Multiple Diseases, Insect Pests Resistant Genotypes and Their Utilization in Breeding for Resistance in Wheat and Triticale

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A total of 347 numbers of genotypes of Triticum aestivum, 66 of T. durum, 8 of T. dicoccum and 18 of triticale possessing resistance against multiple diseases and insect pests resistance were taken for the study. These were identified resistant to biotic stresses through rigorous evaluation under artificially inoculated conditions at hot spot locations in six agro ecological zones of India during 1998-99 till 2011-12 cropping seasons. The diseases and insect pests targeted were three rusts (stem, leaf and stripe rust), Karnal bunt, flag smut, leaf blight, powdery mildew, loose smut, brown wheat mite, root aphid, foliar aphid and shoot fly. The seeds of these genotypes along with passport data on disease resistance were shared with breeders at 30 main wheat and triticale breeding centres in India. The percentage of centres utilized these genotypes for hybridization and resistance breeding ranged from 4.0-63.6%. The per cent utilization was maximum in case of T. aestivum followed by T. durum, T. dicoccum.

Utilization of 18 numbers of triticale genotypes was 4.0-14.8% only. It may be due to lesser preference of triticale as compared to bread and durum wheat for breeding. The major preference of breeders was on genotypes having resistance against three or two rusts depending on agro climatic zones. The genotypes having Lr34 gene which is known for providing resistance to leaf rust were also found to be resistant to other diseases and aphids. The incorporation of resistance genes from resistant genotypes shared in breeding programme has helped greatly in management of diseases and insect pests using host resistance and avoided or reduced application of costly fungicides on wheat and producing pesticide free wheat in India. The deployment of resistant cultivars strategically in areas of prevalence of diseases and insect pests helped to further curtail losses in yield and quality of wheat and outbreak of rusts and other diseases thus ensure food self sufficiency as well as export of surplus wheat in future. These genotypes will be good source for molecular studies related to multiple disease and insect pests.
Agricultural crops benefit from resistance to pathogen that endures over years and generations of both pest and crop. Breeding for resistance to diseases and insect pests in wheat is an important component of crop improvement as well as containing diseases. Over years the deployment of host resistance has helped in countering the threats of epiphytotics of rusts and other diseases in wheat in India. The use of resistant cultivars has been the most effective and easy way to minimize losses due to biotic stresses in wheat. The long-term success of breeding for disease resistance is influenced by the nature of the pathogen and diversity of virulence in the population, availability, diversity and type of genetic resistance, screening methodology and selection environment for tracking resistance (Singh and Rajaram, 2014). Durable disease resistance, which may be partial or complete, can be controlled by several genes. Some of the most devastating fungal pathogens in wheat are leaf rust, stripe rust, and powdery mildew (Krattinger et al., 2009). The breeders are, however, in need of new sources of resistance to incorporate these in the future cultivars to tackle the threat of evolving new virulence of pathogens as well as insect species. The new entries of wheat in yield trials as well as in specific nurseries are tested against major diseases and insect pests at hot spot locations under artificially inoculated conditions and those found resistant consistently over a period of three years are identified and termed as truly resistant in India. Besides resistance to rusts both at seedling and adult stages, these genotypes also possess resistance to other biotic stresses therefore identified as ‘multiple disease and insect pests resistant’. Since 1998-99, such genotypes are shared with breeders of major breeding centres of wheat and triticale in India. In past, listing of sources of resistance against rusts and individual disease