## FIG. 1



FIG. 2


FIG. 3


U.S. Patent

FIG. 4


FIG. 5


FIG. 6


FIG. 7


FIG. 8


FIG. 9


FIG. 9


U.S. Patent

FIG. 10


FIG. 11


FIG. 12A
Phenology Chart 1 Time of fermale receptivity (bottom, red) and pollen shed (top, green) of OSU 880.027 and other hazelnut cultivars (Dec 2011 Mar 2012).

|  | Dec |  | Jan |  |  |  |  |  | Feb |  |  |  |  |  | March |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Genotype | 21-25 | 28.31 | 15 | Q-10 | 12-15 | 18.20 | 21.25 | 28.31 | 1.5 | 6-10 | 11.15 | 10-20 | 21-25 | 28.29 | 1.5 | 0-10 | 12.29 | 25.31 |
| Wepster |  |  |  |  |  |  |  | 10 | 95-20 | -50 | . 90 |  |  |  |  |  |  | B8 |
| (1, 2) | Rd+3 | R $\mathrm{d}+3 \mathrm{n}$ |  | Ran +2 | + +3 | 1+3 | 1+3/5 |  | 1+3/S+3 |  |  |  |  |  |  |  |  |  |
| 06 |  |  |  |  |  | * |  |  | 諨 |  |  | Redith |  |  |  |  |  |  |
| T di Giffoni | $18 t$ |  |  | 5 | 10 | 25 | 75 | . 50 | -90 | B8 | Leaves 14" |  |  |  |  |  |  |  |
| $(\underline{2}, 23)$ | Ran |  | 1+2/S | $1+2 / S+2$ | ms |  |  | ms | Ms |  |  |  |  |  |  |  |  |  |
| 02 |  |  |  |  | + |  |  | + | \% |  |  |  |  |  |  |  |  |  |
| Yamhill |  |  |  |  | 20 | 50 | 95 | 100-50 | -80 | done |  | Orip |  |  | B8 |  |  |  |
| $(8,26)$ | Rd |  | Rd +3 n |  |  | 1/5+2 | 1+2/S+2 |  | 1+2/S+3 | ms | ms |  |  |  |  |  |  |  |
| 109-1 '07 |  |  |  |  |  | Red | Rechak |  | d* |  | \% |  |  |  |  |  |  |  |
| Dorris |  |  |  |  |  | 10 | 50 | 90-20 | -0 | done |  |  |  |  |  |  |  | BB |
| (1, 12) |  |  |  | Rd*2 | Rd+3 |  |  | Ran +3 | 1+2/5 | 1+2/S+2 | ms |  |  |  |  |  |  |  |
| 06 |  |  |  |  | b* |  |  |  | akdok |  | ** |  |  |  |  |  |  |  |
| York |  |  |  |  |  |  |  | 30 | 100.50 | 80 |  |  |  |  |  |  |  | BB |
| $(2,21)$ |  |  | Rd+2 |  | Rd+3 | Rd $+2 n$ | Rdh +3 |  | 1+3/5 |  | 1+3/5+2 |  | ms |  |  |  |  |  |
| 06 |  |  |  |  | * |  | dk |  | ok |  | ** |  | bit |  |  |  |  |  |
| Lewis |  |  |  |  |  | 1st | 25 | 90-20 | 90-30 |  | -80 |  | в8 |  |  |  |  |  |
| (3, 8) |  |  |  | 1 st Rd |  |  | Ran | 1+2 | 1+3 |  | 1 | 1+2/S +2 |  |  |  |  |  |  |
| 02 |  |  |  |  |  |  | Fow temak | Red | Red |  | Rod | Red |  |  |  |  |  |  |
| Santiam |  |  |  |  |  | 19t | 20 | 100.50 | done |  |  |  |  |  |  | BB |  |  |
| (3, 15) | Rd +2 |  |  | Rd+2 | Rd+3 | Rd+3 | $\mathrm{Rd}+2 \mathrm{n}+3$ |  | 1+3/5 |  | 1+2/S +3 | ms |  |  |  |  |  |  |
| 06 | gen |  |  |  | $\stackrel{\text { \% }}{ }$ | \% |  |  | b* |  | b* | 暗 |  |  |  |  |  |  |

Green = Pollen shed (a minus sign in front of the number indicates the percent of catkins that have already shed out); drop $=50 \%$ catkins dropped Red = Fernale flowers; red, blk (black), dk (dark, not quite red, not yet black).
$\mathrm{BB}=$ date of leaf budbreak.

