Additional file 1

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Forward primer 5’-3’** | **Reverse primer 5’-3’** | **TH (**°C) |
| **Catalase 1** | AAAAGCAGGCTTCATGGATC CCTCTAAGTATCG | CAAGAAAGCTGGGTCTCAC ATTGTAGGCTTCACAG | 60 |
| **Catalase 2** | AAAAAGCAGGCTTCATGGAT CCTTACAAGTACCG | CAAGAAAGCTGGGTCTCAT ATGCTTGGTCTCACAT | 60 |
| **Catalase 3** | AAAAAGCAGGCTTCATGGAT CCTTACAAGTATCG | CAAGAAAGCTGGGTCTCAC ATTGTAGGCCTTATAT | 60 |

**Additional file 2**

|  |  |  |
| --- | --- | --- |
| **Motif** | **Sequence** | **Description** |
| **1** | PTCDIKHLTCEEAJRVGGANTPVA | Catalase clade 1 |
| **2** | EVGIPEDYRHIDGFSVKPETL | Catalase clade 1 |
| **3** | KLLQTRIFSYADTQRHRLGPNYLQLPVNAPKCAHHNNHHDGFMNFMHRDE | Catalase clade 1 |
| **4** | TKDLYDSIAAGNYPEWKLFIQTMDPEHEDKFDFDPLDVTKTWPEDILPLQ | Catalase clade 1 |
| **5** | TNEIREIWINYWSQADKSPGQ | Catalase clade 1 |
| **6** | GNFDLVGNNFPVFFIRDGMKFPDMVHALK | Catalase clade 1 |
| **7** | INKAGKAHYVKFHWK | Catalase clade 1 |
| **8** | EVBYFPSRYDPVRHAEQYPIP | Catalase clade 1 |
| **9** | FDPYKYRPGSAYSDP | Catalase clade 1 |
| **10** | LLEDYHLVEKLANFD | Catalase clade 1 |

**Additional file 3**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Gene Name** | **Locus Name** | **Species** |
| 1 | *VvCAT1* | GSVIVT01013367001 | *Vitis vinifera L.* |
| 1 | *AtCAT1* | AT1G20630 | *Arabidopsis thaliana (Linn.) Heynh.* |
| 2 | *AtCAT2* | AT4G35090 |
| 3 | *AtCAT3* | AT1G20620 |
| 1 | *GmCAT1* | Glyma.04G017500 | *Glycine max (Linn.) Merr.* |
| 2 | *GmCAT2* | Glyma.06G017900 |
| 3 | *GmCAT3* | Glyma.14G223500 |
| 4 | *GmCAT4* | Glyma.17G261700 |
| 1 | *TcCAT1* | Thecc1EG000075t1 | *Theobroma cacao L.* |
| 2 | *TcCAT2* | Thecc1EG034390t1 |
| 1 | *GrCAT1* | Gorai.002G115900 | *Gossypium raimondii Ulbr.* |
| 2 | *GrCAT2* | Gorai.009G187600 |
| 3 | *GrCAT3* | Gorai.003G002800 |
| 1 | *CsCAT1* | Cucsa.077510 | *Cucumis sativus* |
| 2 | *CsCAT2* | Cucsa.272110 |
| 3 | *CsCAT3* | Cucsa.272120 |
| 1 | *AlCAT1* | AL1G33580.t2 | *Arabidopsis lyrata v2.1* |
| 2 | *AlCAT2* | AL7G16130.t1 |
| 3 | *AlCAT3* | AL1G33590.t1 |
| 1 | *BdCAT1* | Bradi5g13250.1 | *Brachypodium distachyon* |
| 1 | *CicCAT1* | Ciclev10000948m | *Citrus clementina v1.0* |
| 2 | *CicCAT2* | Ciclev10017962m |
| 3 | *CicCAT3* | Ciclev10000951m |
| 1 | *CisCAT1* | orange1.1g044386m | *Citrus sinensis v1.0* |
| 2 | *CisCAT2* | orange1.1g042356m |
| 1 | *MtCAT1* | Medtr3g115370.1 | *Medicago truncatula* |
| 2 | *MtCAT2* | Medtr1386s0010.1 |
| 1 | *OsCAT1* | LOC\_Os03g03910.1 | *Oryza sativa* |
| 2 | *OsCAT2* | LOC\_Os06g51150.1 |
| 3 | *OsCAT3* | LOC\_Os02g02400.1 |
| 1 | *SbCAT1* | Sobic.001G517700.1.p  | *Sorghum bicolor v3.1.1* |
| 2 | *SbCAT2* | Sobic.004G011566.1.p  |
| 3 | *SbCAT3* | Sobic.010G274500.2.p |

