Nfo fo'y'sk.k vkj e"khu yfu)x rduhd }kjk ikŚksck;kekI dk vuqeku

ruqt feJk] vydk vjksjk*] lqnhi ekjokg] e`.e; js,oavkj- ,l- rkej

vkbZih,,vkj&Hkkjrh; —f"k lkf[;dh vuq{dkku laLFkku] ubZ fnYyh-110 012] HkkjrA

l kjkak

ouLifr ck;kekI 'kq) çkFkfed mRiknu dh x.kuk dk vkèkkj gA ouLifr Qsukv/kbi dsfy, mPp dk;{kerk okyh 'kŚyh l srktk ck;kekI dk vkadyu egRoiwkZgA rktk ck;kekI ekiusdsfy, ikjafjd Qsukv/kbiçix —f"Vdksk l e; u"V djusokyk] Jel è; vkSj fouk'kdkjh gA vktdy çfrPNk;k fo'ysk.k vkèkkfjr ouLifr Qsukv/kbiçix cgqr yksdfç; gA rktk ck;kekI dsvkadyu dsfy, vfèkdrj dyh 1/4Vguh½{ks=Qy dk mi;ksx —'; çfrPNk;k;ka1/2ohvkÃ,l½l svuqekfur djrsgA geusifjdYiuk dh gSfd ohvkÃ,l çfrPNk;k ds,dkdh vkadyu djusdsrqyuk eavohvkÃ,l vkSj ,uvkÃvkj be£tx dsl a;qä mi;ksx l srktk ck;kekI dk vfèkd 'kq) vuqeku yxk;k tk l drk gŜD;ksfd ikuh dh ek= dk rktk ck;kekI ij egRoiwkZçHkko gksrk gSvkSj ba/k&jsM 1/4u vkÃ vkj1/2{ks= 1/4900 nm l s1700 nm½dsfudV rd dk fofdj.k ikuh dksvo'kksf"kr djrk gA bl vè;;u eabukukukth ns'keq[k IykaV Qsukfedl IaVj] vkbZh,vkj&vkbZ,vkjvkÃ] uÃ fnYyh&12 eaLFkkfir yhekVsd lqo£èk dk mi;ksx djdsohvkÃ,l vkSj ,uvkÃvkj çfrPNk;kvkadks,d= fd;k x;k FkkA bl vè;;u eaVLV dsl ds: i eafoflUu ueh okysèkku dsiÙkksadsfy, ohvkÃ,l vkSj ,uvkÃvkj çfrPNk;k;k"adks vfèk—r dj fy;k x;k FkkA çfrPNk;k fo'ysk.k dsfy, eSV yśc l ,¶Vosj j 1/4laLdj.k 2015ch½ dk mi;ksx fd;k x;k FkkA nks çfrPNk;k 0;qRiUu çkpy¨avFkkr ohvkÃ,l 1/4VIS½çfrPNk;k l sxhu yhQ çkiksku 1/4GPR½vkSj ,uvkÃvkj çfrPNk;k l sxsens/; @rhor k 1/4MGV&NIR½ dk eryc yhQ Ý's'k ok/V 1/4LF½ ds: i eartktk ck;kekI dk vuqeku yxkusdsfy, lkf[;dh; e‚My dksfodfl r djusdsfy, fd;k x;k FkkA çLrkfor —f"Vdksk l srktk ck;kekI vuqeku dh dkQh vPNh of) gqbA

Plant biomass estimation using image analysis and machine learning technique

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ABSTRACT

Plant biomass is the basis for the calculation of net primary production. Estimation of fresh biomass in high throughput way is critical for plant phenotyping. Conventional phenotyping approaches for measuring the fresh biomass is time consuming, laborious and destructive in nature. Image analysis based plant phenotyping is very popular nowadays. Most of the approaches used projected shoot area from visual images (VIS) to estimate the fresh biomass. As water content has a significant effect on fresh biomass and water absorbs radiation at near infra-red (NIR) region (900nm to 1700nm), we have hypothesized that the combined use of VIS and NIR imaging can predict the fresh biomass more accurately that the VIS image alone. In this study, VIS and NIR images were collected using LemaTec facility installed at Nanaji Deshmukh Plant Phenomics Center, ICAR-IARI, New Delhi-12. In this study, VIS and NIR imaging were captured for rice leaves with different moisture content as a test case. MATLAB software (version 2015b) was used for image analysis. The two image derived parameter *viz.* Green Leaf Proportion (GPR) from VIS image and mean gray value/intensity (MGV_NIR) from NIR image were used to develop the statistical model to estimate the fresh biomass in the form of Leaf Fresh Weight (LFW). The proposed approach significantly enhanced the fresh biomass estimation.

