Integratedeffectof*Trichodermaharzianum* withselectedbotanicalsextractsonAlternaria leafspotof**broccoli**(*Brassicaoleracea*var. *italica*)causedby*Alternariabrassicae*(Berk.) Sacc

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ABSTRACT

Broccoli (*Brassicaoleracea*var. *italica*) is an important cole crop vegetable,belongtofamilyBrassicaceae.Alternarialeafspotcausedby*Alternariabrassicae*is one of the serious diseases in broccoli. *In vitro* and *in vivo* experiment wereconducted at the research plot of the Department of Plant Pathology, SamHigginbottom University of Agriculture, Technology and Sciences, Prayagraj,Uttar Pradesh in *Rabi* season 2023-2024, to evaluate *Trichodermaharzianum*and botanicals on Alternaria leaf spot of broccoli caused by *A.brassicae*. *In vitro*condition, five botanical extracts were taken at the concentration 10% and *T.harzianum*at 10% and Mancozeb at 0.2% (treated check). *In vivo* condition,eight treatments were taken and all seedlings were treated with *T. harzianum*at10%,Mancozebat0.2%andfoliarsprayofbotanicalextracts@10%exceptT$_0$ – control (untreated check) and (treated check). *In vitro* condition, among thetreatments Neem leaf extract at 10% were observed effective in the per centdiseaseinhibition(%)(79.77)followedbyEucalyptusleafextractat10%(75.69).Among the treatments, under *In vivo* condition, T$_3$- *T. harzianum*(S.T.) + Neemleafextract(F.S.)wasobservedminimumdiseaseintensity(16.59,19.85and 23.28 %) at 45,60 and 75 DAT, respectively. Maximum plant height (9.78, 23.84and 36.66cm) at 30,60 and 90 DAT, number of leaves per plant (9.36, 17.26 and28.00), head weight (0.38 kg) and yield (9.68 t/ha) were found in T$_3$- *T.harzianum*(S.T.) and Neem leaf extract (F.S.) when compared to treated T$_7$- mancozeb(treatedcheck)andT$_0$- Control(untreated check).

*Keywords:*Alternarialeafspot,*Alternariabrassicae*,botanicalsplantextracts, broccoli,*Trichodermaharzianum.*

1.INTRODUCTION

"Broccoli(*Brassicaoleracea*var.*italica*)isanimportantcolecropvegetable,belongto Brassicaceaefamilyoriginatedfromltalyaboutmorethan2000yearsago**(Buck,1956).** BroccoliisnativetotheeasternMediterraneanandAsiaminor,broccoliwascultivatedinItaly inancientromantimes.ItwasintroducedtoEnglandinthe18thcenturyandbecamepopular intheUnitedStatesinthe20thcentury"(**Morenoetal.,2007**)."ThecommonEnglishname broccoli'isderivedfromtheItalianword'broccolo',meaning'thefloweringcrestofacabbage'. Freshbroccoliisdarkgreenincolourwithfirmstalksandcompactbudclusters.Asa vegetable,itisgrownforits edibleflowerbudsandstalk"(**Dasetal.,2021**).

"Broccoliis abiennialplantbelongingtotheBrassicaceaefamilythatiseatenas avegetable throughouttheworld.Theedibleplantpartsarethestalkandlargefloweringhead.Broccoliis arichsourceofvitaminCandvitaminK.BroccolibecameoneofthefavouritefoodsduetoIts highnutrientandfibercontent.Broccolialsocontainsnumerousphytochemicals,suchas polyphenols,namelykaempferol,quercetinglucosides,isorhamnetin,glucosinolates,and theirderivatives.Theseareresponsibleforitsantioxidantandanticancerpropertiesandother healthbenefits".(**Nagrajetal.,2020**).43