**Additional file 4**





**Additional file 5**

d1m7sa\_ --------------------TDT**LT**R**D**N**GA**V**VGDNQ**---**NSQTAG**AQ**GPVLL**Q**D**V**QLL**Q**K**

StCAT1 -----MD--PSKYRPSSAYDTPF**LTTN**A**GG**P**VYNN**V---**SSLTVG**P**RGPVLLEDYYLIEK**

StCAT2 -----MD--PYKYRPSSAFNSPFC**TTN**S**GA**P**VWNNN**---**SSLTVG**A**RGPVLLEDYHL**V**EK**

StCAT3 -----MD--PYKYRPSSAANSPF**MTTN**S**GA**P**VYNNN**---**SSLTVG**T**RGP**I**LLEDYHLLEK**

c2j2mD\_ ---------------------KK**LTTN**Q**GV**P**IGDNQ**---**NSRTAG**R**RGPTLLEDYQLIEK**

c4qoqC\_ --------------------HKN**LTTN**Q**GV**P**VGDNQ**---**NSRTAG**H**RGPS**F**L**D**DYHLIEK**

c3ej6D\_ ----EVDARQRLKEVEVDDNGQF**MTTD**F**GG**N**I**EEQ----F**SLKAG**G**RG**S**TLLEDFI**F**R**Q**K**

c1sy7B\_ ---------------------AR**LTTD**Y**GV**KQ**TTAD**DWLRIV**SD**DKI**GPSLLED**P**F**A**RE**R

c1p81A\_ (34)RNEKLNSLEDVRKGSENYA**LTTN**Q**GV**R**IADDQ**---**NSLRAG**S**RGPTLLEDFILREK**

d1p80a2 (34)RNEKLNSLEDVRKGSENYA**LTTN**Q**GV**R**IADDQ**---**NSLRAG**S**RGPTLLEDFILREK**

Consensus/80% .......................bTTs.Gs.lhssp...sSbpsG.RGPsLLEDabLbEK

d1m7sa\_ **L**Q**RFDRERIPERVVHARG**T**G**V**KGEFTA**SA**DISDL**S**KAT**VF-KS**G**E**KTPVFVRFS**S**VVH**G**N**

StCAT1 **LATFDRE**K**IPERVVHARGASAKGFFEV**T**HDISHL**S**CADFLR**AP**G**A**QTPVI**C**RFSTVVH**E**R**

StCAT2 **LANFDRERI**A**ERVVHARGASAKGFFEV**T**HDIAHLTCADFLR**AP**G**V**QTPVIVRFSTVIH**E**R**

StCAT3 **LANFDRERIPERVVHARGASAKGFFEV**T**HDISHLTCADFLR**AP**G**V**QTPVIVRFSTVIH**E**R**

c2j2mD\_ **IAHFDRER**V**PERVVHARG**F**GAHG**V**FKV**K**NSM**K**K**Y**TKAAFLQ**EE**G**T**E**V**PVF**A**RFSTVIH**G**T**

c4qoqC\_ **LAHFDRERIPERVVHARGAGA**Y**G**V**FEV**E**NSM**E**K**H**TRAAFLS**EE**G**K**QT**D**VFVRFSTVIH**P**K**

c3ej6D\_ **L**Q**HFDHERIPERVVHARGAGAHGIFTS**YG**DWS**N**IT**A**ASFL**GAK**D**K**QTPVFVRFSTVAG**S**R**

c1sy7B\_ **IMRFDHERIPERVVHARGSGA**F**GKFKV**Y**ES**A**SDLT**M**AP**V**LT**DT**S**R**ETPVFVRFSTVLG**S**R**

c1p81A\_ **ITHFDHERIPER**I**VHARGSAAHGYFQP**Y**KSLSDITKADFLS**DP**N**KI**TPVFVRFSTV**Q**G**GA

