



# —f'k eW; i nkupeku grqy,lx 'k,V&Vezeekjh ¼ y-, l -Vh, e-½vk/Wfjr U; jyy uWodZdk mi ; kx

jkur tk; l oky<sup>12</sup> fxjh'k dekj >k<sup>1</sup> dfi y pksjh<sup>1</sup> jktho jatu dekj<sup>3</sup>

## I kjlk

i "BMe%—f'k eW; i nkupeku viuh vuBh fo'kSkrvka ds dkj.k l e; J[kyk fo'ySk.k ds l cl sdfBu {ks-ka ea l s, d gA bl v/; u e, d xj&fLfj vj xj&j[th; —f'k eW; J[kyk dh l Vhd i nkupeku dsfy, y,lx 'k,V&Vezeekjh ¼ y-, l -Vh, e-½e, My dk mi ; kx fd; k x; k gA

fof/k; k%, d , y-, l -Vh, e- e, My viusvkorZ rfd=dk okLrpyk vj fNisgq ukM+ eami; kx fd, tkusokyseekjh QD'ku ds dkj.k , d tfVy l e; J[kyk ds vYidkyd vj nh?kdkfyd nkuavLFkk; h i S/uZdk çHkkoh <x l sfo'ySk.k vj vf/k—r djrk gA

ifj.Me%eDdsdh vrjjk"Vh; ekf l d eW; J[kyk dk mi ; kx djrsq fofHku i nkupeku eW; kdu ekunMkadsifj.kke vuq kj vl; e, Mykaf d ryuk eafodf l r , y-, l -Vh, e- e, My ds ifj.kke JSBrk dks Li"V : i l sçnf'kZ djrs gA vr%, y-, l -Vh, e- e, My fdl kuk 0; ki kfj; k vj uhfr fuekZrkvka dks—f'k eW; i nkupeku ds {ks= eaykHkkf l or djs ds fy, dkQh l Hkkouk, afn[krk gA

"lh d fH%y,lx 'k,V&Vezeekjh Vbke fMysU; jyy uWodZ eW; i nkupekuA

## Agricultural Commodity Price Prediction using Long Short-Term Memory (LSTM) based Neural Networks

Ronit Jaiswal<sup>1,2</sup>, Girish K. Jha<sup>1</sup>, Kapil Choudhary<sup>1</sup>, Rajeev Ranjan Kumar<sup>3</sup>

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### ABSTRACT

**Background:** Agricultural price forecasting is one of the research hotspots in time series forecasting due to its unique characteristics. In this paper, we develop a standard long short-term memory (LSTM) for accurately predicting a nonstationary and nonlinear agricultural price series.

**Methods:** An LSTM model effectively analyses and captures short-term and long-term temporal patterns of a complex time series due to its recurrent neural architecture and the memory function used in the hidden nodes.

**Result:** The empirical results using the international monthly price series of maize demonstrate the superiority of the developed LSTM model over other models in terms of various forecasting evaluation criteria. Overall, LSTM model shows great potential for improving the accuracy and reliability of agricultural price predictions, benefiting farmers, traders, and policymakers in making informed decisions.

**Key words:** Long short-term memory, Price forecasting, Time-delay neural networks.

## çLrkouk

—f'k oLrqvka dk l e; ij vj l Vhd eW; i nkupeku fdl kuk mi Hkksäkvka vj uhfr fu; kstdkadsfy, egRo i wZ vj mi ; kxh tkudkj çnku dj l drk gA —f'k oLrqvka ds mRi knu dh ekS eh çHkkoh mudh ekx dh 0; i Uu ç—fr tyok; q ifjorZ'khyrk cktkj dh [kfe; k oShdj.k l êk 0; ki kj] vkfn ds dkj.k —f'k oLrqvka dh dherka ea xj&fLfjrk vj xj&j[th; [kdr tS h tfVy fo'kSkrvka, agS tks l e; J[kyk i nkupeku dsfy, , d cMh pqs h gS %cut hZ br; kfn 2021; pksjh br; kfn] 2019%A dekj br; kfn ½2019%

