UnveilingtheImpactof SalinityLevelsonChilli: Growth,YieldandQualityAnalysis

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ABSTRACT

This study investigates the effect of salinity on the growth, yield, and quality and diseaseinfestation on Chilli. A factorial randomized block design with three replications wasimplemented, consisting of combinations of four salinity levels (0 dS/m, 3 dS/m, 6 dS/m, and9 dS/m) and three genotypes (Surajmukhi, AVT-2 2019 CHIHYB-5, and AVT-2 2019CHIHYB-6).Thepurposeofthestudyistoevaluatetheplantsinterms ofvariousparameterssuch as plant height (at 30, 60, and 90 days after transplanting), number of fruits per plant,average fruit weight, fruit yield per plant, fruit yield per hectare, total soluble solids (TSS),ascorbicacidcontent,chlorophyllcontent,anddiseaseinfestation.Amongallthegenotypes, AVT-22019CHIHYB-6exhibitedsuperiorperformancewhengrownunderasalinitylevelof0dS/m. It demonstrated desirable plant height at 30, 60, and 90 days after transplanting (30.06cm, 32.50 cm,and78.00 cm, respectively), alongwitha highernumberof fruitsperplant(40), average fruit weight (94.86 g), fruit yield per plant (1769.20 g), fruit yield per hectare(65.52 tonn/ha), TSS (6.16 Brix), ascorbic acid content (113 mg/100g), chlorophyll content(34.4 mg/m^2), and disease resistant (99%). Significant differences were observed amonggenotypesandtheirinteractionsconcerningsalinitylevelsacrossallattributesinvestigated.
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Keywords:Chilli, Salinity,Growth,Yield,Genotypes.

1.INTRODUCTION

Chili(*Capsicumannuum*L.)isoneofthevegetableorspicesknownandusedalloverthe worldforitsgreenfruitsandpungency. ChillibelongstothegenusCapsicumfamily Solanaceae. It is a diploid (2n=24) species and genetically self-pollinated and chasmogamouscropwhoseflowersopenonlyafterpollination.However,2to96%out-crossingwasobservedunderopenpollination(AVRDC,2000).Therearemainlyfour cultivatedCapsicumspeciesandtheyareoriginatedfromSouthandCentralAmerica,chili hasmorethan25speciesofwhichonlyfive(*C.annuum*L.,*C.chinense,C.frutescens*L., *C.baccatum*L.*andC.pubescens*.)aredomesticatedandcultivated.Chillihasbeenused sinceancienttimes,traditionallyintheformofspice.Itisalsousedasanaturalflavorand colorantinfoodindustryaswellasrawmaterialforthepharmaceuticalindustry.Chilliis nutritiouscrop,every100gmofgreenanddrychilliyieldabout229and297caloriesof energy.Itismainlycultivatedforthreeconstituentsoffruitsviz.,capsaicin,capsanthinand oleoresin.Chillirequires15-35°Coftemperatureforcultivation.Chilliesshouldnotbeina positionwherethenightlytemperaturefallsbelow12°C.Growthwillbeinhibitedif temperaturesfallbelow15°C.Chilliplantsisatypeofseasonalcrops(annualplant)which onlyliveforoneseasonthendied.Ifcultivatedthisplantcangrowandproduceforseveral monthsafter plantingafter whichitwilldie.

Salinityisbecomingoneofthemajorbarriersagainstsuccessfulproductionofcropsin India.Itisoneofthecriticalstressestowhichcropplantsareexposedandisaserious limitingfactoragainstcropproduction.Salinitycausesstuntedgrowthofplantsthat ultimatelyleadstoreducedyield.Manyhorticulturalcropsaremoreorlesssusceptibleto salinityasaresultproductionofthesecropsishugelyaffectedbythis.Chilliisreportedas acropwhichissensitivetomoderatelysensitivetosalinity.AccordingtoCarter(1994),a salinitylevelofless than1920ppmissuitableforchilli.Understressedconditionsuchas lowtemperatureandsalinity, delayedandnon-uniformgerminationofchilliisobserved.

2.MATERIALANDMETHODS

Theinvestigationentitled"UnveilingtheimpactofsalinitylevelsonChilli:Growth,Yieldand QualityAnalysis"wasdonetounderstandtheplantgrowth,fruityieldandqualityofChilliusing differentcombinationsoftreatmentusingdifferentvarietieswhichwascarriedoutatHorticultural ResearchFarm(HRF),DepartmentofHorticulture,NainiAgriculturalInstitute,SamHigginbottom UniversityofAgriculture,TechnologyandSciences(SHUATS),Prayagrajduringthe*Rabi*season of2021-2022.