FIG. 12B
Phenology Chart 1. Time of female receptivity (bottom, red) and pollen shed (top, green) of OSU 880.027 and other hazelnut cultivars (Dec 2011 - Mar 2012).


Female flower stages: RD = Red dot; I = styles protruding $\sim 1-3 \mathrm{~mm}$, straight; FS = First appearance of 'spiders' (reflexed styles), and MS = majority of flowers are in 'spider' stage.
Green = Pollen shed (a minus sign in front of the number indicates the percent of catkins that have already shed out); drop $=50 \%$ catkins dropped Red = Female flowers; red, blk (black), dk (dark, not quite red, not yet black)
$\mathrm{BB}=$ date of leaf budbreak.

FIG. 13A
Phenology Chart 2.' Bloom stage and pollen shed of hazelnut cultivars, pollinizers and selections (Dec 2012-Mar 2013).

|  | Des |  | Jan |  |  |  |  |  | Fab |  |  |  |  |  | March |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Genotype | 21.25 | 26-31 | 4.5 | 6-10 | 11-15 | 16-20 | 21-25 | 26-31 | 1.5 | 6-10 | 11-15 | 16.20 | 21-25 | 26-31 | 1.5 | 6-10 |  |  |
|  | 22-Dec | 30-Dec | 4-Jan | ${ }^{8}$-Jan | 15-Jan | 20-Jan | 25-Jan | 30-Jan | 5-Feb | 10-Feb | 15-Feb | 19-Feb | 25-Feb | $28-\mathrm{Feb}$ | 7-Mar | 11-Mar | 18-Mar | 27-Mar |
| Area 11 |  |  |  |  |  |  |  | wemraty |  |  |  |  |  |  |  |  |  |  |
| T Pacifica |  |  |  | 5 |  |  | 40 | 70 | 100.40 | \$0 |  | Grip |  |  | 88 |  |  |  |
| $(1,2)$ |  | Rd | Rd+3 | Rdh +2 |  |  | Rd/ $/+3$ | 1+3 | 1/5+3 | ms |  |  | ms |  |  |  |  |  |
| 00 |  |  |  |  |  |  | Dork |  |  | Reswert |  |  | Dask |  |  |  |  |  |
| Area 12 (planted 1990) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| TGDL | 30 | 50 | 75 | .90 | -95 |  |  |  |  |  | Grup | 88 |  |  |  |  |  |  |
| ( 2,7$)$ |  | Rd |  | 1+2/S*2 |  |  |  | ms |  | ms | ms |  | ms |  |  |  |  |  |