"Broccoliisconsideredacoolseasoncrop,whichhasnowbeendistributedtobothtropicaland subtropicalareas"**(Shivakumaretal.,2022).**"Thiscropcanbecultivatedinvariouspartsof Indiaduringthewinterseason,especiallyinregionswhererainfallisnotexcessive.Areaswith moderaterainfallandcoolertemperaturesaregenerallysuitableforbroccolifarming.Beinga coolseasoncrop,itrequires15-20°Ctemperatureforheadcreation.Temperatureabove25° Cisn'tfavourableforitsdevelopmentandcancauseslackeninganddartingofheads"**(Kumar *etal*.,2021).**

"Theglobalproductionofbroccoliandcauliflowerwas25,531,274tonsfromanareaof 1,357,186ha,inwhichEuroperanksthird(afterChinaandIndia)andcontributes9.5and 10.5%inproductionandarea,respectively"**(Siomosetal.,2022).**"Thisvegetable,closely resemblingcauliflowerbutusuallygreenincolor,introducedinIndiamanyyearsaftercabbage andcauliflowerandhasgainedpopularityinshortspanoftime.Now,Indiastandsatsecond positionforcauliflowerandbroccoliproductionwithanannualproductionof6.7milliontonnes" **(Tejaswinietal.,2018).**" ItismostlycultivatedinhillyareasofHimachalPradesh,Uttar Pradesh,JammuandKashmir,NilgiriHillsandNorthernplainsofIndia"**(Meenaetal.,2020**).60

"Therearemanydiseasesandpestscollectivelythatlowertheyieldandqualityofbroccoli crops.Broccoliisinfectedbyvarioustypesofpathogensincludingbacteria,fungi,andviruses, whichleadtoreductionofyieldandquality"**(Zhangetal.,2022).**" Amongallthediseases Alternarialeafspotdiseasecausedby*Alternaria*sp.isthemostimportantmajordiseasewhich resultedsignificantdeclineintheyieldofallcultivars"**(Lafietal.,2022).**

"Amongthedifferentdiseasescausedbythegenus*Alternaria*,Alternarialeafspotdisease ismostdominantonethatcausesaverageyieldlossintherangeof32-57%"**(Singhetal., 2015).**"During2017and2018,severesymptomsofdarkspotsonleaveswereobservedon broccoliplants(*Brassicaoleracea*L.var.*italica*)cultivarwith45to37%diseaseincidenceand 70%yieldloss"**(DeBrittoetal.,2020).**

Forthemanagementofthisdiseasefungicideshavebeenrecommendedtomanagethe disease,butpresent-dayfarmerperceptionsandenvironmentalhazardsarecompellingto searchforalternativeeco-friendlydiseasemanagementstrategies**(Sakhareetal.,2021)**So thissituationcompelstofocusondiseasemanagementbyutilizingbiologicalagents,plant extractsandfungicidesinlowestconcentration.Applicationofbiologicalagentsandextractis

eco-friendlyandasustainableapproachapartfrombeingapromisingalternativetofungicide application.Inthepresentstudy amongtheplantextracts,*Lantanacamara*wasfoundtobe effectiveinmanagingtheAlternariablightinfectioninthefield(71.92%reductionindisease severityand68.18%increaseinyield)incomparisontobio-agent(*Trichodermaviride*)36.27% reductionindiseaseseverityrespectively.**(AhmadandAshraf,2016).**

2.MaterialsandMethods

Theexperimentwasconductedattheresearchplotof theDepartmentofPlantPathology, CentralResearchField,SamHigginbottomUniversityofAgriculture,TechonologyAnd Sciences,Prayagrajduringthe*Rabi*seasonof2023-2024.Fieldexperimentwaslaidoutin RandomizedBlockDesignwitheighttreatmentshavingthreereplications.