have been published (Singh et al., 2001, 2002, 2003a; b, 2004, 2005, 2007, 2008). Khan et al. (2012) found wheat cultivar ‘Cook’ possessing multiple disease resistance genes in Australia. In North Dakota, USA, (Project report, 2014) a project is in operation aiming to characterize the genes/QTLs controlling resistance to three fungal diseases, including Fusarium head blight (FHB), tan spot, and Stagonospora nodorum blotch (SNB), in domesticated emmer wheat, to exploit the novel resistance genes for developing durum wheat germplasm adapted to the Northern Great Plains. The previously identified Persian wheat (Triticum turgidum L. sub sp. carthlicum) and cultivated emmer wheat (T. dicoccum) accessions with resistance to FHB, tan spot, and SNB are being used. The resistance genes are being transferred from some of these accessions into ND durum cultivars using the backcross method coupled with doubled haploid (DH) and single-seed descent (SSD). In West Asia and North Africa (WANA) region, resistance to rusts, septoria leaf blotch, and tan spot is essential. Virulence analysis of leaf rust (Puccinia recondita) showed that ten “Lr” resistance genes (Lr1, Lr2a, Lr6, Lr15, Lr19, Lr24, Lr25, Lr26, Lr28, and Lr29) were effective on bread wheat, six on durum wheat (Lr1, Lr2a, Lr20, Lr25, Lr26, and Lr30), and six among these “Lr” genes were effective on both crop species. Known resistance genes to yellow rust (Puccinia striiformis f.sp. triticici) were evaluated for their effectiveness against yellow rust in Syria, Lebanon, Turkey, Tajikistan, Uzbekistan, Iran, Ethiopia, and Yemen. Four resistance genes to yellow rust “Yr” were effective at all sites (Yr8, Yr9, Yr15, and Yr17). For the diverse climatic conditions and cropping systems in Center West Asia and North Africa (CWANA), the development of multiple disease resistance is essential. Durum wheat breeding nurseries were screened for multiple disease resistance. Genotypes that conferred resistance to combination of foliar diseases were identified (Yahyaoui et al., 2000). The present studies deals with the utilization of multiple disease and insect pests resistant genotypes in breeding for resistance in wheat in India. The spectrum of identified stem rust resistant genes were Sr2+5+7b+8a+8b+9b+9e+10+11+12+13+23+24+26+31 + whereas leaf rust resistant genes were Lr1+5+10+13+23+24+26+34+ in genotypes having resistance to rusts and other diseases as well as insect pests. Likewise stripe rust resistant genotypes were Yr2+3+7b+9+18+27+.

MATERIALS AND METHODS

A total of 347 numbers of genotypes of Triticum aestivum, 66 of T. durum, 8 of T. dicoccum and 18 of Triticale were identified possessing multiple disease and insect pests resistance through rigorous screening of these under artificially inoculated conditions and epiphytotics of diseases at hot spot locations in six agro ecological zones of India during 1998-99 till 2011-12 crop seasons. The diseases and insect pests against which these were resistant were stem rust (Puccinia graminis Pers.), leaf rust (Puccinia triticici Eriks.), stripe rust (Puccinia striiformis Westend.), Karnal bunt (Tilletia indica Mitra), flag smut (Urocystis agropyri Preuss A.A. Fisch. Waldh.), leaf blight (Bipolaris sorokiniana Sacc. Shoemaker), powdery mildew (Erysiphe graminis f. sp. tritici E.J. Marchal), loose smut (Ustilago tritici Pers. C.N. Jensen Kellerm. & Swingle), brown wheat mite (Petrobia lateens Müller), root aphid (Tetraneura nigrabdominalis Sasaki), foliar aphid (Macrosiphum miscanthi Tak., and shoot fly (Atherigona naqvii Steyskal). The average coefficient of rusts was always ranging from 0-10 in rust resistant genotypes. The level of resistance to other diseases and insect pests was determined according to standard procedures followed in All India Coordinated Wheat and Barley Improvement Programme (Sharma et al., 2012). The gene postulation for rust resistance was done at DWR RS Flowerdale, Shimla and data belonging to it were reproduced. The seeds of these genotypes along
with passport data on disease resistance were shared with breeders at 30 main wheat and Triticale breeding centres through ‘National Plant Genetic Stock Nursery’ (NPSN). The percentage of centres utilized for each genotype was calculated.