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usik; k fd fi Nysdbzn'kdkaep' 'kkdkrkd/ka uschkkoh vlsj  
doky le; Jdkyk imkZepku e, My ds fMtkbu vlsj  
fodkl ea xgjh #fp yh gA

eW; imkZepku dsfy, fodfl r fofHku le; Jdkyk  
-f'Vdkskka dksk/srksj ij nksJf.k; kaeafokkftr fd; k tk  
l drk gS vFkkZ- l kA; dh; e, My vlsj vkfVfO'k; y  
bafsytd e, MyA vkfVfO'k; y bafsytd ¼ -vkbZ/e, My  
; k e'khu yfuZ ¼ e-, y-½ e, My vius yphys ifjpkYu  
fMtkbu vlsj 'kfä'kkyh Lo&f'k{k.k {kerkvka ds l kfk gky  
gh ea le; Jdkyk imkZepku ds fy, , d vk'kktud  
fodYi cu x, gA -f=e rfi=dk us/odZ¼ -, u-, u-¼ , e-  
, y- ds egROIwZ {ks=ka ea l s , d] Mv/k l pkfyr gS tks  
ikj fjd e, My vk/kkfjr fof/k; ka dsfoijhr Lo&vuuphyh  
-f'Vdksk dk ikyu djrsgA ose, Mfyax dsfy, 'kfä'kkyh  
midj.k gS [kk dj tc varfuZgr Mv/k mRiUu djus dh  
çfØ; k Kkr ughagA QhM&Q, joMZ çdkj ds rfi=dk us/odZ  
us/odZ dh buiV ij dsf l uSfVd Lrj ij le; dh ngjh  
ds mi; kx dsek; e l sfdl h Hkh le; Jdkyk ds vLFkk; h  
i SvZdks i dM+yrs gS ¼ k bR; kfn] 2013¼A ; s QhM&Q, joMZ  
us/odZ çR; d mnkgj .k ¼ Mv/k fcnq/kadk uewZ ds çl d j .k  
ds ckn viuk otu v | ru djrsg vlsj bl çdkj us/odZ  
dh dkbZ Hkh fLFkr l xghr ughagksh gA bl le; dh ngjh  
vYidkfyd fuHkjr ds fy, i; kZr gks l drh gS yfdu  
fuf'pr : i l s okNuh; ugha gS tc ge fdl h Hkh le;  
Jdkyk l s fuiVrs gS fti ea bl ds Mv/k fcnq/ka ds chp  
nh?kZdkfyd fuHkjr dh l a fuk gksh gA nli jh vlsj vkorZ  
rfi=dk us/odZ ¼ RNN¼ buiV l svkmViV rd esi x QD'ku  
l h[krs le; fVlif.k; ka ds chp Øe dh Li"V gMfyax dks  
tkMfsgA vkj-, u-, u- okLro eafdl h fo'kSk le; eafdl h  
Hkh buiV vuØe ds, dy rRokadks l a kf/kr djrsg vlsj  
mudh fNi h gDZ bdkb; ka ea, d 'LVV/ oDVj^ cuk, j[krs  
gA fQj Hkh] tc Mv/k fuHkjr dk varjky c<rk gS rks  
ekud vkj-, u-, u-; k rksytr gksjgs xM, V/ ; k , DI lykMx  
xM, V/ dh l eL; k l s xZr gks tkrsgA bl fy,] ekud  
vkj-, u-, u- nh?kZdkfyd fuHkjr ds l kfk l eL; kvka dh  
Hkfo"; ok.kh djusea l cl s vPNk fodYi ugha gks l drk gS  
¼ cat hvks bR; kfn] 1994¼A bl fLFkr dsfy,] ych vof/k dh  
fuHkjr ¼ y-, l -Vh-, e-½ vk/kkfjr vkj-, u-, u- dks nh?kZdkfyd  
fuHkjr l sfuiVus dsnks ku ytr gksjgh <ky dh l eL; k  
dks nj djus ds fy, fMtkbu fd; k x; k gS ¼ ysd  
bR; kfn] 2015¼A