2.1.Locationandclimaticconditions

Prayagrajislocatedinthecentralplainsub-zoneofAgro-climaticZoneV,accordingtothe PerspectiveandStrategicPlan(SPSP)forIWMPofUttarPradesh,issuedbytheDepartmentof LandDevelopmentandWaterResources,GovernmentofU.P.Naini,situatedbetweenlatitude 20°33' 40"to 21' .50'Nand longitude 73° 27' 58"to 73° 56'36"E, experiencesatropicalclimate. Theareahasrelativelyhotsummers,moderatelycoldwinters,andahumidandwarmmonsoon season.TheregionreceivesheavyrainfallprimarilyduringJunetoSeptember,withthemajority ofprecipitation occurringduring the monsoonmonthsofJulyand August.

2.2.ExperimentalMaterials

Table1:Factor–A(Genotypes)

S.No.	Notations	Hybriddetails	Source
1	**V_1**	SURAJMUKHI	SahaviHybridseeds
2	**V_2**	AVT-22019(CHIHYB-5)	IIVR,Varanasi
3.	**V_3**	AVT-22019(CHIHYB-6)	IIVR,Varanasi

Table2:Factor–B(Treatments)

S.No.	Notations	TreatmentDetails
1.	**T0**	0dS/m
2.	**T1**	3dS/m
3.	**T2**	6dS/m
4.	**T3**	9dS/m

Table3:Factor–A XFactor-B(Genotypesand treatmentcombinations)

S.No.	Notations	TreatmentDetails(Factor-A×Factor-B)
1.	V_1T_0	Surajmukhi(Saltconcentration@0dS/m)
2.	V_1T_1	Surajmukhi(Saltconcentration@3dS/m)
3.	V_1T_2	Surajmukhi(Saltconcentration@6dS/m)
4.	V_1T_3	Surajmukhi(Saltconcentration@9dS/m)
5.	V_2T_0	AVT-22019(CHIHYB-5)(Saltconcentration@0dS/m)
6.	V_2T_1	AVT-22019(CHIHYB-5)(Saltconcentration@3dS/m)
7.	V_2T_2	AVT-22019(CHIHYB-5)(Saltconcentration@6dS/m)
8.	V_2T_3	AVT-22019(CHIHYB-5)(Saltconcentration@9dS/m)
9.	V_3T_0	AVT-22019(CHIHYB-6)(Saltconcentration@0dS/m)
10.	V_3T_1	AVT-22019(CHIHYB-6)(Saltconcentration@3dS/m)
11.	V_3T_2	AVT-22019(CHIHYB-6)(Saltconcentration@6dS/m)
12.	V_3T_3	AVT-22019(CHIHYB-6)(Saltconcentration@9dS/m)

3. RESULTSANDDISCUSSION

3.1.GrowthParameters

3.1.1.PlantHeightfor30 DAT,60 DATand90DAT(cm)

Thesignificanteffectonplantheightat30,60and90DATshowsthatthemaximumplantheight wasrecordedinV_3T_0[AVT-22019(CHIHYB-6)(saltconc.@0dS/m)]with(30.06cm),(32.50cm) and(78.00cm)respectivelyandtheminimumplantheightwasrecordedinV_1T_3[Surajmukhi(salt conc.@9dS/m)]with(6.50cm),(12.66cm)and(25.26cm)respectively.Salinitysignificantly reducedplantheight,stemdiameter,andleafareaofchilliplants.Thedecreaseinplantheight wasattributedtoareductionincellexpansionduetotheosmoticstresscausedbysalinity. Salinitycancauseoxidativestressinplantsbygeneratingreactiveoxygenspecies(ROS)such assuperoxideradicals, hydrogenperoxide,andhydroxylradicals.ROScandamagelipids, proteins,andnucleicacids,whichcanimpairplantgrowthanddevelopment.Overall,the combinedeffectsofwaterstress,iontoxicity,andoxidativestresscausedbysalinityresultsin reducedplantheightandbiomass.Similarfindingswerereportedby **Singh*etal*(2012)**[1].