2.1Isolationandidentificationofpathogen

Theleaveswerecollectedfrominfectedplantsbearingcharacteristicsymptomsof Alternaria leafspotofbroccoli.Theleaveswerethoroughlywashedunderrunningtapwater.The symptomsonleavesaftermountingonslidewereexaminedundermicroscopetoconfirmthe presenceof*Alternaria*sp.Theinfectedleafparts alongwiththehealthyportion wascutinto smallpiecesunderasepticconditionsandsurfacesterilizedwith1%sodiumhypochlorite (NaOCl)solutionfor1minuteandwashedthreetimeswithsteriledistilledwatertoremove anytracesofsodiumhypochlorite(NaOCl)adheredwithleafbits.Thentheywereplacedon filterpapersothatextrawatergetsabsorbed.Afterthatfiveleafbitsweretransferredon PDA media**(Tuite,1969)**containedinsterilizedpetriplateswiththehelpofforceps.Toavoid bacterialcontaminationstreptomycin@100ppm,wasaddedinthemediumatlukewarm stagebeforepouringPDAintoPetriplates.ThenPetriplateswerewrappedandincubatedat 27±2°CinBOD,after3daysmyceliagrowthwasobservedaroundleafbits.Withthehelpof corkborer a portionfromthe peripheryhavingsinglehyphaltipfromthiscolonygrowthwas separatedandtransferredtootherpetriplateshavingmediumtogetpureculture and identificationofthepathogenwasrecordedbyobservingthemorphologicalfeaturesofcolony, sporecharacteristicsandreferringtherelevantliterature**(BarnettandHunter,1972)**.

2.2Evaluationofbotanicalextractsand*Trichodermaharzianum*against Alternarialeafspotofbroccoli

2.2.1*Invivo*evaluation

Botanicalextractswerepreparedusingmethodofstandardproceduregivenby**Mahapatra andDas(2013).** Maturedleavesandotherbotanicalswerecollected andsterilizedwithdistilled water,theleaveswerehomogenizedinapestleandmortar,sterilizeddistilledwater.Aqueous extractofthisbotanical(1%w/v)werepreparedbymixing100gfreshleaves/botanicalsof plantwith100mlofsteriledistilledwaterandcrushinginwarringblender.Theextractwas filteredthroughfourlayersofmoisturemuslincloth.Thefiltratethusobtainedwasconsidered asstock solution. Thephyto-extractsweresprayed @10%preparedfromstandardsolution, Mancozebataratio0.2%,fungalbio-agent*T.harzianum*werealsosprayed@10% aftertheappearanceofthefirstsymptomsinthefieldatthirtydaysaftertransplanting(DAT), thefoliarsprayofbotanicals,mancozebandT.harzianumwasappliedthreetimes atfifteendaysinterval.Unsprayedplotswerekeptascontrol.

2.2.2DiseaseIntensity

Theintensityofdiseasewasvisuallyassessedinalltheplotsatweeklyintervalfromfirst appearanceofdiseaseforeachtreatment.Diseaseintensitywascalculatedusingtheformula givenby**Wheeler(1969)**.

$$\text{DiseaseIntensity}(\%)=\frac{\text{Sumofalldiseaseratings}}{\text{Totalnoofratings}\times\text{Maximumdiseasegrade}}\times 100$$

2.2.3*Invitro*evaluation

Culture of*T.harzianum*

Onegofproductwastakenandmixedinninemlofsterilizeddistilledwaterinacleanand sterilizetesttubetomake10^{-1} dilution(1:10)shakenwellandonemlofthesuspensionofnine mlofsterilizewaterwastakeninatubetomake10^{-2}dilution(1:100).Similarly,fourmore serialdilutioninthesamewaywasdonetoget10^{-6}dilutionandtransferredonemlofthis suspensiontosterilepetriplatecontaining15-20mlofsterilizedmeltedandcooledPDAmedia theplateswererotatedgentlyandallowedtosolidify.Thepetriplateswereincubatedin BOD incubatorat25+2°Cforfivetosevendays.Thedevelopmentoftypicalcolonyof *T.harzianum*wasobserved.