d1p80a2 **ITHFDHERIPER**I**VHARGSAAHGYFQP**Y**KSLSDITKADFLS**DP**N**KI**TPVFVRFSTV**Q**G**GA

Consensus/80% lhpFD+ERIPERVVHARGttA+GbFps.psbtclTpAsFLp..s.pTPVbVRFSTVhh.p

d1m7sa\_ H**SPETLRD**PH**GFATKFYT**AD**GNWDLVGNNFP**T**FFIRDAIKFPDMVHA**F**KPDPRTNL**D**N**--

StCAT1 **GSPE**S**IRD**I**RGFAVKFYTREGNFDLVGNNVPVFF**N**RDAK**S**FPD**T**I**R**ALKPNPKSHI**Q**E**--

StCAT2 **GSPETLRD**P**RGFAVKFYTREGNFDLVGNNFPVFFIRD**G**MKFPDMVHALKPNPKSHI**Q**E**--

StCAT3 **GSPETLRD**P**RGFAVKFYTREGNFDLVGNNFPVFF**V**RD**G**MKFPDMVHALKPNPKSHI**Q**E**--

c2j2mD\_ H**SPETLRD**P**RGF**S**VKFYTEEGNWD**F**VGNNLPVFFIRDAMKFPDMVHSLKPDPRTNI**Q**D**--

c4qoqC\_ **GSPETLRD**P**RGFAVKFYTEEGNYDLVGNNLPIFFIRDALKFPDMVHSLKPDP**V**TNI**Q**D**--

c3ej6D\_ **GSADT**A**RD**VH**GFAT**R**FYTDEGNFD**I**VGNNIPVFFIQDAI**R**FPDLIHSVKPSP**D**NEV**P**Q**AA

c1sy7B\_ **GSADTVRD**V**RGFAVKFYTEEGNWDLVGNNIPVFFIQDAIKFPD**V**IHA**G**KPEPHNEV**P**Q**AQ

c1p81A\_ **GSADTVR**EI**RGFATKFYTEEG**I**FDLVGNNTPIFFIQDAHKFPDFVHAVKPEPH**WA**I**P**Q**GQ

d1p80a2 **GSADTVR**QI**RGFATKFYTEEG**I**FDLVGNNTPIFFIQDAHKFPDFVHAVKPEPH**WA**I**P**Q**GQ

Consensus/80% GSs-TlRD.RGFAsKFYTcEGNaDLVGNNhPlFFIpDAbKFPDblHtlKPpP+spl.p..

d1m7sa\_ --**D**S**RRFDFFSH**V**PEAT**R**TLT**L**LYS**N**EG**T**P**A**GYR**F**MDG**N**GVH**A**YKLVN**AK**GEVHYVKFHW**

StCAT1 --**N**W**RILDFFSF**L**PESLHTFAFFYDD**VCL**P**T**DYRHMEG**F**GVH**A**YQLIN**KE**GKAHYVKFHW**

StCAT2 --**N**W**R**V**LDFFSHHPESLHMFTFLFDDIGIP**Q**DYRHMDG**S**GVHTFTLIN**RA**GKSTYVKFHW**

StCAT3 --**N**W**RILDFFSHHPESLHMF**S**FLFDDLGIP**Q**DYRHMDG**F**GV**N**TY**M**LIN**KA**GKAQYVKFHW**

c2j2mD\_ --PD**RYWDFMTLRPEST**N**MLMHIFTDEGIP**A**SYRKMRG**SS**VHSFK**W**VN**AH**G**N**T**V**Y**I**K**LR**W**

c4qoqC\_ --PD**RYWDFMTLTPESTHMLTWLFSDEGIP**A**NY**A**EMRG**S**GVHTFR**W**VN**KY**GETKYVKYHW**

c3ej6D\_ TA**H**D**S**A**WDFFS**S**QP**S**ALHTLFWAMS**GN**GIP**R**SYRHMDG**F**GIHTFRLV**TED**GKSK**L**VKWHW**

c1sy7B\_ SA**H**N**NFWDFQ**FN**H**T**EATHMFTWAMSDR**A**IP**R**S**L**R**M**M**Q**G**F**GV**N**TYTLIN**AQ**GK**R**HFVKFHW**