; g v/; ; u -f'k eW; Jdkyk ds l Vhd imkZepku ds  
l kfk&l kfk bl ds ifjorZ dh fn'kk ea; kxnku djus ds  
mif; l s l æf/kr gA pfd QhM&Q, joMZ, , u, u -f'k eW;  
Jdkyk ds mPp xj&jj[kdrk] yas varjky vlsj fo'ke xqkka  
dks l Vhd : i l se, My djusea vl efkZ gS bl fy, ; g  
v/; ; u , y-, l -Vh-, e- l y ds ykHka dk ykHk mBkdj  
vkorZ rfi=dk us/odZ ij vk/kkfjr eW; imkZepku e, My  
dk çLrko djrk gA vf/kd l Vhd : i l s fodfl r e, My  
-f'k eW; Jdkyk dh vYidkfyd vlsj nh?kZdkfyd fuHkjr  
nksuka dh igpku djds mi; kx tkudkj h fudkyus vlsj  
vkrfjd çfruf/kRo l h[kus ea , y, l Vh, e ds eekjh l y  
dh vknr dk mi; kx djds -f'k eW; dh Hkfo"; ok.kh  
djrk gA bl ds vykok] fodfl r e, My eavxyseghus dh  
fn'kk dh Hkfo"; ok.kh djus dh {kerk gA ; g /; ku fn; k  
tkuk pkfg, fd VfuZ i, bV l s l æf/kr 0; ki kj pØ ds  
pj.kk adks l e>us dsfy, imkZepku dh , d h fn'kk vFkZ kL=  
ea fo'kSk : i l s eW; oku gA fodfl r e, My dk vlsj  
eW; kadu fd; k gS vlsj bl dh rgyuk , -vkj- vkbZ, e-, - vlsj  
Vh-Mh-, u-, u- e, My l s dh gA

### l kexh , oai jh{k.k fof/k

tk; l oky bR; kfn ¼ 2021¼ ds vuq i oSuf'kak xM, V/ dh  
l eL; k dsfy,] y-, l -Vh-, e- , d çHkkoh l ek/kku gS tks  
vYidkfyd vlsj nh?kZdkfyd fuHkjr nksuka dks l h[kus ea  
l {ke gA , y-, l -Vh-, e- dh l j pukRed l j puk bl sfuk  
fdl h dfBukbZ ds ych vof/k dsfy, tkudkj h dks; kn  
j[kusea l {ke cukh gA , d ekud vkj-, u-, u ds fNi sgq  
ukMf ea, d cgr gh l jy l j puk gksh gS tS sfl Xe, bM  
; k fl xy Vd i j rA bl dsfoijhr] , y-, l -Vh-, e- ea, d  
vf}rh; tfVy l j pukRed l j puk gksh gS fti ea pkj  
}kj gksg vlsj , d dks'kdk volFkk , d fo'kSk rjhds l s  
ij l i j fØ; k d j rh gA

l y LVV ¼ c½ , y-, l -Vh-, e- dh dçh gS tks dN  
Nksh ckrphr ds l kfk i j h nkgj kbZ tkus okyh Jdkyk ds  
l ekurj pyrh gA l y dh fLFkr ea tkudkj h dks gVkus  
; k tkMx dsfy, xVt dk mi; kx fd; k tkrk gA ; s }kj  
fl Xe, bM l fØ; .k QD'ku l s cus gksgD; kad ; g 'kM;  
vlsj , d ds chp ds eku mRiUu djrk gS vlsj bl çdkj  
}kj ds Hkhrj l puk ds çokg dks fu; fi=r djrk gA , d  
, y-, l -Vh-, e- ea rhu xV gksg gS tS s Qkj xV xV ¼ ¼  
buiV xV ¼ ¼ vlsj vkmViV xV ¼ ¼ fl Xe, bM l fØ; .k