RESULTS AND DISCUSSION

The passport data related to resistance to different biotic stresses, pedigree and percentage of centres utilized for a particular genotype in breeding for resistance during 1998-99 till 2011-12 are presented in Table 1 . Amongst three species, the genotypes of *T. aestivum* were preferred for use in breeding for disease resistance at different centres. Forty six genotypes of *T. aestivum*, out of 347 were utilized at centres in the range of 33.3-63.6%. These were, ‘DBW 18’, ‘DBW 32’, ‘GW 276’, ‘HD 2851’, ‘HD 2964’, ‘HD 2997’, ‘HW 2044’, ‘HW 3027’, ‘HPW 42’, ‘HPW 155’, ‘HPW 237’, ‘HPW 285’, ‘HUW 620’, ‘HS 295’, ‘HS 318’, ‘HS 345’, ‘HS 375’, ‘HS 420’, ‘HS 468’, ‘HS 493’, ‘HW 2045’, ‘HW 3083’, ‘HW 5037’, ‘HW 5208’, ‘K 9351’, ‘K 9441’, ‘MACS 295’, ‘MACS 2959’, ‘NW 3087’, ‘NW 1012’, ‘PBW 373’, ‘PBW 475’, ‘PBW 521’, ‘PBW 550’, ‘PBW 554’, ‘PBW 573’, ‘PBW 589’, ‘Raj 3765’, ‘Raj 4012’, ‘RAJ 4120’, ‘RAJ 4131’, ‘UP 2425’, ‘UP 2719’, ‘VL 801’, ‘VL 868’ and ‘VL 907’. In case of *T. durum*, 66 genotypes were utilized by 4.0-36% centres. However, only eight genotypes, ‘AKDW 4155’, ‘CDW 04’, ‘GW 1139’, ‘HI 8498’, ‘MACS 3313’, ‘PDW 267’ and ‘PDW 312’ were preferred (18.0-36.0%) better than others in breeding programme at centres. Eight genotypes of *T. dicoccum*, were utilized in the range of 4.0-32% at centres with maximum utilization of ‘MACS 2956’ (32.0%) and ‘MACS 2971’ (15.0%). Eighteen genotypes of triticale were used at centres in the resistance breeding and range was 4.0-14.8% only. Only six numbers of triticale genotypes, ‘TL 2959’, ‘TL 2966’, ‘TL 2915’, ‘TL 2930’, ‘DT 132’ and ‘HPT 6’ were used in the range of 10-14.8% centres. It may be due to lesser preference of triticale as compared to bread and durum wheat for breeding at thirty centres. The major preference of breeders was on genotypes having resistance against three or two rusts depending on agro climatic zones (Table1). Gurung et al. (2011) evaluated 633 winter wheat accessions for multiple resistance against leaf blight pathogens and found only fifty-six accessions were resistant to three or more diseases, and of these, five (‘Citr16595’, ‘PI 278612’, ‘PI 351330’, ‘PI 361858’, and ‘PI 351983’) were resistant to all four diseases. The disease targeted were Tan spot (TS, caused by *Pyrenophora tritici-repentis*), Stagonospora nodorum blotch (SNB, caused by *Phaeosphaeria nodorum*), spot blotch (SB, caused by *Cochliobolus sativus*), and Septoria tritici blotch (STB, caused by *Mycosphaerella graminicola*). These multiple disease resistance sources will be useful in wheat breeding programs. In another study, the cultivar ‘Cook’ was found to have multiple disease resistance genes for leaf and stripe rusts, powdery