Preparationofplantextracts

Thebotanicalsusedfortheexperimentwere Neem,Blacknightshade,Eucalyptus,Datura, Lantana.Thebotanical partused forthetreatmentwere Neemleafextract10%,Blacknight shade leafextract10%, Eucalyptusleafextract10%,Daturaleafextract10%,Lantanaleaf extract10%.Aqueousplantextractswere obtainedasper themethoddescribedby**Bhatti, (1988).**A 100-gramsampleofeachfreshleaveswere gentlywashunderrunningtap water andagain washitin steriledistilledwater. Theneachsample wasgrindseparatelybyusing sterilepestleandmortalwith100mlsteriledistilledwater.Theextractofeachsample thusobtainedwasfilteredseparatelythroughasterilizeddoublelayeredmuslinclothto removethebitsofplantmaterialisfiltrate.Thenextractwasagainfilteredthroughafilterpaper (WhatmanNo.1).Thisformedthestandardplantextractssolution(100%).Alltheglassware usedinthestudywere sterilizedbeforeuse.Alltheplantextractswere testedat10percent concentrationagainstthetestpathogenusingPDAasabasalmedium.Toobtain10percent concentrationofplantextracts,100mloflukewarmPDAwasmixedwith10mlofstandard plantextractsin250mlconicalflask,separatelyandthenitwasstirredwelltoobtain homogenizedmixture.

2.2.4DualCultureTechnique

Twentymlofsterilizedandcooledpotatodextroseagarmediumwaspouredintosterilized petriplates.Fungalantagonistswereevaluatedbyinoculatingapathogenatonesideofthe petriplateandtheantagonistatexactlyoppositesideofthesameplatebyleavingaspaceof 4cm.Afterrequiredperiodofincubationi.e.,whenthe growthincontrolplaterecords90mm indiameter,theradialgrowthofthepathogenswasmeasured**(Vincent,1947)**.

Percentageinhibitionofmyceliagrowthoftestpathogenwascalculatedusingtheformula:

$$I = \frac{C - T}{C} \times 100$$

Where,

I=Percentreductioningrowthoftestpathogen

C=Radialgrowth(mm)incontrol

T=Radialgrowth(mm)intreatment

2.2.5Poisonedfoodtechnique

Fivemmdiameterofculturediscof*A.brassicae*wasbekeptatthecenterofeachpetri platecontainingthebotanicalsofrequiredconcentrationdissolvedinPDA.Threereplications were maintained.Theplateswereincubatedat27±2°Cforsevendaysandcolonydiameter wasrecorded**(Vincent,1947).**

Percentinhibitionofmycelialgrowthwascalculatedbyusingtheformula:

$$I = \frac{C - T}{C} \times 100$$

Where,

I=Percentinhibition

C=Growth(mm)oftestfungusinuntreatedcontrolplate

T=Growth(mm)oftestfungusintreatedplate

3.RESULTSANDDISCUSSION

3.1Effectofplantextractson*A.brassicae*bypoisonfoodtechnique

Radialgrowth(mm)of*A.brassicae*

Thedatapresentedintable1,depictedrevealsignificantreductioninT3- Neemleafextract (18.20mm)followedbyT2–Eucalyptusleafextract(21.87mm),T5–Blacknightshadeleaf extract(23.83mm),T4 –Lantanaleafextract(26.00mm),T1-Daturaleafextract (26.98mm)ascomparedtomancozeb(treatedcheck)-(2.50mm)anduntreatedcheck controlT0-(90mm).

Percentinhibitionofmyceliagrowth

Thedata presentpresentedintable1andfigure1 revealthattherewassignificant increase inT3-Neemleafextractat10%(79.77%)followedbyT2–Eucalyptusleafextractat10% (75.7%),T5–Blacknightshadeleafextractat10%(73.52%),T4–Lantanaleafextractat10% (71.11%),T1-Daturaleafextractat10%(70.02%)ascomparedtoT7-mancozeb(treated check)(97.21%)anduntreatedcheckcontrolT0-(0%).Theprobablereasonforsuchfindings maybeduetothefactthatNeemleafcontainsactivecompoundssuchasazadirachtinaswell assalanin,nimbim.Constituentssuchasnimbim,nimbidin,limonoidswhichdisruptsthecell ofthepathogenandrestrictstheperformanceofsomeenzymesthatareimportanttoproliferate fungiinnatureandleadstotheirdeath.The currentfindings are consistingwith theresearch conductedby**Vijaykumar*etal*.(2022)andKumar*etal*.(2007)**whotestedtheeffectiveness ofdifferentphytoextractsagainst*A.brassicae*andfoundthattheantifungalactivity andpotentialityofnimbicidinandNeemleafextracthavebeenprovedsuccessfullyagainst the causal fungus..