| R01.05 |  |  |  | Red |  |  |  | Red |  | Redok | Dank |  | Breck |  |  |  |  |  |
| Area 12 (planted 2007) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Yamhill |  |  |  |  |  |  | 1 tst | 25 | 75 | 100.20 | . 00 |  | Grip | 88 |  |  |  |  |
| (8, 26) |  | Rd | Rd +2 | Rd/I | n/c | n/c | Ran +2 | 1+2/S+2 | \%/ | ms |  |  | ms |  |  |  |  |  |
| 109-1 07 |  |  |  | Red |  |  | Rod | 只 |  | Redem |  |  | Brack |  |  |  |  |  |
| Area 17 <br> Dortis |  |  |  |  |  |  |  | 30 | 90 | $100-40$ |  |  |  |  |  |  |  |  |
| $\begin{aligned} & (1,12) \\ & 06 \end{aligned}$ | Rd+3 | Rd $+2 / 1$ |  | Rd |  |  | Rd+3 | 1+3/5 | 1+2/S+2 |  |  |  | ms | ms |  | Grip | BB |  |
|  |  |  |  |  |  |  | Daik |  |  |  |  |  | Okolk | Brack |  |  |  |  |
| $\begin{aligned} & \text { York } \\ & (2, \underline{21}) \end{aligned}$ |  |  |  |  |  |  |  | 1 st | 25 | 75 | 100-30 | . 90 |  | Grto |  |  | 日B |  |
|  | Rd+2 | Rd+3 |  |  |  | Rd+3/1 | $\mathrm{Rd}+2 / 1+2$ | 1+3/5 |  | us +3 |  |  | 1/5+3 |  |  |  |  |  |
| 06 |  |  |  |  |  |  | Dk | Rod |  | D* |  |  | Denk | Brack |  |  |  |  |
| 880.027 |  |  |  |  |  |  |  | 25 | 75 | \$0 |  |  |  | Grtip |  | B8 |  |  |
| $\begin{aligned} & (2,15) \\ & 06 \end{aligned}$ | Rd+2 | Rd+3 |  |  |  | Rd+211 | $\mathrm{Ra} / 1+3$ | 1+2/s+3 | Ms |  | ms |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | Red |  | Red |  | Dank |  |  |  |  |  |  |  |
| $\begin{aligned} & \text { Wepsier } \\ & (1,2) \end{aligned}$ |  |  |  |  |  |  |  | 1ot | 20 | 08 | -80 |  |  | Grtip |  |  | 88 |  |
|  | Rd+3n | Rd+3n |  | Rd +3 n |  |  | Rdan 3 | 1/5+3 |  |  | MS |  |  |  |  |  |  |  |
| 06 |  |  |  | Ped |  |  | Red |  |  |  | Dank |  |  |  |  |  |  |  |