mildew and Karnal bunt (Khan et al., 2012). Ogbonnaya et al. (2008) tested a collection of 253 synthetic hexaploid wheats (SHWs) produced from 192 *Aegilops tauschii* accessions and 39 elite durum varieties to identify, characterise, and evaluate potentially untapped diversity of disease resistance in wheat. The diseases for which resistance was sought included cereal cyst nematode (CCN), root lesion nematode (RLN), *Stagonospora nodorum* blotch (SNB), *Septoria tritici* blotch (STB), and leaf, stem and stripe ruts. Five SHWs, ‘Aus26860’, ‘Aus30258’, ‘Aus30294’, ‘Aus30301’, and ‘Aus30304’, exhibited high levels of resistance to either 3 or 4 diseases. For the diverse climatic conditions and cropping systems in Center West Asia and North Africa (CWANA), the development of multiple disease resistance is essential. Durum wheat breeding nurseries were screened for multiple disease resistance. Genotypes that conferred resistance to combination of foliar diseases, were identified (Al Naimi et al., 2000). The development of wheat genetic maps based on microsatellite (SSR) markers is giving researchers an unprecedented view into genome organization and breeding population structure. When this DNA-based technology is coupled with phenotypic data, QTL analysis and trait mapping are facilitated. This ultimately enables design of experiments to assemble complex genotypes that pyramid multiple traits (Somers et al., 2007). Out of 64 genotypes of Indian origin tested, ‘EGPSN 137’, ‘EGPSN-143’, ‘EGPSN-152’, ‘EGPSN-153’, ‘EGPSN-157’, ‘K-68’, and ‘Halna’ showed the presence of potential resistant genes viz., Lr46 and Sr2 based on linked SSR markers and were resistant to all the prevailing races of leaf rust and stem rust thus termed as ‘multiple rust resistant’ genotypes (Sharma and Sharma, 2014).

The rust resistant gene (*Lr34*) was found associated not only providing resistance against leaf rust but also other fungal diseases like spot blotch, Karnal bunt, powdery mildew, loose smut, flag smut and insect pests like foliar and root aphids during present study (Table 1). Such genotypes having multiple disease and insect pests resistance and *Lr34* gene were ‘HD 2501’, ‘HD 2733’, ‘HPW 42’, ‘HPW 185’, ‘HPW 191’, ‘HS 240’, ‘HS 295’, ‘HS 375’, ‘HS 420’, ‘K 9107’, ‘PBW 550’, ‘VL 738’, ‘VL 803’, ‘VL 804’, ‘VL 818’, ‘VL 829’, ‘VL 832’ and ‘VL 852’ in case of *T. aestivum*. Earlier also *Lr34* gene has been reported to have some linkages with other genes providing resistance to other fungal disease in wheat (Risk et al., 2013).