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Key words: Green leaf proportion, Image analysis, LFW, Non-destructive phenotyping, Rice.

iLrkouk

ouLifr ck;kekl 'kq) çkFkfed mRiknu dh x.kuk dk vkèkkj gÅ ouLifr QukV/kbi dsfy, mPp dk;Zkerk okyh 'kS/yh Isrktk ck;kekl dk vkdyu egRoiwkZ gÅ rktk ck;kekl ekiu dsfy, ikjaifjd QukVkbÇix –f"Vdksk Ie; u"V djusokyk] Jelkè; vkS§ fouk'kdkjh gÅ vktdy çfrPNk;k fo'y"k.k vkèkfjr ouLifr QukVkbÇix cgr ykèdfç; gÅ rktk ck;kekl dsvkdyu dsfy, vfèkdrj dyh ½guh½{k=Qy dk mi;ksx] –'; çrkPNk;k;ka ¼ohvkÃ,I½ Is vuqekfur djrs gÅ geus ifjdYiuk dh gSfd ohvkÃ,I çrkPNk;k ds,dkdh vkdyu djusdsrÇyuk esa],vkS§ ,uvkÃvkj be¶tx ds la;katk mi;ksx Isrktk ck;kekl dk vfèkd 'kq) vuqeku yxk;k tk Idrk gS¼ D;ksfd ikuh dh ek= dk rktk ck;kekl ij egRoiwkZçHkko gkrk gS vkS§ bÝYk&jM ¼,u vkÃ vkj½¼k=¼900 nm Is1700 nm½dsfudV rd dk fofdj.k ikuh dksvo'kksf"kr djrk gÅ bl vè;;u eåukukukth nš'keq[k lykkV Qukfe>I I§Vj] vkÃI h,vkj&vkÃ,vkjvkÃ] uÃ fnYyh&12 e¼ LFkkfir yhekVkd Iµ½okk dk mi;ksx djdsohvkÃ,I vkS§,uvkÃvkj çrkPNk;k;kadks,d= fd;k x;k FkkA bl vè;;u eåVLV dI ds:i e¼fofHkkUu ueh okysèkku ds iÙkka dsfy, ohvkÃ,I vkS§,uvkÃvkj çrkPNk;k;k;ädks vfék–r dj fy;k x;k FkkA çrkPNk;k fo'y"k.k dsfy, eV ybÇ I,¶Vosj ¼Idj.k 2015ch½dk mi;ksx fd;k x;k FkkA nksçrkPNk;k 0;kÇllu çkpY;avFkkkr ohvkÃ,I ¼VIS½çrkPNk;k Isxthu yhQ çfäikbÇku ¼GPR½ vkS§,uvkÃvkj çrkPNk;k Isxthu eV;@rhork ¼MGV&NIR½ dk eryc yhQ Ý"k ol¼ ¼LF½ds:i e§rktk ck;kekl dk vuqeku yxkusdsfy, Ikèk[;dh; e,My dksfodflr djusdsfy, fd;k x;k FkkA çLrkfor –f"Vdksk Isrktk ck;kekl vuqeku dh dkQh vPNh of) gqÃ A

ifjp;

pqukSfrhiwkZ i;kbj.kh; ifjfLFkfr;kadksrgr] rsth Isc<+rh ekuo tuI[;k ifj–'; ¼kadk Ikeuk djusdsfy, dkQh cgrj QInY y fdLekadk vko';drk gksrh gS¼Ýkcfid ,V vy 2009 ¼fLVdyu ,V vy 2007½A –f"k o¼Kkfudka vkS§ uhfr fuekrkvksdsfy,] pqukSfrhiwkZ i;kbj.kh; ifjfLFkfr;ka dsrgr Hkfo"; e¼–f"k mRiknu dh ekax dksiwjk djuk I clsc M+ pqukSfr gS¼ck Eek] 2003½A bl ç;kstu dsfy,] ç: ih y{k.kkadks0;ofLFkr ek=kk fu/kkj.k ;k vkuqokf'kd dksfo'kk ?kVdkadk fn, x, okrkoj.k e¼Bgjko vko';d gSrkdsifni