c1p81A\_ SA**H**D**TFWD**YV**SLQPE**T**LH**NV**MWAMSDRGIP**R**SYRTMEG**F**GIHTFRLIN**AE**GKATFV**R**FHW**

d1p80a2 SA**H**D**TFWD**YV**SLQPE**T**LH**NV**MWAMSDRGIP**R**SYRTMEG**F**GIHTFRLIN**AE**GKATFV**R**FHW**

Consensus/80% ..p.pbbDFb\*bpPEthHhbhahbsDbGIP.sYRpMcG.GlH\*apLlN..GcspaVKaHW

d1m7sa\_ **K**SLQ**G**IK**NLD**PK**E**VAQ**V**QS**KD**Y**SHLTNDL**VG**AIK**K**GDFPKWDLYVQVL**KP**EE**LA**KFDFD**P

StCAT1 **KP**TC**G**VK**C**M**S**E**EEA**I**RV**G**GTN**H**SHATKDLYDSI**A**AGNYPEWKLFIQTMD**P**ED**VD**KFDFD**P

StCAT2 **KP**TC**G**VK**SL**LE**EEA**I**RV**G**G**A**N**H**SHATQDLYDSI**A**AGNYPEWKLFIQIMD**P**DH**ED**KFDFD**P

StCAT3 **KP**TC**G**VK**CL**LD**EEA**I**KV**G**G**A**N**H**SHATKDLYDSISAGNYPEWKLFIQTID**P**DH**ED**RFDFD**P

c2j2mD\_ V**P**KE**G**VH**NLS**A**DEA**T**EV**Q**GKD**F**NHASND**T**F**Q**AIENGDFPEWDLFVQVLD**PA**D**VEN**FDFD**P

c4qoqC\_ **RP**SE**G**IR**NLS**M**EEA**A**EI**QA**ND**FQ**HATRDLYD**R**IE**K**GNYP**A**WDLYVQLMP**LS**D**YD**E**L**D**Y**D**P

c3ej6D\_ **K**TKQ**G**KA**ALV**W**EEA**QV**L**A**GKN**A**DFHRQDLWDAIESGN**A**P**S**WELAVQLID**E**DK**AQAYG**FD**L

c1sy7B\_ T**P**EL**G**VH**SLV**W**DEA**L**KL**A**GQD**P**DFHRKDLWEAIENGAYPKWK**F**GIQAIA**E**ED**EH**KFDFD**I

c1p81A\_ **KP**LA**G**KA**SLV**W**DEA**Q**KL**T**GRD**P**DFHRR**E**LWEAIEAGDFPE**Y**ELG**F**QLIP**E**ED**EF**KFDFD**L

d1p80a2 **KP**LA**G**KA**SLV**W**DEA**Q**KL**T**GRD**P**DFHRR**E**LWEAIEAGDFPE**Y**ELG**F**QLIP**E**ED**EF**KFDFD**L

Consensus/80% +P..G..sLs.-EA.cl.Gps.sahppDLa-tIpsGsaPcWcLhlQhbs.-c..cFDFD.