Table4:EffectofsalinityonPlantheight(cm)

Notations	TreatmentDetails	PlantHeight(cm)		
		30DAT	60DAT	90DAT
V_1T_0	Surajmukhi(saltconc.@0dS/m)	15.00	30.20	70.66
V_1T_1	Surajmukhi(saltconc.@3dS/m)	9.76	16.5	32.90
V_1T_2	Surajmukhi(saltconc.@6dS/m)	7.33	14.46	28.96
V_1T_3	Surajmukhi(saltconc.@9dS/m)	6.50	12.66	25.26
V_2T_0	AVT-22019(CHIHYB-5) (saltconc.@0dS/m)	23.23	31.30	72.13
V_2T_1	AVT-22s019(CHIHYB-5) (saltconc.@3dS/m)	11.33	23.5	46.83
V_2T_2	AVT-22019(CHIHYB-5) (saltconc.@6dS/m)	8.50	16.7	32.3
V_2T_3	AVT-22019(CHIHYB-5) (saltconc.@9dS/m)	7.13	14.10	28.13
V_3T_0	AVT-22019(CHIHYB-6) (saltconc.@0dS/m)	30.06	32.50	78
V_3T_1	AVT-22019(CHIHYB-6) (saltconc.@3dS/m)	24.45	25.50	47.16
V_3T_2	AVT-22019(CHIHYB-6) (saltconc.@6dS/m)	22.23	17.46	35.5
V_3T_3	AVT-22019(CHIHYB-6) (saltconc.@9dS/m)	20.20	15.40	27.76

3.2.YieldParameters

3.2.1.Numberof fruitsperplant

Theaveragenumberoffruitsperplantvariedsignificantlyamongdifferenttreatment combinations.Themaximumaveragenumberoffruitsperplant(40.00)wasobservedinV_3T_0 [AVT-22019(CHIHYB-6)(saltconc.@0dS/m)]andtheminimumaveragenumberoffruitsper plant(6.00)wereobservedinV_1T_3[Surajmukhi(saltconc.@9dS/m)]whiletheremaining treatmentswere moderate.Studies haveshownthat highlevelsofsalinitycanreducethenumber offruitsproducedbytheplant.Thisisbecausesaltstresscanaffectvariousphysiologicaland biochemicalprocessesintheplant,suchasphotosynthesis,wateruptake,andnutrient absorption.

3.2.2.AverageWeight of10fruitsperplant (g)

Theaverageweightof10fruitsvariedsignificantlyamongdifferenttreatmentcombinations.The maximumaveragefruitweight(94.86g)wasobservedininV$_3$T$_0$[AVT-22019(CHIHYB-6)(salt conc.@0dS/m)]andtheminimumaverageweightof10fruits(13.53g)wereobservedinV_1T_3 [Surajmukhi(saltconc.@9dS/m)]whiletheremainingtreatmentsweremoderate.Salinitylevels ledtoadecreaseintheavailabilityofnutrientssuchasnitrogen,phosphorus,andpotassium, resultinginreducedgrowthandfruitweight.Theresearchersalsofoundthatsalinitycaused oxidativestressintheplants,leadingtoadecreaseinphotosynthesisandultimatelyareduction in fruit weight.Similarfindingswere reportedby **khan*et al*(2000)**[2].

3.2.3.Averagefruityieldperplant(g)

Theaveragefruityieldperplantvariedsignificantlyamongdifferenttreatmentcombinations.The maximumaveragefruityieldperplant(1769g)wasobservedinV_3T_0[AVT-22019(CHIHYB-6) (saltconc.@0dS/m)]andtheminimumaveragefruityieldperplant(261.19g)wasobservedin V_1T_3[Surajmukhi(saltconc.@9dS/m)]whiletheremainingtreatmentsweremoderate.when plantsareexposedtohighlevelsofsalt,theosmoticpotentialofthesoilsolutionincreases, makingitmoredifficultforplantstoabsorbwaterandnutrients.Thiscanleadtowaterstress, nutrientdeficiency,andreducedplantgrowth.Additionally,saltstresscandamagetheplant's cellularmembranes,affectenzymeactivity,anddisruptthebalanceofionsandhormonesinthe plant,furtherreducingfruityield.Similarfindingswerereportedby **Pariyar*etal*.(2019)**[3].

3.2.4.<u>Fruityieldper hectare(ton/ha)</u>

Thefruityieldperhectarevariedsignificantlyamongdifferenttreatmentcombinations.The maximumfruityieldperhectare(65.52tonn/ha)wasobservedinV_3T_0[AVT-22019(CHIHYB-6)(saltconc.@0dS/m)]andtheminimumaveragefruityieldperplant(9.67tonn/ha)wasobserved inV_1T_3[Surajmukhi(saltconc.@9dS/m)]whiletheremainingtreatmentsweremoderate.salinity levelaffectedthephysiologicalandbiochemicalpropertiesoftheplants.Specifically,theyfound thatthe salinitylevelincreasedtheconcentration of sodiumandchlorideionsintheplanttissues, whichcan causeion toxicityanddamageto theplantcells.In addition,theyfound that the salinity leveldecreasedtheconcentrationofchlorophyllandcarotenoidpigments,whichcanleadtoa decreaseinphotosynthesisandareductionintheplant'sabilitytoproducefruit.Thisstudy providesevidencethathighlevelsofsalinitycanhaveanegativeimpactontheyieldandquality ofchillifruitbycausingwaterstress,iontoxicity,andreducingtheplant'sabilitytocarryout photosynthesis.Similarfindingswerereportedby**Razzaghi*etal*(2011)**[4].