QukfeDI] ikSèkkadh of)] ikSèksdh vk—fr foKku dsçsn'kÇu dsvkèkkj ij 'kjhj foKku vkS§ ç: ih y{k.kka dk ikSèksdh fo'kkrkjkvkdk vè;;u gSA yfdu bu y{k.kkadsikjaifjd eki dksgkFk Is¼d djnÇfd;k tkrk gStksu dksy vfékd Ie; y;usokyh vkS§ Jeçèkku gScfYd cMÅek==kea MSkI V çklr djuseÇHkh =¼V gksl drh gÅ bl fy,]fiNys diN o"kka Is¼;ku Is Vhcl] ;FkkFkZ vkS§ rhozQukVkbÇix ij dfSer fd;k x;k gÅ bl çlx e¼mPp&çokg {kerk çrkPNk;k fo'y"k.k ¼Qjcsd ,V vy 2009½ouLifr of)] fodkI I Is¼fekkr dÃ QukVkbfid ekinÇMka dks fudkyusdsfy, fd;k tkjgk gSrFkk vfékd tfVy y{k.kka dsvkèkkj ij 0;fäxr ek=kRed ekinÇMka dh eyg eki dh tkjgh gÅ ouLifr ck;kekl]dk;kRed Ia= tho foKku vkS§ fodkI fo'y"k.k dsvè;;u ea,d egRoiwkZHkfedk fuHkkrk gÅ ik¼ksdh of) nj dsIkFk&IkFk 'kq) çkFkfed mRiknu Ia= ck;kekl dsvkèkkj ij fuékkjr fd;k tkrk gÅ dyh ¼guh½ dsLoPN otu dk mi;ksx mit ds IkFk&IkFk ck;kekl dk vuqeku yxkusdsfy, fd;k tkrk gS¼iz#,yks ,V vy ukxy 2000½ fudYl vkS§ ,ufDoLV 2002½A ijEijkxr ck;kekl ds—"k Qy uewusdsHkkjjRed eV;kdu Isekik tkrk gS¼ ;g fofék cgr I e; yÇsokyh] Je xgu vkS§ fouk'kdkjh gSA bl çlx e¼ fMftVy Nfo fo'y"k.k dks,d ofdYid –f"Vdksk ds:i e¼fodflr fd;k x;k gSA ohvkÃ,I Nfo dk 0;kid ç;ksx dj] vuqekfur dyh {k=Qy dsjf[kd Qyu ds:i e¼dksck ck;kekl dk vuqeku yxkusdsfy, mi;ksx fd;k tkrk gS¼i#,yks ,V vy 2000] fetko vkS§ el rkuh 2003] xksytfj;u ,V vy 2011] 'khjjeku ,,V vy 2016½A ck;kekl eaikuh dh ek=k egRoiwkZ gkrh gS bl fy,, ;g rktk ck;kekl ds çe[k fuékkjd ¼I yhgx ,V vy 2008½ gÅ ck;kekl eaikuh] ,uvkÃvkj {k=¼ eafofdj.k dksvo'kksf"kr djrk gS¼bl fy,,] vkækRdek&ek=k dk vuqeku yxkusdsfy, ,uvkÃvkj ijkorZu çrkPNk;k dk mi;ksx fd;k tk Idrk gS¼LVucxZ,V vy 2010] QukV/ht ,V vy 2015½A vr%dyh ohvkÃ,I Is ç{kfir dyh {k=¼ dk mi;ksx dj fodflr fd, x, i#Zkeku e,My Is,dne I gh rktk ck;kekl dk vuqeku ugÅ yxk I drk gÅ IQVsjj ,V vy dsvuqdkj ½2016½ çrkPNk;k vkèkkjr ouLifr QukVkbÇix dh Hkfo"; çofÙk] y{k.k fu"d"kZ vkS§ MSVk fo'y"k.k dsmíš'; fy,] çrkPNk;k çl rdj.k vkS§ e'khu vfékxeu rduhd dk la;ä ç;kl gksxkA vr%bl fy,,] u erktk iÙkk otu ¼LFW½ dk

vuçeku yxkusdsfy, ohvkÃ,I&,uvkÃvkj ¼VIS&NIR½ çfrPNk;k MÙk dsla,kstu dk mi;ksx djdsck;kekl dk vuçeku yxkusdsfy, çfrxeu –f"Vdksk dksfu;kfstr fd;k x;k FkkA