3.2Effectoftreatmentsondiseaseintensityof Alternarialeafspotofbroccoli causedby*A.brassicae*

Thedatapresentedinthe Table(2)revealthatthediseaseintensity(%)onbroccolisignificantly reducedbyT3–*T.harzianum*+Neemleafextractat10%(23.28%)followedbyT6- (*T.harzianum*at10%(26.31%),T5–(*T.harzianum*+Blacknightshade leafextractat10%(30.26%),T4-(*T.harzianum*+Lantanaleafextractat10% (32.56%),T2–*T.harzianum*+Eucalyptusleafextractat 10%(36.83%),T1- (*T.harzianum*+Daturaleafextractat 10%(37.28%)ascomparedtotheT7– mancozebat0.2%(treatedcheck)(18.96%)aswellas(T0)–control(untreatedcheck) (40.64%).Similarfindingshavebeenreportedby**AnshikaandZacharia(2023)**and**Ravella *etal*.(2023)**Theprobablereasonforthisresultmaybeduetothe Neemhavinganti-microbial activity.Neemhasreportedtoexhibitantifungal,antibacterialandinsecticidalproperties.The ethanolicextractofNeemleavesstopsthegrowthoffungi**.***T.harzianum*hasshown significantresultsondiseaseintensityandyieldattributes,whereasyieldhasbeen significantlyincreasedanddecreaseddiseaseintensitywhichmaybeduetothemycoparasite

natureandabilitytogeneratevolatileandnon-volatilecompoundsagainstpathogenwithgreat anti-microbialactivity.

3.3Effectoftreatmentsonplantheight(cm)ofbroccoli

ThedatapresentedintheTable(3)revealthatthe plantheight(cm)onbroccolisignificantly increasedplantheightinT_3–(*T.harzianum*+ Neemleafextractat10% (36.66 cm)followedbyT_6-(*T.harzianum*at 10%(33.70cm),T_5–(*T. harzianum*+Blacknightshadeleafextract@10%(31.10cm),T_2-(*T.harzianum* +Eucalyptusleafextractat10%(29.93cm), T_4–(*T.harzianum*+Lantanaleaf extractat10%(28.41cm),T_1-(*T.harzianum*+Daturaleafextractat10%(27.78 cm)ascomparedtotheT7–Mancozeb at0.2% (treatedcheck)(39.47 cm) aswellas (T_0) –control(untreatedcheck)(23.01cm).Theprobablereasonforthisresultmaybedueto Neemaqueousextractshowedapromotiveeffectonshootlengths,branchesandleaves numbers.Thebio-efficacyofNeemextractoverpathogenscanbeattributedtothefactthat Neemhasactivecompoundssuchasazadirachtin,nimbin,nimbidin,nimbineneand azadironewhichareantifungal,anti-bacterialandanti-insecticidalinnature**Nahak*etal*. (2015).***Trichoderma*strainscoloniesplantroots,establishingchemicalcommunicationand systemicallyalteringtheexpressionofnumerousplantgenesthatalterplantphysiology. Applicationof*T.harzianum*significantlyincreasedcurdcircumferencelength,the diameterofthestem**Rosa*etal*.(2019).**