Flower stages: RD = Red dot; I = styles protruding $\sim 1-3 \mathrm{~mm}$, straight; FS = First appearance of 'spiders' or flowers with reflexed styles, and MS = majority of flowers are in 'spider' or fully reflexed stage.
Green = Pollen shed $\{$ a minus sign in front of the number indicates A382the percent of catkins that have already shed out); drop $=50 \%$ catkins dropped Red = Female flowers; red, blk (black), dk (dark, not quite red, not yet black).

FIG. 13B
Phenology Chart 2. Bloom stage and pollen shed of hazelnut cultivars, pollinizers and selections (Dec 2012 - Mar 2013).

|  | Dec |  | Jan |  |  |  |  |  | Feb |  |  |  |  |  | Märch |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 21-25 | 26-31 | $1-5$ | 6-10 | 11-15 | 16-20 | 21-25 | 26-31 | 1.5 | 6-10 | 11-15 | 16-20 | 21-25 | 26-31 | 1-5 | 6-10 |  |  |
| Genotype | 22-Dec | 30-Dec | 4-Jan | 8 -Jan | 15-Jan | 20-Jan | 25-Jan | 30-Jan | 5-Feb | 10-Feb | 15 -Feb | 19-Feb | 25-Fab | 28-Feb | 7-Mar | 11-Mar | 18-Mar | 27-Mar |
| Area 17 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Santiam |  |  |  |  |  |  |  | 65 | 100 |  |  |  |  | Gr ip | S8 |  |  |  |
| (3, 15) |  |  | Rd |  | Rd+2 |  | Rd/1+2 | 1+2/S+2 | 1/S+3 | MS |  |  | MS |  |  |  |  |  |
| 06 |  |  | Oark |  |  |  | dk |  |  | dk |  |  | blk |  |  |  |  |  |
| Yamhill |  |  |  |  |  |  |  | 20 | 60 | 95 | -60 |  | Gr tip |  | B8 |  |  |  |
| ( 8 , 26) | Rd+3 | Rd $+3 / 1$ |  | 1+3/S |  |  | 1+3/s | 1/5+3 | S+3 | MS | MS |  |  |  |  |  |  |  |
| 06 |  |  |  |  |  |  | Red |  |  | Red | Dark |  |  |  |  |  |  |  |
| Jefferson |  |  |  |  |  |  |  |  |  | 40 | 100 | -60 |  |  |  | Gr tip | 88 3/22 |  |
| $(1,3)$ |  |  |  |  | 1st Rd |  |  | Rd+2/1+2 |  | 1+2 |  | 1+3 | 1+2/S+2 | MS |  | MS |  |  |
| 06 |  |  |  |  |  |  |  | Red |  | Red |  | Red/dk | Dark |  |  | Dark |  |  |
| Sacajawea |  |  |  |  |  |  |  | 1st | 20 | 100 | -90 |  | Gr tip | BB |  |  |  |  |
| (1, 22) | $1+3$ |  | 1+3 | 1+3/S+2 |  |  |  | MS |  |  | MS |  | MS |  |  | MS |  |  |
| 06 |  |  | Red |  |  |  |  | Rou |  |  | Oark |  | dkJblk |  |  | Black |  |  |
| Eta / VR |  |  |  |  |  |  |  |  |  |  | 30 | 70 | 100-30 | -80 |  |  | 883/22 |  |
| (11, 26) |  |  |  |  | 1 st Rd |  |  | Rd |  | Rd/ $/+2$ | 1+2/S |  | 1/S+3 |  |  | MS |  |  |
| 06 |  |  |  |  |  |  |  |  |  | Roud |  |  | Fed |  |  | Fedicaik |  |  |
| Theta / VR |  |  |  |  |  |  |  |  |  |  |  |  | 5 | 40 | 75 | 90 | -70 |  |
| $(5,15)$ | 1st Rd |  | Rd |  | Rd+2 |  |  | $\mathrm{Rd} / \mathrm{l}$ |  | 1+3 | 1+3/5 |  |  |  |  | MS | Gr tip | post 3/22 |
| 06 |  |  |  |  |  |  |  |  |  |  | Red |  |  |  |  | Red/Black |  |  |
| A 11 South |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Felix |  |  |  |  |  |  |  |  | 5 | 25 | 80 | 100-40 | . 90 |  | Gr fip |  | 88 3/22 |  |
| (15, 21) | Rd | Rd+2 |  | Rd+3 |  |  | $\mathrm{Rd} / \mathrm{l}$ |  | 1/S+3 |  | MS |  | MS |  |  |  |  |  |
| 107 |  | - - | 1 |  |  |  | Uk | Red | Red/dk |  |  |  | DW/Bik |  |  |  |  |  |

FIG．13C
Phenology Chart 2．Bloom stage and pollen shed of hazelnut cultivars，pollinizers and selections（Dec 2012 －Mar 2013）．