d1m7sa\_ **LDATKIWP**D--**VP**E**K**K**IG**Q**MVLNKN**V**DNFF**Q**ETEQVA**MA**PA**N**LVPGI**EP**SED**R**LLQGRVF**

StCAT1 **LDVTKTWPEDLLPL**IP**VGRLVLNRN**I**DNFFAENEQLAFNPGHIVPGI**Y**YSED**K**LLQTRIF**

StCAT2 **LDVTKTWPEDILPLQ**P**VGRLVLNKN**I**DNFFNENEQLAFCPSIVVPGV**Y**YSDD**KM**LQTRIF**

StCAT3 **LDVTKIWPEDILPLQ**P**VGRLVLNKN**I**DNFFAENEQLAFCPAIIVPGV**Y**YSDD**K**LLQTRVF**

c2j2mD\_ **LDATK**D**W**F**EDVIP**F**Q**H**VG**T**MTLNKN**V**DN**Y**FAETE**S**V**G**FNPGVLVPG**MLP**SED**K**LLQGRLF**

c4qoqC\_ C**DPTKTW**S**EE**DY**PLQ**K**VGRMTLNRN**PE**NFFAETEQAAFTPSALVPGI**E**ASED**K**LLQGRLF**

c3ej6D\_ **LDPTKFLPEEF**A**PLQ**V**LGEMTLNRN**PM**N**Y**FAETEQI**S**FQPGHIV**R**GV**D**FTED**P**LLQGRL**Y

c1sy7B\_ **LDATKIWPEDLVPVR**Y**IGEM**E**LNRN**P**D**E**FFP**Q**TEQIAFC**T**SHVV**N**GI**G**FSDD**P**LLQGR**N**F**

c1p81A\_ **LDPTKLIPEELVPVQ**R**VGKMVLNRN**P**DNFFAENEQAAFHPGHIVPGL**D**FT**N**D**P**LLQGRLF**

d1p80a2 **LDPTKLIPEELVPVQ**R**VGKMVLNRN**P**DNFFAENEQAAFHPGHIVPGL**D**FT**N**D**P**LLQGRLF**

Consensus/80% LDsTKhbPE-hlPlp.lGcbsLN+N.DNFFsEsEQhAFpPthlVPGl.h\*-D.LLQsRlF

d1m7sa\_ **SYADTQM**Y**RLG**-**AN**G**LSLPVN**Q**P**K**VAVNN**G**NQDGALNTGHTTS**G**VNYEPSRL**E**P**R----P

StCAT1 A**YADTQRHRIG**-**PNYMQLPVN**A**P**K**CGHHN**N**HRDGAMNMTHRDE**E**VDYLPSRFDP**C----R

StCAT2 **SYSDTQR**Y**RLG**-**PNYLQLP**A**N**A**P**K**CAHHN**N**H**Y**DG**S**MNFMHRDE**E**IDYFPSRYD**QV----R

StCAT3 **SYADTQRHRLG**-**PNYLQLPVN**A**P**K**CAHHN**N**HH**E**GFMNFMHRDE**E**VNYFPSRLDP**C----R

c2j2mD\_ **SYSDTQRHRIG**-**PNYQQLPIN**C**P**F**A**Q**VNN**Y**QRDGAM**P**F**K**QQTS**S**VNYEPNRY**Q**D**E----P

c4qoqC\_ **SYPDTQRHRLG**-**ANYMRIPVN**C**P**Y**APVHN**N**QQDGFMTTTR**P**S**GH**INYEPNRYDD**Q----P

c3ej6D\_ **SY**L**DTQLNR**HRG**PNFEQLPIN**R**P**V**SGVHN**N**HRDG**QG**QAWIH**K**N**I**H**H**Y**S**PS**Y**LN**KGYPAQA

c1sy7B\_ **SY**F**DTQISRLG**-**VNFQELPIN**R**P**V**CPV**M**N**F**NRDGAMRHTIS**RGT**VNYYPNRFDA**----CP

c1p81A\_ **SYTDTQISRLG**G**PNFHEIPIN**R**P**T**CPYHN**F**QRDGMHRMGIDTN**P**ANYEPNSIND**NWPRET

d1p80a2 **SYTDTQISRLG**G**PNFHEIPIN**R**P**T**CPYHN**F**QRDGMHRMGIDTN**P**ANYEPNSIND**NWPRET

Consensus/80% SYsDTQbpRlG.sNabplPlN.P.sshpN.ppDGhbphhbpsp.hsYbPspbss......

d1m7sa\_ AD**D**----KARYSELP**LSG**-**T**T**QQ**AK**ITR**E**QNFKQA**GD**LYRSYSA**K**EKT**D**LVQ**K**FG**E**SLAD**

StCAT1 P-**A**E---Q**Y**PIPA**C**V**LNG**-**R**R**TN**CV**I**P**K**E**NNFKQA**G**ERYRSW**E**S**D**RQD**R**YIT**K**WV**E**SLSD**