The multiple resistant genotypes identified in India may serve as an important source of resistant genes for future resistance breeding as well as for genetic and molecular studies in future and may be tested against those pathogens not yet entered in India. These seeds have been stored in gene bank at DWR Karnal and NBPGR New Delhi. These may also serve as important sources for resistance for breeding resistant varieties in other countries. Many of these seeds are featuring in the pedigree of varieties recently promoted
in evaluation trials and also released in India by central as well as state varietal release committees. Such varieties are supposed to minimize losses in wheat and triticale yields further due to diseases in future.

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REFERENCES


Table 1: Multiple disease and insect pests resistant genotypes and their passport data on the resistance in wheat and Triticale utilized by centres during 1998-99 till 2011-12 cropping seasons

<table>
<thead>
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<th>S. No.</th>
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<tr>
<td></td>
<td></td>
<td>Sr</td>
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<td>Yr</td>
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<td>51</td>
<td>'HD 2957'</td>
<td>24+2+</td>
<td>24+</td>
<td>IWP72/165/HW741///HW 741</td>
<td>SR, LR, FS, BWM</td>
</tr>
<tr>
<td>53</td>
<td>'HD 2962'</td>
<td>13+</td>
<td>26+</td>
<td>PBW 343/2//KUNIK</td>
<td>Three rusts</td>
</tr>
<tr>
<td>54</td>
<td>'HD 2963'</td>
<td>13+</td>
<td>26+</td>
<td>PBW 343/2//KONK</td>
<td>Three rusts</td>
</tr>
<tr>
<td>55</td>
<td>'HD 2964'</td>
<td>31+</td>
<td>26+23+</td>
<td>PBW 343/2//KHAVAKI</td>
<td>Three rusts</td>
</tr>
<tr>
<td>56</td>
<td>'HD 2978'</td>
<td>23+1+</td>
<td>-</td>
<td>HD 2705/DL 788-2</td>
<td>Three rusts, PM, KB</td>
</tr>
<tr>
<td>58</td>
<td>'HD 2987'</td>
<td>2+</td>
<td>24+</td>
<td>HI1011/HW2348//MENDOS/WP72/DL153-2</td>
<td>Three rusts, FS</td>
</tr>
<tr>
<td>59</td>
<td>'HD 2997'</td>
<td>31+2+</td>
<td>26+23+10+</td>
<td>BOW//HD 2285//HD 2444</td>
<td>Three rusts</td>
</tr>
<tr>
<td>60</td>
<td>'HD 2998'</td>
<td>8a+</td>
<td>23+</td>
<td>RL6010/6/YR70/3*SERI82</td>
<td>Three rusts</td>
</tr>
<tr>
<td>61</td>
<td>'HD 3007'</td>
<td>-</td>
<td>-</td>
<td>HW2002//CPAN2044//EC414149</td>
<td>Three rusts, KB, FS</td>
</tr>
<tr>
<td>63</td>
<td>'HI 1454'</td>
<td>2+</td>
<td>13+</td>
<td>-</td>
<td>SR, LR</td>
</tr>
<tr>
<td>64</td>
<td>'HI 1462'</td>
<td>11+</td>
<td>-</td>
<td>Raj 1972/Raj 1923</td>
<td>SR, LR, KB, LB, FS, FA, BWM</td>
</tr>
<tr>
<td>65</td>
<td>'HI 1462'</td>
<td>-</td>
<td>13+</td>
<td>-</td>
<td>SR, LR, KB, LB, FS, FA, BWM</td>
</tr>
<tr>
<td>66</td>
<td>'HI 1498'</td>
<td>-</td>
<td>-</td>
<td>NID96-46/HW2449/RAJ3160</td>
<td>Three rusts, LB</td>
</tr>
<tr>
<td>67</td>
<td>'HI 1514'</td>
<td>2+</td>
<td>-</td>