Table5 :EffectofsalinityonNumberoffruitsperplant,weightof10fruits(g),average fruityieldperplant(g)andfruit yieldperhectare(t/ha).

Notations	TreatmentDetails	Number of fruitsper plant	Weight of10 fruits(g)	Average fruit yieldperplant (g)	Fruit yieldperhectare (ton/ha)
V_1T_0	Surajmukhi(saltconc.@0dS/m)	23.33	28.06	868.39	32.16
V_1T_1	Surajmukhi(saltconc.@3dS/m)	18.66	24.4	706.41	26.16
V_1T_2	Surajmukhi(saltconc.@6dS/m)	16.33	19.26	605.59	22.42
V_1T_3	Surajmukhi(saltconc.@9dS/m)	6.00	13.53	261.19	9.67
V_2T_0	AVT-22019(CHIHYB-5)(saltconc.@0dS/m)	30.00	28.36	1070.20	39.63
V_2T_1	AVT-22019(CHIHYB-5)(saltconc.@3dS/m)	27.00	24.30	955.8	35.39
V_2T_2	AVT-22019(CHIHYB-5)(saltconc.@6dS/m)	20.66	19.36	736.21	27.26
V_2T_3	AVT-22019(CHIHYB-5)(saltconc.@9dS/m)	13.66	16.70	510.21	18.89
V_3T_0	AVT-22019(CHIHYB-6)(saltconc.@0dS/m)	40	94.86	1769.20	65.52
V_3T_1	AVT-22019(CHIHYB-6)(saltconc.@3dS/m)	31.66	81.93	1441.60	53.39
V_3T_2	AVT-22019(CHIHYB-6)(saltconc.@6dS/m)	28.33	48	1137.99	42.14
V_3T_3	AVT-22019(CHIHYB-6)(saltconc.@9dS/m)	25.66	58.1	1118.61	41.42

3.3.QualitativeParameters

3.3.1.TotalSolubleSolids(Brix^0)

TheTSSofthefruitvariedsignificantlyamongdifferenttreatmentcombinations.Themaximum TSS(6.16Brix^0)wasobservedinV_3T_0[AVT-22019(CHIHYB-6)(saltconc.@0dS/m)]andthe minimumTSS(3.73Brix^0)wasobservedinV_1T_3[Surajmukhi(saltconc.@9dS/m)]whilethe remainingtreatmentsweremoderate.Astudyby**Guo*etal.*(2018)**[5]investigatedtheeffectof saltstressontheaccumulationofTSSinchillifruits.Theresearchersfoundthatsaltstress reducedtheactivityofkeyenzymesinvolvedinthesynthesisof sugars,suchassucrose synthaseandinvertase.Theysuggestedthatthisreductioninenzymeactivitymaybe responsibleforthedecreaseinTSSaccumulation.

3.3.2.Ascorbicacid(mg/100g)

Theascorbicacidofthefruitvariedsignificantlyamongdifferenttreatmentcombinations.The maximumascorbicacid(113mg/100g)wasobservedinV_3T_0[AVT-22019(CHIHYB-6)(salt conc.@0dS/m)]andtheminimumascorbicacidcontent(70.33mg/100g)wasobservedinV_1T_3 [Surajmukhi(saltconc.@9dS/m)]whiletheremainingtreatmentsweremoderate.Astudyby **Pandey*etal.*(2018)**[6]foundthatsalinitystressdecreasedthenetphotosyntheticrate,stomatal conductance,andtranspirationrateinchilliplants,leadingtoareductioninplantgrowthand ascorbicacidcontent.Salinitystressalsocausedanimbalanceinionhomeostasis,withhigher accumulationofsodiumandchlorineionsinleaves,leadingtotoxicitysymptomsanddecreased ascorbicacidcontent.salinitystressaffectsmultiplephysiologicalprocessesinchilliplants, leadingtodecreasedascorbicacidcontent.Thedisruptionofphotosynthesisandiontransport, aswellastheinductionofoxidativestress,contributetothenegativeimpactofsalinityon ascorbicacidcontent inchillipeppers.