QD'ku ds vykokj , d vl; I fD; .k QD'ku vkerkj ij tanh½ dk mi; kx , y, l -Vh, e- l sy ea Hkh fd; k tkrk gS rkfd ofuf'kak xM, v/ dh l eL; k dks nj fd; k tk l dš tksfd yas l e; rd nh jsD; iilu dks cuk, j [k l drk gA , y-, l -Vh, e- dsek/; e l sl puk dks l d kf/kr djusea igyk dne l sy dh fLFkr l svckl fxd tkudkj dks nj djuk gA ; g igysx/ jkjk fd; k tkrk gS ftl eaf l Xe, bM QD'ku gkrk gA

$$f_t = \sigma(W_f \cdot [h_{t-1}, y_t] + b_f)$$

vxyk pj.k l sy fLFkr ea ubz; k çkl fxd tkudkj l xghr djuk gA ; g , d vl; x/ jkjk fd; k tkrk gS ftl eaf l Xe, bM QD'ku gkrk gS ftl s "bui/ x/" dgk tkrk gS vkj , d tanh ijr gkrh gA

$$i_t = \sigma(W_i \cdot [h_{t-1}, y_t] + b_i)$$

$$C_t = \tanh(W_c \cdot [h_{t-1}, y_t] + b_c)$$

vr ej vkmVi/ , d fl Xe, bM ijr vkj tanh ijr dk mi; kx djds v/ ru l sy fLFkr ij vk/kfjr gkrk gS tks , d l kfk dpy mu fgl ka dks vkmVi/ djrk gA

$$C_t = f_t \times C_{t-1} + i_t \times C_t$$

$$o_t = \sigma(W_o \cdot [h_{t-1}, y_t] + b_o)$$

$$h_t = o_t \times \tanh(C_t)$$

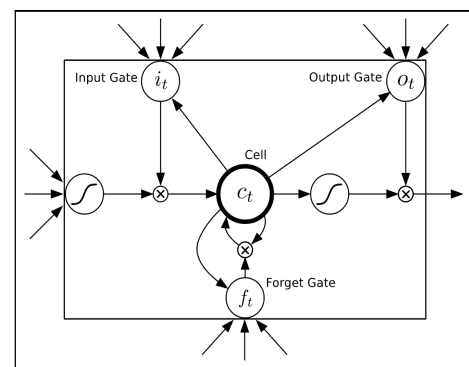
tqk w Hkhj vkD; w dk çrfuf/kRo djrk gS b , d imkzg in gS ¼½ , d fl Xe, bM Qyu gS vkj tanh ¼½ , d vfrijoyf; d Li 'kz jk Qyu gA fp= 1 , d , y-, l -Vh, e- l sy ea bu l ehdj. ka dk mi; kx djds l puk ds çokg dks n'kkrk gA

### ifj.kk , oafoopuk

orèku v/; ; u dsfy, ] tuojh 1980 l stykbZ 2020 dh vof/k fo'o cfd deksMVh eW; Mv/k fied 'khV½ l s, d= fd, x, eDdk dh ekf l d dher ¼½, e-Vh½ dk ç; kx fd; k x; k gA ewy eW; Jkkyk dks nks l v/ka ea foHkfr fd; k x; k gS vFkr-çf'k{k.k l v/ ¼tuojh 1980 l stykbZ 2019½, oaijh{k.k l v/ ¼xLr 2019 l stykbZ 2020½ fp= 2 ea l e; Jkkyk dk ly, V fn; k x; k gA bl v/; ; u ea ç; j eW; Jkkyk ds ewy o.kkRed vkdMsrkfydk 1 ea çLr fd, x, gA