<td>HDR162/DA17</td>
<td>LR, YR</td>
</tr>
<tr>
<td>68</td>
<td>'HI 1531'</td>
<td>2+</td>
<td>-</td>
<td>HI 1182//CPAN 1990</td>
<td>SR, LR, FS, RA</td>
</tr>
<tr>
<td>69</td>
<td>'HI 1544'</td>
<td>2+</td>
<td>-</td>
<td>HINDI 62//BOB WHITE//CPAN 2099</td>
<td>SR, LR, FS, RA</td>
</tr>
<tr>
<td>70</td>
<td>'HI 1552'</td>
<td>-</td>
<td>-</td>
<td>HW 3260/MACS 2496</td>
<td>Three rusts</td>
</tr>
<tr>
<td>71</td>
<td>'HI 1560'</td>
<td>31+</td>
<td>26+</td>
<td>SKAUZ*2/FCT</td>
<td>SR, LR</td>
</tr>
<tr>
<td>72</td>
<td>'HI 1571'</td>
<td>-</td>
<td>-</td>
<td>LIRA<em>2//RRI</em>S/TONI</td>
<td>LR, YR, SF</td>
</tr>
<tr>
<td>73</td>
<td>'HP 1761'</td>
<td>31+</td>
<td>26+</td>
<td>RL6010/6/INIA 66/3*KAUZ</td>
<td>Three rusts, LB, FA</td>
</tr>
<tr>
<td>74</td>
<td>'HP 1782'</td>
<td>31+</td>
<td>26+</td>
<td>HUW2002/KS-64-KL REND//HD1944/3/RAJ 3077</td>
<td>Three rusts, RA</td>
</tr>
<tr>
<td>75</td>
<td>'HP 1911'</td>
<td>5+</td>
<td>23+10+</td>
<td>PBW 343/RAJ 3777//WH 736</td>
<td>Three rusts, RA</td>
</tr>
<tr>
<td>76</td>
<td>'HW 2017'</td>
<td>-</td>
<td>2+</td>
<td>HD2402//TR38014*7/3AG14</td>
<td>SR, LR</td>
</tr>
<tr>
<td>77</td>
<td>'HW 2044'</td>
<td>2+</td>
<td>-</td>
<td>SUNSTAR 16/C 80-116/PBW 226</td>
<td>SR, LR, LB, KB</td>
</tr>
<tr>
<td>78</td>
<td>'HW 2045'</td>
<td>2+</td>
<td>-</td>
<td>SUNS-AR/6e80-1/5/HW2402</td>
<td>Three rusts</td>
</tr>
<tr>
<td>79</td>
<td>'HW 3007'</td>
<td>31+</td>
<td>26+</td>
<td>UNAATH KAL/VEE*5</td>
<td>Three rusts, LB, PM, FS</td>
</tr>
<tr>
<td>80</td>
<td>'HW 3024'</td>
<td>2+</td>
<td>-</td>
<td>PBW226//TR380-14*-14*7/3AG74</td>
<td>SR, LR, KB</td>
</tr>
<tr>
<td>N</td>
<td>Code</td>
<td>Traits</td>
<td>Resistance</td>
<td>Source</td>
<td>Yield</td>
</tr>
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<td>--------</td>
<td>------------</td>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>81</td>
<td>'HW 3027'</td>
<td>2+</td>
<td>-</td>
<td>HD2285/HW1042</td>
<td>SR, LR, KB, FS</td>
</tr>
<tr>
<td>82</td>
<td>'HW 3061'</td>
<td>2+9e+12+</td>
<td>-</td>
<td>CPAN6120/CPAN6093</td>
<td>SR, LR</td>
</tr>
<tr>
<td>83</td>
<td>'HW 3064'</td>
<td>-</td>
<td>-</td>
<td>K.SONA/'YR'6/WRT2385/TR38014^7/3AG14</td>
<td>SR, LR</td>
</tr>
<tr>
<td>84</td>
<td>'HW 3067'</td>
<td>2+</td>
<td>-</td>
<td>HW1042/C306</td>
<td>SR, LR, PM, CCN</td>
</tr>
<tr>
<td>85</td>
<td>'HW 3070'</td>
<td>-</td>
<td>-</td>
<td>HI1077/HW1042/C306</td>
<td>SR, LR, FS</td>
</tr>
<tr>
<td>86</td>
<td>'HW 3080'</td>
<td>-</td>
<td>-</td>
<td>UKS/BW1109</td>
<td>SR, LR, FS</td>
</tr>
<tr>
<td>87</td>
<td>'HW 3083'</td>
<td>31+</td>
<td>-</td>
<td>BOW//BUC/BUL/CLRP-6</td>
<td>Three rusts, KB, FA, RA</td>
</tr>
<tr>
<td>88</td>
<td>'HW 3087'</td>
<td>2+</td>