3.3.3.Chlorophyllcontent

Thechlorophyllcontentinthefruitvariedsignificantlyamongdifferenttreatmentcombinations. Themaximumchlorophyllcontent(34.4mg/m^2)wasobservedinV_3T_0[AVT-22019(CHIHYB-6) (saltconc.@0dS/m)]andtheminimumchlorophyllcontent(10.23)wasobservedinV_1T_3 [Surajmukhi(saltconc.@9dS/m)]whiletheremainingtreatmentsweremoderate.Astudyby **Zhang*etal*.(2018)**[7]showedthatsalinitystressdecreasedchlorophyllcontentindifferentchilli cultivarsbyreducingtheactivitiesofenzymesinvolvedinchlorophyllsynthesis,suchasδ-aminolevulinicacidsynthaseandprotochlorophyllideoxidoreductase.Salinityalsoimpairedthe uptakeandtransportofminerals,suchasnitrogen,magnesium,andiron,whichareessentialfor chlorophyllsynthesisandstability.Moreover,salinity-inducedoxidativestressaffectsthestability andfunctionofchlorophyllmolecules,leadingtochlorophylldegradationandreducedchlorophyll content.

Table6 :EffectofsalinityonTSS(Brix^0),ascorbicacid(mg/100g)andchlorophyllcontent

Notations	TreatmentDetails	TSS (Brix^0)	Ascorbic acid(mg/100g)	Chlorophyll content (mg/m^2)
V_1T_0	Surajmukhi(saltconc.@0dS/m)	5.43	102.33	21.30
V_1T_1	Surajmukhi(saltconc.@3dS/m)	5.33	96.33	19.36
V_1T_2	Surajmukhi(saltconc.@6dS/m)	4.23	72.33	15.30
V_1T_3	Surajmukhi(saltconc.@9dS/m)	3.73	70.33	10.23
V_2T_0	AVT-22019(CHIHYB-5) (saltconc.@0dS/m)	5.96	102.33	23.3
V_2T_1	AVT-22019(CHIHYB-5) (saltconc.@3dS/m)	5.26	91.33	21.3
V_2T_2	AVT-22019(CHIHYB-5) (saltconc.@6dS/m)	4.96	81.33	15.33
V_2T_3	AVT-22019(CHIHYB-5) (saltconc.@9dS/m)	4.70	72.33	12.33
V_3T_0	AVT-22019(CHIHYB-6) (saltconc.@0dS/m)	6.16	113	34.42
V_3T_1	AVT-22019(CHIHYB-6) (saltconc.@3dS/m)	6.00	106.33	32.26
V_3T_2	AVT-22019(CHIHYB-6) (saltconc.@6dS/m)	5.16	93	28.23
V_3T_3	AVT-22019(CHIHYB-6) (saltconc.@9dS/m)	4.93	85.66	25.26

3.4.Diseaseincidence

Diseaseincidencevariedsignificantlyamongdifferenttreatmentcombinations.Leafcurl resistance(99%)wasobservedinV_3T_0[AVT-22019(CHIHYB-6)(saltconc.@0dS/m)]andthe leafcurlsusceptible(49.80%)wasobservedinV_1T_3[Surajmukhi(saltconc.@9dS/m)]whilethe remainingtreatmentsweremoderate.Astudyby**Zaidi*etal.*(2019)**[8]investigatedtheeffectof salinityontheincidenceofChiliLeafCurlVirus(CLCV)diseaseinchiliplants.Theresultsofthis studyshowedthatassalinitylevelsincreased,theincidenceofCLCVdiseasealsoincreased. Theauthorssuggestedthatthehighsaltlevelsmayhaveaffectedtheactivityofenzymes involvedinthebiosynthesis ofplanthormones,leadingtoadecreaseinthelevelsofsalicylic acid (SA)andjasmonicacid(JA)intheplant.Thesetwohormonesareknowntoplayakeyrolein plantdefenseagainstviralinfections.Anotherstudyby**Khan*etal.*(2019)**[9]investigatedthe effectofsalinityontheincidenceofPepperveinyellows virusdiseaseinchiliplants.

4.CONCLUSION

From the experimental finding it is concluded that V_3T_0 [AVT-22019 CHIHYB-6(salt conc.@0dS/m)]isbestintermsofgrowth,yield,qualityanddiseaseincidenceparameters viz.,plantheight(30,60and90DAT),weightof10fruitsperplant,numberoffruitsperplant,fruit yieldperplant,fruityieldperhectare,TSS,ascorbicacidandchlorophyllcontentanddisease incidence

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