3.4Effectoftreatmentsonnumberofleavesperplantofbroccoli

ThedatapresentedinTable(4)revealthatnumberofleavessignificantlyincreasedinT_3– (*T.harzianum*+Neem leafextractat10%(28.00)followedbyT_6-(*T. harzianum*at10%(25.20),T_5–(*T.harzianum*+Blacknightshadeleafextract at10%(23.40),T_2-(*T.harzianum*+Eucalyptusleafextractat10%(21.13),T_4 –(*T.harzianum*+Daturaleafextractat10%(20.66),T_1-(*T.harzianum*+Lantana leafextractat10%(20.40)ascomparedtotheT7–Mancozebat 0.2%(treatedcheck)(31.53)aswellas(T_0)control(untreatedcheck)(16.00).Theprobable reasonforthisresultmaybedueto Neemaqueousextractshowedapromotiveeffecton shootlengths,branchesandleavesnumbers.Thebio-efficacyofNeemextractover pathogenscanbeattributedtothefactthatNeemhasactivecompoundssuchas azadirachtin,nimbin,nimbidin,nimbineneand azadirone whichare antifungal,antibactrial andanti-insecticidalinnature**Nahak*etal*.(2015).***Trichoderma*strainscoloniseplantroots, establishingchemicalcommunicationandsystemicallyalteringtheexpressionofnumerous plantgenesthatalterplant physiology.Application of*T.harzianum*significantly increasedcurdcircumferencelength,thediameterofthestem,andtheleafgreennessindex value**Rosa*etal*.(2019).**

3.5Effectoftreatmentsonheadweight(kg)ofbroccoli

ThedatapresentedinTable(5)andFigure(2)revealthatheadweight(kg)ofbroccoli significantlyincreasedinT_3–*T.harzianum*+Neemleafextractat10%(0.38kg) followedbyT_6-*T.harzianum*at 10%(0.35kg),T_5–*T.harzianum*+ Blacknightshadeleafextractat10%(0.304kg),T_4-*T.harzianum*+Lantanaleaf extractat10%(0.301kg),T_2–(*T.harzianum*+Eucalyptusat10%(0.21),T_1-*T.harzianum*+Daturaleafextractat10%(0.20kg)ascomparedtotheT7– Mancozebat0.2%(treatedcheck)(0.40kg)aswellas(T_0)–control(untreatedcheck) (0.16kg).Theprobablereasonforsuchfindingsmaybethatthe Trichodermaandplant interactionproducethesecondarymetabolitessuchasauxin-likecompoundsorauxin-

inducingsubstancesthatresultedinimprovedgrowth,headdiameterandyield**Tanwar*et al*.(2013).**Neemextractiscomposedofantimicrobialingredientssuchasalkaloids, glycosides,flavonoids,andsaponins,whicharecommonantibioticsfoundinplants.At concentrationsof0.1and0.4gmL^{-1},Neemextractinhibitedthegrowthofsoil microorganisms**Sarawaneeyaruk*etal*.(2015).**

3.6Effectoftreatmentsonyield(t/ha)ofbroccoli

ThedatapresentedinTable(6)andFigure(3)revealedthatyieldofbroccolisignificantly increasedheadweightT3–*T.harzianum*+Neemleafextractat10%(9.68 tha^{-1})followedbyT6-*T.harzianum*at 10%(7.92t/ha),T5–(*T. harzianum*+Blacknightshadeleafextractat10%(6.81tha^{-1}),T4-(*T.harzianum* +Lantanaleafextractat10%(6.50tha^{-1}),T4–(*T.harzianum*+Eucalyptusleaf extractat10%(6.19 tha^{-1}),T1-(*T.harzianum*+Datura leaf extract @10% (5.68 tha^{-1})ascomparedtotheT7–Mancozebat0.2%(treatedcheck)(11.55th^{-1})aswellas (T0)–control(untreatedcheck)(3.85t/ha).Theprobablereasonforthisresultmaybedue totheproductionofsecondarymetabolitessuchasantibiotics,isocyanide,acidsandcellwall degradingenzymeswhichareimplicatedinthegrowthinthegrowthinhibitionofmany phytopathogenicfungi**Supriya*etal*.(2022).***T.viride***hasshownsignificant resultsonyieldattributes,theyieldhasbeensignificantlyincreasedwhichmaybealtributed tothemycoparasiticnatureandabilitytogeneratevolatileandnon-volatilecompounds againstpathogenwithgreatanti-microbialactivity**(Ravella*etal*.,2023).**