bl v/; ; u ej -f'k eW; Jkkyk dk imkzku yxkus ds fy, , d ekud , y-, l -Vh, e- e, My fodf l r fd; k

x; k gA e, Myak çfD; k Mv/k l keW; hdj.k ds l kfk 'kq gkrh gS vkj mlga i; Dfkr f'k{k.k çk: i eacny nrh gA fQj foHkku gkbijjkehVj dks cnys ds vk/kkij ij , y-, l -Vh, e- e, My ds foHkku fol; kl ka dks çf'k{k.k l v/ ij fQV vkj çf'k{k.k fd; k tkrk gA fNisgg ukM dh l ; k vkj bui/ dh l ; k dks cnys l imkzku l Vhdk ij i; kLr çHko iMfrk gS tcd vl; gkbijjkehVj tS s; qka dh l ; k çp vkdkj vkj l fD; .k QD'ku ds çdkj dk cgr de çHko iMfrk gA ; qka dh l ; k vkj çp dk vkdkj 100 ij l v/ gS vkj ReLU dk mi; kx fgMu vkj vkmVi/ ys j nkuakeal fD; .k dk; kds: i eaf; k tkrk gA çkjHkd jkd fof/k dk mi; kx l gh l e; ij çf'k{k.k dks jkdj vkofQVak l scpk tkrk gS vkj l gh l ; k ea ; q çkl djusea enn djrk gA y, l QD'ku dk vuqpyu LVkdSLVd xM, v/ fmi v/ eFM ds , d çedk l d j.k jkjk fd; k tkrk gS ftl s, Me ¼ MfVo ekv , LVhesku½ v, flVekbtj dgk tkrk gA fd l h Hkh v, flVekbtSku , YxkjFke dh l h[kusdh nj ml ds l qe vfHkl j .k dsfy, cgr egRo iWZ gSyfdu bl dseW; dks puk l eL; kxLr gSD; kcd mPp eW; l s, YxkjFke fopyu gsl drk gS vkj de eW; /kheh vfHkl j .k cukrk gA bl çdkj] , d svuqpyd



fp= 1%, y-, l -Vh, e- l syA

rkfydk 1%eW; ¼½, e-Vh½ Jkkyk dso.kkRed vkdMA

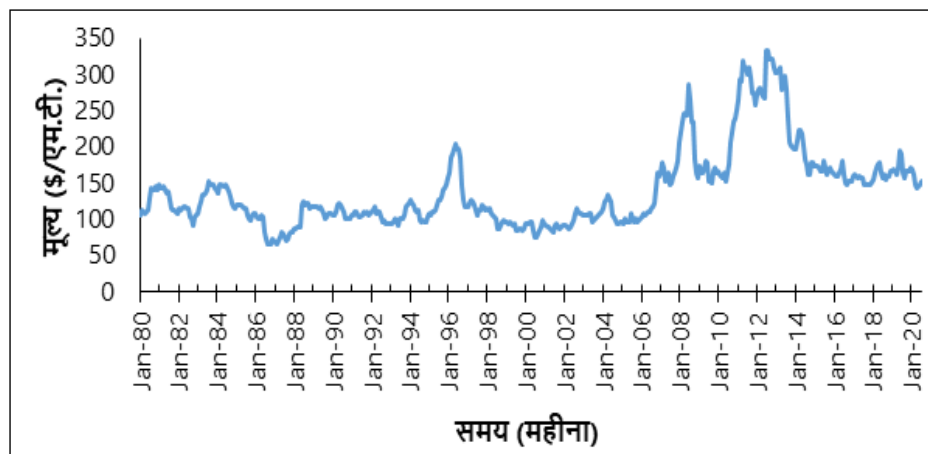
l k[; dh	oY; w
U; wre	65-31
vkj r	139-59
vf/kdre	333-05
ekud fopyu	54-85
frjNki u	1-57
dplrk	5-26
tkd&çjk	304-63