|  | Dec |  | Jan |  |  |  |  |  | Feb |  |  |  |  |  | March |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Genotype | 21－25 | 26－31 | 1－5 | 6－10 | 11.15 | 16－20 | 21－25 | 26－31 | 1－5 | 6－10 | 11－15 | 16－20 | 21－25 | 26－31 | 1.5 | 6－10 |  |  |
|  | 22－Doc | 30－Dec | 4－Jan | 8 －Jan | 15－Jan | 20－Jan | 25－Jan | 30－Jan | 5－Feb | 90－Feb | 15－Feb | 19－Fөb | 25－Feb | 28－Feb | 7－Mar | 11－Mar | 18－Mar | 27－Mar |
| $\begin{aligned} & \text { A11 South } \\ & \text { Jefferson } \end{aligned}$ |  |  |  |  |  |  |  |  | 1 st | 30 | 90 | 100．70 |  |  | Grip |  | 88 3／22 |  |
| $\left(\begin{array}{ll}13\end{array}\right)$ |  |  |  |  |  |  |  | Rd＋3 | Rd＋2／I | 1＋3 | 1＋3／5 | 1＋3／s | 1＋2／s＋2 | 1／8＋3 |  | MS |  |  |
| 07 |  |  |  |  |  |  |  | Red |  | Red |  | Reaidk | Orik |  |  | 8lack |  |  |
| Santiam |  |  |  |  |  |  | 0 | 50 | 100－10 |  |  |  |  |  | Gr tip | 日8 |  |  |
| （3，15） | Rd 1st | Rd |  | Rd＋2 | Rd＋3 | Rd＋3／I |  | 1＋2／s | 1＋2／S＋2 | ms |  | ms |  |  |  |  |  |  |
| 07 |  | Da\％ |  |  |  |  |  |  | Daik |  |  | Black |  |  |  |  |  |  |
| Lewis |  |  |  | 1 st |  |  |  | 40 | 95 | 100.50 | ．90 | Gritip | в8 |  |  |  |  |  |
| （3，8） |  | Rd＋2 |  | $\mathrm{Rd} / 1+2$ |  |  | $\mathrm{Rd} / 1+2$ | 1＋2／S | S＋3 | MS |  | MS | MS |  |  |  |  |  |
| 104－25 |  | 只es |  | Weather cotd |  |  | Red | 足 4 | Red | Row |  | Red | Redtck |  |  |  |  |  |
| Area 17 Jefferson |  |  |  |  |  |  |  |  | 10 | 20 | 85 | 100．30 | ．90 |  |  | Grip | B83120 |  |
| $(1,3)$ |  |  |  |  |  |  |  | Rd／I |  | $\mathrm{Rd} / 1+2$ | 1＋3／S | 1＋2／S＋2 | Ms |  |  | Ms |  |  |
| 09 |  |  |  |  |  |  |  |  |  |  | Redtutin | dk | dk |  |  | Black |  |  |
| Gamma |  |  |  |  |  |  |  | 5 | 85 | $100-40$ | －80 |  |  | Gr tip |  |  | B83／22 |  |
| （2，10） |  |  |  |  |  |  | Rd | $\mathrm{Rd} / 1+2$ | 1＋2／s＋2 |  | 1／5＋3 |  | ms |  |  | MS |  |  |
| 09 |  |  |  |  |  |  |  | Red |  |  | dk |  | Dark |  |  | Black |  |  |
| Yamhill |  |  |  |  |  |  | 1 st | 15 | 80 | 100．20 | －80 |  | Gr lip |  | 88 |  |  |  |
| （8．26） | Rd＋2 | Rd＋2／1 |  | Rd／ $1+3$ | 1＋3 |  |  | 1＋2／S＋2 | S＋3 | Ms |  |  | ms |  |  |  |  |  |
| 09 |  |  |  | Red |  |  |  |  | Red | Da－\％ |  |  | Black |  |  |  |  |  |
| Santiam |  |  |  |  |  |  |  | 30 | 100－10 | －90 |  |  |  |  |  |  |  |  |
| （3，15） |  | Rd |  | Rd | Rd +3 |  |  | 1＋3 | 1＋3／s＋2 | MS |  |  |  |  |  |  |  |  |
| 09 |  |  |  | Da＊＊ |  |  |  |  | Dark | Black |  |  |  |  |  |  |  |  |
| Eta（984．075） |  |  |  |  |  |  |  |  |  |  | 1 st | 30 | 80 | ． 70 | －85 |  | Grtip |  |
| （11．26） |  |  |  |  |  |  |  | Rd |  | $\mathrm{Rd} / 1+2$ | 1＋2／5 | $1+3 / \mathrm{S}$ |  | 1／S＋2 |  | ms | 日B atter | 22－Mar |
| ｜09 |  |  |  |  |  |  |  |  |  | 品枵 |  | Redidk |  | Red |  | Black |  |  |