Table1.Effectofselectedplantextractsonradialgrowth(mm)of*A. brassicae*

Sr.No.	Treatments	Concentration	Meancolony diameter(mm)	Percent inhibition
T0	Control(untreatedcheck)	-	90.00	0.00
T1	Daturaleafextract	10%	26.98[a]	70.02
T2	Eucalyptusleafextract	10%	21.87	75.69
T3	Neemleafextract	10%	18.20	79.77
T4	Lantanaleafextract	10%	26.00[a]	71.10
T5	Blacknightshadeleafextract	10%	23.83	73.51
T6	Mancozeb	0.2%	2.50	97.21
S.Em.(+)			0.51	0.57
C.D(5%			1.59	1.76

Figure1:-Efficacyofplantextractonpercentmycelial inhibitionof*A.brassicae*bypoisonedfood technique.**

Table2.Percentdiseaseintensity(%)at45,60and75DAT asaffectedbytreatments

Sr.No.	Treatments	45DAT	60DAT	75DAT
T_0	Control(untreatedcheck)	25.98	33.83	40.64
T_1	*T.harzianum*10%(S.T.)+Daturalea fextract10%(F.S.)	23.40	29.88	37.28
T_2	*T.harzianum* 10% (S.T.)+Eucalyptusleaf extract10%(F.S.)	22.50	29.55	36.83
T_3	*T.harzianum*10%(S.T.)+Neem leafextract10%(F.S.)	16.59	19.85	23.28
T_4	*T.harzianum*10%(S.T.)+Lantanale afextract10%(F.S.)	21.34	27.51	32.56
T_5	*T.harzianum*10%(S.T.)+Blacknightshadeleaf extract10%(F.S.)	20.28	25.64	30.26
T_6	*T.harzianum* 10%(S.T.)+*T.harzianum* 10%(F.S.)	18.26	22.36	26.31
T_7	Mancozeb(treatedcheck)0.2%(S.T.+F.S.)	11.66	15.90	18.96
S.Em.(+)		0.36	0.30	0.34
C.D(5%		1.09	0.92	1.03

Table3.Effectoftreatmentsonplantheight(cm)ofbroccoliat30,60and90DAT

Sr.No.	Treatments	30DAT	60DAT	90DAT
T_0	Control(untreatedcheck)	6.92	15.40	23.01
T_1	*T.harzianum*10%(S.T.)+Daturaleafextract10% (F.S.)	7.46	17.06	27.78
T_2	*T.harzianum*10%(S.T.)+Eucalyptusleafextract1 0%(F.S.)	8.96	19.16	29.93
T_3	*T.harzianum*10%(S.T.)+Neem leafextract10%(F.S.)	9.78	23.84	36.66
T_4	*T.harzianum*10%(S.T.)+Lantanaleafextract10% (F.S.)	8.21	18.28	28.41

T_5	*T.harzianum*10%(S.T.)+Blacknight shadeleafextract10%(F.S.)	9.64	20.12	31.10
T_6	*T.harzianum*10%(S.T.)+*T.harzianum* 10%(F.S.)	10.43	21.37	33.70
T_7	Mancozeb(treatedcheck)0.2%(S.T.+F.S.)	12.72	26.43	39.47
S.Em.(+)		0.17	0.40	0.45
C.D(5%		0.53	1.23	1.31

Table4.Effectofselectedtreatmentsonnumberofleavesperplantofbroccoliat 30,60and90DAT

Sr.No.	Treatments	30DAT	60DAT	90DAT
T_0	Control(untreatedcheck)	7.73	10.46	16.00
T_1	*T.harzianum*10%(S.T.)+Daturaleaf extract10%(F.S.)	8.16	12.40	20.66
T_2	*T.harzianum*10%(S.T.)+Eucalyptusleafextract10 %(F.S.)	8.93	13.40	21.13
T_3	*T.harzianum*10%(S.T.)+Neem leafextract10%(F.S.)	9.36	17.26	28.00
T_4	*T.harzianum*10%(S.T.)+Lantanale afextract10%(F.S.)	8.46	12.93	20.40
T_5	*T.harzianum*10%(S.T.)+Blacknightshadeleaf extract10%(F.S.)	8.86	14.16	23.40
T_6	*T.harzianum*10%(S.T.)+*T.harzianum* 10%(F.S.)	9.76	15.73	25.20
T_7	Mancozeb(treatedcheck)0.2%(S.T.+F.S.)	10.13	20.13	31.53
S.Em.(+)		0.11	0.21	0.21
C.D(5%		0.33	0.66	0.64