dkS pPuk geSkk cgrj gkrk gSftl dh l h[kus dh nj fi Nysifj.kkkaadsvk/kkj ij [kpn dksvupfyr dj l drh gSvkj cf'k{k.k ea l dkj dj l drh gA vr%ge fofHklu gkbijijkehVj dks LFkbbZ djs dsfy, , Me v,fivekbtj dk c; kx djrs gA ; fn i buiV ukM+ dh l d; k gSvkj h fNisgq ukM+ dh l d; k gS rks cf'kf{kr ekinMka dh l d; k 4x[h(h+i)+h] gA gkbijijkehVj dsdbZvyx&vyx fol; kl fxM [kkt i) fr vkj mudh Vi fuax dk mi ; kx djdsQV fd, tkrsgA nksukaew; J[kyk dsfy,] dy 81 ,y-, l -Vh, e- e,My fNisgq ukM+ ¼ y-, l -Vh, e- dks kdkvka dh l d; k vkj varjy dh l d; k dsl Hkh l Hkfor l a kst uka l sfufeZ gkrsgA nksuka2 l s10 rd gkrsgA cR; d d,flQxj sku dks rc 50 ckj nksj; k tkrk gS vkj vf/kd oSk vkj etcar ifj.kkkaadsvf,] ifj.kkkaadk vkj r fy; k tkrk gA 81 ,y-, l -Vh, e- e,Mykaea l 3 4 buiV ukM+ vkj 2 fgMu ukM+ okyk e,My eDdk eV; J[kyk ds cf'k{k.k vkj ij h{k.k l V nksuka ij ckr iMkuZeku eV; kdu ekunMka dsl mHkZeavU; cfrLi/khZe,My dh rgyuk eacgrj c'n'ku djrk gA

bl v/; u e; gekjk /; ku vYidkfyd iMkuZeku ij gS vkj bl fy,] geusckjg eghuksrd dsiMkuZeku f{kfrt

ij fopkj fd, gA Dyevt bR; kfn ¼1977½ usbz eMh vk/kkfjr ,-, u-, u- dh iMkuZeku {kerk dh rgyuk vkj-, e-, l -bz ,e-, -ih-bZ ¼vkj r fujiSk cfr'kr =QV¼ ,e-, Mh-¼ek/; fujiSk fopyu½ vkj D<sub>stat</sub> dsl mHkZeavU; ,-, u-, u- vkj , -vkj-vkbZ, e-, - l sdh gA rkfydk 2] Li "V : i l scnf'kr djrh gSfd ,y-, l -Vh, e- dh iMkuZeku l Vhdkr ,-, u-, u- vkj , -vkj-vkbZ, e-, - e,My dh rgyuk eacgrj gA

bl v/; uu ea; g nSk tk l drk gSfd iMkuZekfur J[kyk dseV; ,y-, l -Vh, e- dk mi ; kx djdscklr fd, tkus ij okLrfod eV; J[kyk dseV; ka ds vf/kd djhc gA ,y-, l -Vh, e- dh ; g JSBrk igys l s gh fofHklu iMkuZeku eV; kdu ekunMka ds ifj.kkka }kj i q"V dh xbz gStS k fd rkfydk 2 eafn[kk; k x; k gA rkfydkvkaea; g nSk x; k gSfd rhu eV; kdu ekunM vkj-, e-, l -bz ,e-, -ih-bZ vkj ,e-, -Mh- yxkrkj , -vkj-vkbZ, e-, - e,My l s ,y-, l -Vh, e- e,My rd ?kv jgs gA fo'kSk : i l seDdk J[kyk dsfy,] ,y-, l Vh, e dk mi ; kx djdsx.kuk fd, x, eV; kdu ekunM usvupfyr vkj-, e-, l -bz e,My l s yxHkx 72% vkj vupfyr Vh-Mh, u-, u- e,My l s 47% dh deh fn[kkbZgA vkadMk Li "V : i l sbfxr djrk gSfd ,y-, l -Vh, e- e,My dk cR; d eV; kdu ekunM dsfy,



