendimethalin 1000 g(PE) fb quizalofop 60 g $ha^{-1}$ (PoE) | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pendimethalin 1000 g(PE) fb clodinafop 60 g $ha^{-1}$ (PoE) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pendimethalin 750 g(PE) fb quizalafop 60 g + oxyfluorfen 200 g $ha^{-1}$ (PoE) | 0 | 1 | 2 | 7 | 8 | 3 | 0 | 2 | 2 | 4 | 8 | 8 | 0 | 1 | 2 | 8 | 8 | 8 | 0 | 2 | 3 | 8 | 8 | 8 |
| Oxyfluorfen 200 g $ha^{-1}$ (PE) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oxyfluorfen 200 g (PE) fb quizalofop 60 g $ha^{-1}$ (PoE) | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oxyfluorfen 200 g (PE) fb clodinafop 60 g $ha^{-1}$ (PoE) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oxyfluorfen 200 g + quizalofop 60 g $ha^{-1}$ (PoE) | 0 | 2 | 5 | 8 | 8 | 8 | 0 | 1 | 5 | 6 | 8 | 8 | 0 | 0 | 5 | 8 | 8 | 8 | 0 | 2 | 3 | 8 | 8 | 8 |
| Oxyfluorfen 200 g + fb clodinafop 60 g $ha^{-1}$ (PoE) | 0 | 2 | 4 | 7 | 7 | 7 | 0 | 1 | 4 | 5 | 7 | 7 | 0 | 1 | 2 | 5 | 7 | 7 | 0 | 2 | 3 | 7 | 7 | 7 |
| Imazethapyr 75 g $ha^{-1}$ (PoE) | 0 | 1 | 3 | 5 | 7 | 3 | 0 | 4 | 5 | 7 | 5 | 2 | 0 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 0 | 0 |
| Pendimethalin 1000 g (PE) fb imazethapyr 75 g $ha^{-1}$ (PoE) | 0 | 1 | 3 | 5 | 7 | 3 | 0 | 4 | 5 | 7 | 5 | 2 | 0 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 0 | 0 |
| Pendimethalin 1000 g (PE) fb imazethapyr 75 g + quizalofop 60 g $ha^{-1}$ (PoE) | 0 | 1 | 3 | 7 | 8 | 4 | 0 | 4 | 5 | 8 | 6 | 3 | 0 | 0 | 0 | 1 | 3 | 4 | 0 | 0 | 2 | 3 | 4 | 4 |
| Weed free | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Weedy check | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

DAHA=Dayafterherbicideapplied

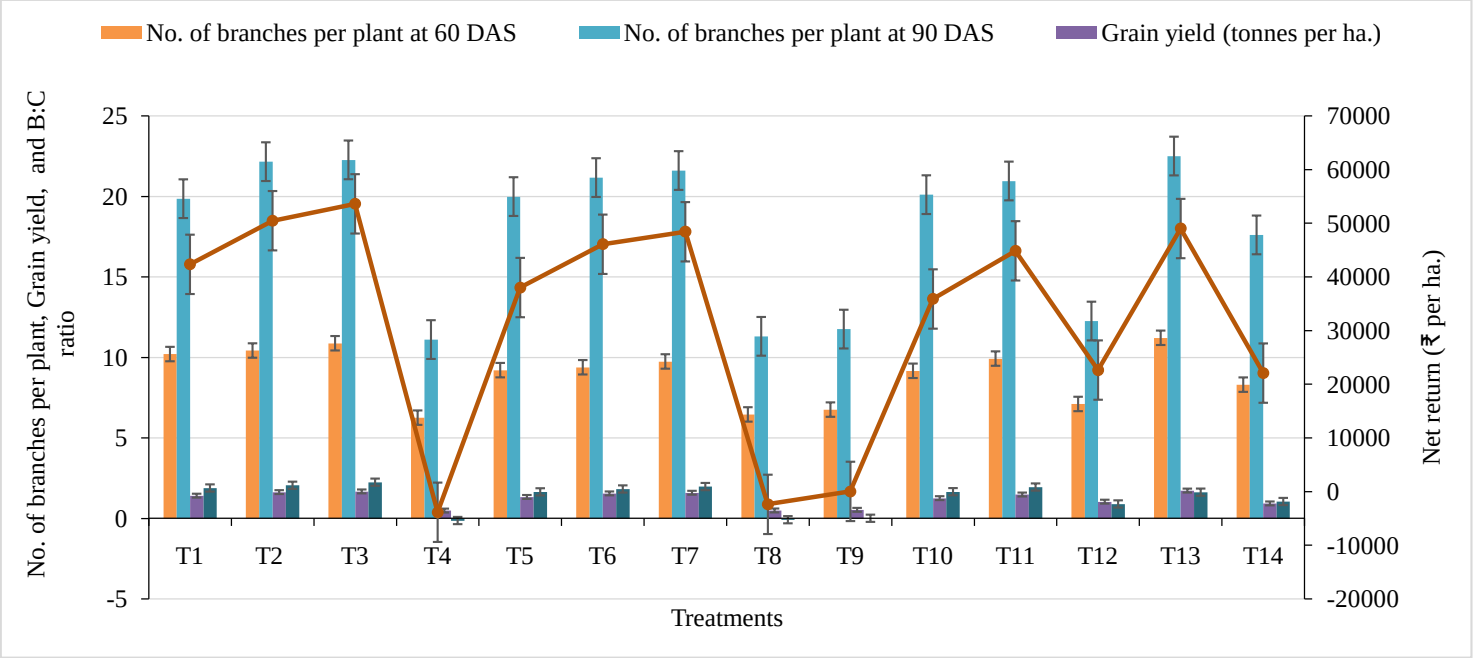


**Figure No. 2:**Effectofherbicideson numberofbranches,yield,andeconomicsofchickpea

$T_1$: Pendimethalin 1000 g $ha^{-1}$ (PE), $T_2$: Pendimethalin 1000 g (PE) fb quizalofop 60 g $ha^{-1}$ ( PoE), T3: Pendimethalin 1000 g (PE) fb clodinafop 60 g $ha^{-1}$ (PoE), T4: Pendimethalin 750 g (PE) fb quizalofop 60 g + oxyfluorfen 200 g $ha^{-1}$ (PoE), $T_5$: Oxyfluorfen 200 g $ha^{-1}$ (PE), $T_6$: Oxyfluorfen 200 g (PE) fb quizalofop 60 g $ha^{-1}$ (PoE), $T_7$: Oxyfluorfen 200 g (PE) fb clodinafop 60 g $ha^{-1}$ (PoE), $T_8$: Oxyfluorfen 200 g + quizalofop 60 g $ha^{-1}$ (PoE), $T_9$: Oxyfluorfen 200 g + fb clodinafop 60 g $ha^{-1}$ (PoE), $T_{10}$: Imazethapyr 75 g $ha^{-1}$ (PoE), $T_{11}$: Pendimethalin 1000 g (PE) fb imazethapyr 75 g $ha^{-1}$ (PoE), $T_{12}$: Pendimethalin 1000 g (PE) fb imazethapyr 75 g + quizalofop 60 g $ha^{-1}$ (PoE), $T_{13}$: Weed free, and $T_{14}$: Weedy check.