FIG. 13D
Phenology Chart 2. Bloom stage and pollen shed of hazelnut cultivars, pollinizers and selections (Dec 2012 - Mar 2013 )

|  | Dec |  | Jan |  |  |  |  |  | Feb |  |  |  |  |  | March |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Genotype | 21-25 | 26-31 | 1-5 | 6-10 | 11-15 | 16-20 | 21-25 | 26-31 | 1-5 | 6-10 | 11-15 | 16-20 | 21-25 | 26-31 | 1-5 | 6-10 |  |  |
|  | 22-Dec | 30-Dec | 4-Jan | 8 -Jan | 15-Jan | 20-Jan | 25-Jan | 30-Jan | 5-Feb | 10-Feb | 15-Feb | 19Feb | 25-Feb | 28-Feb | 7-Mar | 11-Mar | 18-Mar | 27-Mar |
| Area 17  <br> Theta (1001.008)  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | 181 | 10 | 50 | 70 | 85 | 100 | Grip | lata BB |
| $\begin{aligned} & \text { Theta (1001.008) } \\ & (5,15) \end{aligned}$ |  |  |  |  |  | Rd |  | Rd | Rd/ | $1+3$ |  |  | 1+3 |  | 1+2/S | 1+3/S |  |  |
| 09 |  |  |  |  |  |  |  |  |  | Danh |  |  | Dark |  |  | Biack |  |  |
| $\left\lvert\, \begin{aligned} & 880.027^{*} \\ & 2,15 \\ & 09 \text { Border } \end{aligned}\right.$ |  |  |  |  |  |  |  | 5 | 70 | 100-40 | -90 |  |  | Grtip |  | B8 |  |  |
|  |  | Rd | $\mathrm{Rd}+3 / 1$ |  |  | $\mathrm{Rd} / 1+2$ | $\mathrm{Rd}+3 / 1+3$ | $1+2 / \mathrm{S}+3$ | S+3 | MS | MS | MS | MS |  |  | MS |  |  |
|  |  |  |  |  |  |  | Red |  |  | Red | Red/dk | Dask | DK/8ilk |  |  | Black |  |  |
| Dorris |  |  |  |  |  |  |  | 1st | 75 | 100-25 | -90 |  |  |  |  | Gr tip | 883/21 |  |
| $\frac{1}{1}, \frac{12}{09}$ |  | Rd |  | Rd+2 | Rd +3 |  | Rd+2/I | 1+2/S |  | MS | Ms |  |  |  |  |  |  |  |
|  |  |  |  |  | dk |  |  | Red |  | Dar: | Black |  |  |  |  |  |  |  |
| $\begin{aligned} & \text { Wepster } \\ & 1.2 \\ & 09 \text { border } \end{aligned}$ |  |  |  |  |  |  |  |  | 10 | 50 | -90 |  |  |  |  | Gr tip | 883/22 |  |
|  | Rd+3 | Rd+2/I |  | Rd | $\mathrm{Rd}+2 / 1+2$ |  | 1+3 | 1+3/S+2 |  | 1/S+3 | MS |  | MS |  |  |  |  |  |
|  |  |  |  |  | Red |  |  | Red |  | Red | Dark |  | Black |  |  |  |  |  |
| NCGR |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Butler |  |  |  |  |  |  |  | 1 st | 40 | 100-20 | -50 | -95 |  |  |  |  |  |  |
| ( 2,3 3) |  |  |  |  | 1st Rd |  | Rd// | 1+2 | 1+2 | 1+2/S+2 | n/c | U/S+3 | MS |  |  |  |  |  |
| N04.18 |  |  |  |  |  |  |  |  | Red |  |  |  | RediDark |  |  |  |  |  |
| Daviana |  |  |  |  |  |  | 1st | 30 | 75 | 100-20 | -80 |  |  |  |  |  |  |  |
| (3, 11) |  |  |  |  |  |  |  | Rd | Rd/ +2 | 1+2/S +2 | $\mathrm{n} / \mathrm{c}$ | vs+3 | MS |  |  |  |  |  |
| N05.20 |  |  |  |  |  |  |  |  | Rod |  |  |  | Fed |  |  |  |  |  |