Table5.Effectoftreatmentsonheadweight(kg)ofbroccoli

Sr.No.	Treatments	Headweight/kg
T_0	Control(untreatedcheck)	0.16
T_1	*T.harzianum*10%(S.T.)+Daturaleafextract 10%(F.S.)	0.20
T_2	*T.harzianum*10%(S.T.)+Eucalyptusleafextract10%(F.S.)	0.21
T_3	*T. harzianum*10%(S.T.)+Neemleafextract 10%(F.S.)	0.38
T_4	*T.harzianum*10%(S.T.)+Lantanaleafextract 10%(F.S.)	0.301
T_5	*T.harzianum*10%(S.T.)+Blacknightshadeleafextract10%(F. S.)	0.304
T_6	*T.harzianum*10%(S.T.)+*T.harzianum*10%(F.S.)	0.35
T_7	Mancozeb(treatedcheck)0.2%(S.T.+F.S.)	0.40
S.Em.(+)		0.05
C.D(5%		0.15

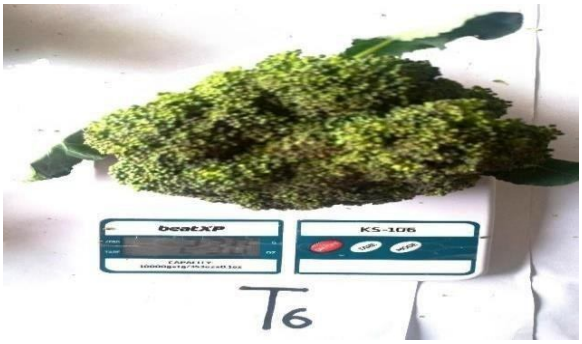

Figure2:-Weighingofbroccoli

Table6.Effectoftreatmentsontotalyield(t/ha)ofbroccoli

Sr.No.	Treatments	Yield(t ha^{-1})
T_0	Control(untreatedcheck)	3.85
T_1	*T.harzianum*10%(S.T.)+Daturaleafextract 10%(F.S.)	5.68
T_2	*T.harzianum*10%(S.T.)+Eucalyptusleafextract10%(F.S.)	6.19
T_3	*T.harzianum*10%(S.T.)+Neemleafextract10%(F.S.)	9.73
T_4	*T.harzianum*10%(S.T.)+Lantanaleafextract 10%(F.S.)	6.50
T_5	*T.harzianum*10%(S.T.)+Blacknightshadeleafextract10%(F.S.)	6.81
T_6	*T.harzianum*10%(S.T.)+*T.harzianum*10%(F.S.)	7.35
T_7	Mancozeb(treatedcheck)0.2%(S.T.+F.S.)	11.55
S.Em.(+)		0.12
C.D(5%		0.37

Figure3:-Yieldofbroccoli

4.CONCLUSION

ItcanbeconcludedthatT.*harzianum*andbotanicalsNeemleafextractis significantincontrolling*A.brassicae*inbroccoli.Thisstudycontributesvaluable insightsintosustainablediseasemanagementpracticesbytheusedofbio-controlagent andplantextractsthatcanbenefitbothfarmersandtheagriculturalsector.Itisimportantto notethatthisinvestigationhasbeenconductedinaspecificcroppingseasonwithinthe agro-climaticconditionsofPrayagraj.Furthertrialsindiverselocationsandseasonsare recommendedtoexpanduponthesepromisingresults.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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Details of the AI usage are given below:

1.
2.
3.

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