I kexh ,oai jh{k.k fof/k

èkku dh ifÙk;ka dks dkVk x;k rFkk vyx&vyx rkts æ0;eku ds I kFk èkku ds iÙkk dsueumsmRiÙu djus dsfy, dejsdsrkieku ij fut?yhdj.k fd;k x;kA ifÙk;k dks ,d g&j eæ0;ofLFkr fd;k x;k FkkA ukukth ns"ke[k I ykÙ/ QxukfeDI I Vj] Hkk—vi&Hkk—vI uÃ fnYyh] Hkkjr] ea ohvkÃ,I vkÿ ,uvkÃvkj I æ ed ¼yÈuÝd th,ech,p] vkpsu] teÈuh½dk mi;ksx djdsiÙkh dsueumdads104 I V/ dh çfrPNk;k;a,d= dh xbÃ dÙy 26 çfrPNk;k yh x;h vkÿ çR;d çfrPNk;k ea ifÙk;kads4 I V/ ¼,kuh] 104 I V/½ g§] ftl ea 3 iÙkksçfr I V/ g§A vkjthch¼jÈM xÝhu CyÈdÉjs dh o.kØeh; çfrfØ;k 400 I s 700 ,u,e ds I kFk I æ ed ¼5576 x 4384 fi DI y½ dk ç;ksx ohvkÃ,I çfrPNk;k;a dks ,d= djus dsfy, fd;k x;k] tcfd buxÝ I æ ed ¼inGaS½ I æ ed ¼640 x 480 fi DI y½ds I kFk o.kØeh; çfrfØ;k 900 I s 1700 ,u,e dsxÝ/MÙk vkÃ ih&032 ,I MÙyÿvkÃvkj dÉjs dk mi;ksx ,uvkÃvkj çfrPNk;kvka yus dsfy, fd;k x;k FkkA çfrPNk;k;kdks ksyrI e,, i"BHkfue dks,d I eku I Qn jx cuk, j[kk x;k rkfd i"BHkfue vkÿ iÙkh {ks&a dks vkl uh I s vyx fd;k tk I dÀA –f"Vdksk ds tehuh I R;rk eV;kadksfofèkekU; djusgÝij] ,d ,Q MÙyq dksrkÇ,y e'khu dh I gk;rk I s çR;d I V/ dsfy, ekik x;k FkkA nksçfrPNk;kdksÃ0;Åiiu ekin.Mka;kuh xbÃ yhÙQ ç,ijsku ¼thihvkj½ dksoh vkÃ,I çfrPNk;k;k I s vkÿ ehu xÝ bÝÙ/kl Vh ¼MGV&NIR) dks,u vkÃ vkj çfrPNk;k;k I s çkIr fd;k vkÿ ,y ,Q MÙyq dk vkdyu djdsfy, çfrxeu e,My eamRiknd I kexh dks: i eami;ksx fd;k x;kA thihvkj gjh irh {ks&Qy ¼,k]xhÙ/u fi DI y ,fj;k½;eÿ dÙy irh {ks&Qy dk vuqikr g§A ,ethoh&,uvkÃ,vkj ¼MGV&NIR) dh x.kuk dsfy, ifr;kaokÿgh ,uvkÃvkj

çfrPNk;k ij çfrPNk;k dk fuLipnu dyufoèkÉh yxk djdh xÃ FkhA eÅyÿC I ¶Voÿ j ¼Ldj.k 2015ch] eÝkodÇ] uÝVd] ,e,½dk mi;ksx çfrPNk;k 0;Åiiu ekin/kadh x.kuk dsfy, fd;k x;k FkkA çfrxeu e,My fodfI r djusdsfy,] MÙkI V/ dksnksHkkxksxaeaanfu#íS;rk I sfoHkkftr fd;k x;k Fkk% çf'k{k.k dsfy, 85% vkÿ çf'k{k.k dsfy, 15%A e,My fodfI r djusenksLor= pj ¼,ethoh&,uvkÃ,vkj vkÿ thihvkj½ vkÿ ,d vkfJr pj ¼,y ,Q MÙyk½dk mi;ksx fd;k x;k FkkA e,My dsçn'ku dksehÿux ,CI kÿ;V/ ij I V/ ,jj ¼,e,ihÃ½ vkÿ ekè; oxZ ¼vkj,e,I Ã½ dh x.kuk djds vkdk x;k g§A e,My dsfu"iknu dk fu.kZ ehu ,CI kÿ;V/ ij I V/ ,jj ¼,e,ihÃ½vkÿ : V ehu LDok;j ,jj ¼vkj,e,I Ã½ dh x.kuk }kjk x;k g§A