fp= 2%vrjklVh; cktkj dh ekfl d eDdk eV; J[kyk dk Vkke ly,VA

rkfydk 2%vrjklVh; cktkj dsekfl d eDdk eV; dsfy, cR; d iMkuZeku e,My dh rgyukA

e,My	vkj-, e-, l -bz	, e-, -ih-bZ	, e-, -Mh	D <sub>stat</sub> ¼¼½	gkbijijkehVj
, -vkj-vkbZ, e-, -	0-110	31-194	0-105	45	p <sup>¾</sup> 41] d <sup>¾</sup> 41 and q <sup>¾</sup> 40
Vh-Mh, u-, u-	0-058	14-027	0-046	54	Lags <sup>¾</sup> 45]
					Hidden nodes <sup>¾</sup> 46
, y-, l -Vh, e-	0-031	7-337	0-026	63	Lags <sup>¾</sup> 44]
					Hidden nodes <sup>¾</sup> 42

rkfydk 3%Mh, e- Vh, I -Vh, e- ifj. kkeA

Vh, I -Vh, e- My	cpekdl e, My	
	, -vkj-vkbz, e-, -	Vh-Mh, u-, u-
Vh-Mh, u-, u-	4-87 10-0002½	
, y-, I -Vh, e-	4-47 10-0004½	2-00 10-03½

I cl sde eW; gA , y-, I -Vh, e- u dW okLrfod dherka ds I nHkZ eacfyd ifjorZka dh fn'kk ds I nHkZ eahkh cgrj c'n'ku djrk gA rkfydk 2 eafn, x,  $D_{stat}$  ifj. kkeka us I R; kfi r fd; k fd , y-, I -Vh, e- ifjorZ dh fn'kk dks nh jka dh ryuk eacgrj rjhds I sidM+yrk gA vU; e, Myka ij , y, I Vh, e dh Hkfo"; dgusokyk I Vhdk dh JSBrk (DM) ij h{k.k }kj fu/kkZjr dh tkrh gA rkfydk 3 eafn[kk, x, Mh, e- ij h{k.k ds ifj. kke ; g I kfcr djrs gA fd , y-, I -Vh, e- ea J[kyk ds fy, vU; cpekdl e, My dh ryuk ea iokZepuka eae gROI wZ I Vhdk gA

## fu"d"Z

bl v/; ; u eaeDdk dh ekfI d vrjkk"Vh; eW; J[kyk dk mi ; kx djds e, My x vkj iokZepuka nkuks ds I nHkZ ea , -vkj-vkbz, e-, - vkj Vh-Mh, u-, u- e, My ds I kFk , y-, I -Vh, e- e, My ds c'n'ku dh tkp djrk gA ; g nq[kk x; k gsf d , y-, I -Vh, e- e, My xj&j\$[kd I adkka ds fy, , -vkj-vkbz, e-, - vkj Vh-Mh, u-, u- e, My dh ryuk ea fofHku eW; kadu ekunMka ds I nHkZ ea cgrj iokZepuka I Vhdk cnu djrk gA Mh, e- ij h{k.k us vU; nkse, Myka dh ryuk ea , y-, I -Vh, e- dh I Vhdk eahkh egROI wZ I dkj fn[kk; ka vkorZd rfi=dk uVodZ dh okLrdyk vkj fNi s

gq ukMh eami ; kx fd, tkusokys }kj feydkj , y-, I -Vh, e- dksfd I h Hkh tfVy I e; J[kyk dk fo'y\$kk.k djs eacgrj c'n'ku djuseaenn djrs gA dy feydkj] ge dg I drs gA fd cLrkfor e, My -f"k eW; iokZepuka ds {ks- eacR; d -f"k fgr/kkj d ds fy, , d I kjFkh dk dke dj I drk gA

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