StCAT2 H-**A**E---V**Y**PIPS**T**VC**SG**-**K**R**EK**CI**IQK**E**NNFKQP**G**ERYR**T**FTP**D**RQE**R**FIR**R**WV**EA**LSD**

StCAT3 H-**A**E---Q**Y**PIPP**R**V**LTG**-**K**R**EK**VI**IEK**E**NNFKQP**G**EHYRSW**A**P**G**RQE**R**FVC**R**WV**DA**LSD**

c2j2mD\_ KQ**T**P---E**Y**TEDT**Q**P**LH**DDIHG**R**LE**IEK**T**NNF**G**QA**G**E**V**YR**R**MT**EE**EQ**MA**LLN**N**LV**N**DL**QQ

c4qoqC\_ KE**N**P---H**Y**KESEPV**LHG**D**R**MV**R**QK**IEK**P**NDFKQA**G**EKYRSYS**EE**EKQ**A**LIK**N**LT**A**DL**KG

c3ej6D\_ NQ**T**VGRGF**F**TTPG**R**TA**SG**VLN**RE**LS**ATF**D**DHYTQP**R**LFFNSLTP**V**EQQ**FV**IN**A**I**RF**E**A**SH**

c1sy7B\_ PA**S**LKEGG**Y**LEYA**Q**K**V**A**G**I**K**A**R**ARS**AKF**K**EHFSQA**Q**LFYNSMSP**I**EKQ**H**MIN**A**FG**F**ELDH**

c1p81A\_ PP**G**PKRGG**F**ESYQ**E**R**VEG**N**K**V**RE**RSP**SF**G**E**Y**YS**H**P**R**LFW**L**SQTP**F**EQR**H**IVD**G**FS**F**ELSK**

d1p80a2 PP**G**PKRGG**F**ESYQ**E**R**VEG**N**K**V**RE**RSP**SF**G**E**Y**YS**H**P**R**LFW**L**SQTP**F**EQR**H**IVD**G**FS**F**ELSK**

Consensus/80% ..s.....a....p.lpG.p.pp..hpb.ppapQs.bbapSb\*s.cpp.blp.bs.pLsc

d1m7sa\_ **T**LT--ES**K**N**IMLSYL**Y**K**E**D**P**NYGTRVAE**VAKG**D**L**S**KVKSLAASLKD--------------

StCAT1 **P**RVTHE**IR**S**IWISYL**S**QAD**K**S**C**GQKVAS**R**LTVK**P**T**M------------------------

StCAT2 **P**RITYE**IR**S**IWITYW**S**QAD**K**SLGQKLAS**R**LNVR**P**S**I------------------------

StCAT3 LRATHE**IR**S**IWISYW**S**QAD**K**SLGQKLAS**R**LNIR**P**T**M------------------------

c2j2mD\_ **V**RHEN-**T**VL**LAIC**N**F**Y**RAD**A**SLGEKL**S**E**A**LNVD**IKPF-----------------------

c4qoqC\_ **V**N-EK-**TK**L**LAIC**N**F**Y**RAD**E**DYGQRLAD**S**LGVD**IRSYL----------------------

c3ej6D\_ **V**TNEQ-**VK**KN**VL**E**QL**N**KI**SN**D**V**AKRVA**VA**LGLE**A**P**QPDPTY----YHNN--VTRGVSIFN

c1sy7B\_ **C**EDPV-**V**YG**RMV**Q**RL**A**DID**L**GLAQTIAE**MV**G**G**E**A**P**TTTNH----PNHGRKTINLSQTEFP

c1p81A\_ **V**VRPY-**IR**E**RVVDQL**A**HID**L**TLAQ**A**VAK**N**LGIE**L**T**DDQLNITPPPDVNGLKKDPSLSLYA

d1p80a2 **V**VRPY-**IR**E**RVVDQL**A**HID**L**TLAQ**A**VAK**N**LGIE**L**T**DDQLNITPPPDVNGLKKDPSLSLYA

Consensus/80% s.....h+.bhlsbb.phD.sbtpplAp.Lslc.s.........................