i fj.kke ,oafooopuk

fo'y'Sk.k dsmíS; I }ç;ksxkRed MÙkI V/ dksnksHkkxksxaeafu#íS;rk I sfoHkkftr fd;k x;k FkkA çf'k{k.k dsfy, 85 ¼,kuh] 85%½vkÿ ifj{k.k dsfy, 15 ¼,kuh] 15%½A çLrkfor –f"Vdksk dsfu"iknu dh rÿyuk ijEijkxr –f"Vdksk I sdh xÃ g§ tksç{kÉfir dyh{ks=Qy dsjß[kd Qyu ij vkèkÉkfjr g§¼,i#,yks, V vy 2000(fetksm vkÿ ekI rÿkuh 2003(xksytÉfj;u ,V vy 2011(f'kjjjeku ,V vy 2016½A vkj,e,I Ã vkÿ ,e,ihÃ dksçf'k{k.k vkÿ ijh{k.k MkVkI V/ nksuka–f"Vdksk dsfu"iknu dh rÿyuk djusdsfy, ekik x;k FkkA vkÿ ifj.kke rkfydk 1 eafn, x, g§A

fu"d"kZ

bI vè;;u eaohvkÃ,I&,uvkÃvkj çfrPNk;k ds la,kstu ds I kFk çfrxeu e,My dk mi;ksx djds ,y,QMCY;wdk vuçeku yxkusdsfy,, ,d u;k–f"Vdksk çLrkfor fd;k x;k g§A i"BHkfue ?kVko vkÿ vxÝHkfue ds vkÿ r mnkl eV;; dsvkdyu dsfy,] ouLifr I hoh ds,uvkÃvkj beÝÙtx ikbiykbu ds dyufoèkÉh dksmÙyyÈC I,¶Voÿ j eal Qyrkiod ykxwfd;k x;k g§A çLrkfor –f"Vdksk dh eÊ; fo'k'Skrk ;g g§fd ueh vo;o dh voèkÉj.kk dksI fÉEefyr fd;k x;k tkfd ,y,QMCY;wdk

rkfydk 1%çf'k{k.k vkÿ ijh{k.k MÙkI V/ eaçLrkfor çfrxeu –f"Vdksk vkÿ ikjaifjd –f"Vdksk dh rÿyukA

Hkfo"; ok.kh	çf'k{k.k		ijh{k.k	
; FkkFkZrk	ikjaifjd –f"Vdksk ij	çfrxeu –f"Vdksk	ikjaifjd –f"Vdksk ij	çfrxeu –f"Vdksk
I ¿pdksd	vkèkÉkfjr jÉ[kd Qyu dk ç{kÉfir dyh{ks=Qy	ij vkèkÉkfjr thihvkj vkÿ ,ethoh&,uvkÃvkj	vkèkÉkfjr jÉ[kd Qyu dk ç{kÉfir dyh{ks=Qy	ij vkèkÉkfjr thihvkj vkÿ ,ethoh&,uvkÃvkj
vkj,e,I bZ	0.31	0.30	0.34	0.29
,e,ihbZ	27.64	23.42	32.04	24.95

vkj,e,I b& : V ehu LDok;j ,jj(,e,ihÃ& ehÿux ,CI kÿ;V/ ,jj

I cI segRoiwkZ vkèkkj gA bl vè;;u enfuokj.k fd;k x;k fd ,uvkÃvkj çfrPNk;k I sohvkÃ,I çfrPNk;k vk§ ,ethoh& ,uvkÃvkj I sthihvkj dk mi;;kx ,y,QMCY;w dsvkdyu dsfy, çHkkoh: i I sfd;k tk I drk gA bl —f"Vdksk I sxgh tkeôk vkfn vU; vukt QI ykftuds fd ,d tSsvfHkky{k.k g}dsrktk ck;keki dsvkdyu es 0;kid mi;;;ikrk gksI drh gA

fu"d"kZ

çFke y{[kd ftI dk ;g ih,p-Mh ds'kksk dk;Z dk fgLI k gSHkk—Ikvt]uÃ fnYyh] Hkkjr I sçklr Qsykfk'ki dks vkHkkkj 0;äá djrk gA ;g dk;Z jk"Vh; —f"k foKku dk'k¼,u ,, I ,Q½ Hkk—vi] vurku I a,u ,Q ,Q@ih,pb,u&6005@2016&17 }kjk I eAfkr fd;k x;k FkkA

I anHkZ
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