<td>-</td>
<td>HW1042/C306</td>
<td>SR, LR, FS</td>
</tr>
<tr>
<td>89</td>
<td>'HPW 4028'</td>
<td>-</td>
<td>-</td>
<td>PBW 226^5/C66-8/KALYANSONA F4</td>
<td>LR, YR</td>
</tr>
<tr>
<td>90</td>
<td>'HPW 42'</td>
<td>31+</td>
<td>26+1+34+</td>
<td>VEE'S/4/PVN 'S'/CBB//CNO&quot;S&quot;-/3/JAR/ORZ&quot;S&quot;</td>
<td>Three rusts</td>
</tr>
<tr>
<td>91</td>
<td>'HPW 147'</td>
<td>2+</td>
<td>13+</td>
<td>CPAN1869/HIMIO-BA (WS)</td>
<td>LR, YR, KB, MR to LB</td>
</tr>
<tr>
<td>92</td>
<td>'HPW 155'</td>
<td>-</td>
<td>13+</td>
<td>BT 2594/FATH</td>
<td>Three rusts, FS</td>
</tr>
<tr>
<td>93</td>
<td>'HPW 184'</td>
<td>2+31+</td>
<td>26+1+</td>
<td>ATTILA</td>
<td>MR to LB, KB, FA</td>
</tr>
<tr>
<td>94</td>
<td>'HPW 185'</td>
<td>-</td>
<td>26+34+</td>
<td>UPT74303/S308//CPAN1830//TL68/HS74//3/CP AN1922</td>
<td>Three rusts, LB, FS</td>
</tr>
<tr>
<td>95</td>
<td>'HPW 191'</td>
<td>-</td>
<td>26+34+</td>
<td>CPAN1869/HB208</td>
<td>Three rusts, FS, PM</td>
</tr>
<tr>
<td>96</td>
<td>'HPW 217'</td>
<td>31+5+2+</td>
<td>26+23+</td>
<td>HPW 42 /IBWSN 52</td>
<td>Three rusts, MR to LB</td>
</tr>
<tr>
<td>97</td>
<td>'HPW 224'</td>
<td>2+</td>
<td>23+</td>
<td>WW 4/LEHMI P-1</td>
<td>Three rusts, MR to LB</td>
</tr>
<tr>
<td>98</td>
<td>'HPW 232'</td>
<td>31+5+</td>
<td>26+23+</td>
<td>264#112K99-247</td>
<td>LR, YR, PM</td>
</tr>
<tr>
<td>99</td>
<td>'HPW 237'</td>
<td>-</td>
<td>23+13-3+</td>
<td>WW 711/PGS 990/VL 780</td>
<td>KB, FS, RA</td>
</tr>
<tr>
<td>100</td>
<td>'HPW 240'</td>
<td>-</td>
<td>23+10</td>
<td>W W 24XLEHMI PI</td>
<td>Three rusts, PM</td>
</tr>
<tr>
<td>101</td>
<td>'HPW 244'</td>
<td>31+</td>
<td>26+4</td>
<td>W W 24XLEHMI (O)</td>
<td>Three rusts, PM</td>
</tr>
<tr>
<td>102</td>
<td>'HPW 251'</td>
<td>31+</td>
<td>26+3+</td>
<td>WW 24/LEHMI-P2</td>
<td>RA, FS</td>
</tr>
<tr>
<td>103</td>
<td>'HPW 254'</td>
<td>31+5+</td>
<td>26+3+</td>
<td>WW 24/LEHMI P2-U 149</td>
<td>LR, YR, MR to LB</td>
</tr>
<tr>
<td>104</td>
<td>'HPW 298'</td>
<td>-</td>
<td>13+1+</td>
<td>PUNJAB 96</td>
<td>Three rusts, FS, FA, MR to LB</td>
</tr>
<tr>
<td>105</td>
<td>'HUW 468'</td>
<td>2+</td>
<td>13+</td>
<td>CPAN1869/HIMIO-BA LR, YR, MR to LB</td>
<td>13.7</td>
</tr>
<tr>
<td>106</td>
<td>'HUW 510'</td>
<td>2+</td>
<td>24+</td>
<td>HD2287/HUW234/DL230-16</td>
<td>SR, LR, FS</td>
</tr>
<tr>
<td>107</td>
<td>'HUW 555'</td>
<td>5+</td>
<td>13+</td>
<td>RAJ 3879/HD 2733/HUW 395</td>
<td>LR, YR, MR to LB</td>
</tr>
<tr>
<td>108</td>
<td>'HUW 564'</td>
<td>-</td>
<td>-</td>
<td>BOW S'/URES/HUW 300/PRL</td>
<td>KR, YR</td>
</tr>
<tr>
<td>109</td>
<td>'HUW 567'</td>
<td>31+5+</td>
<td>26+23+</td>
<td>HD 2189/HUW 234/HUW 284/HUW 300</td>
<td>Three rusts, LB, KB</td>
</tr>
<tr>
<td>110</td>
<td>'HUW 571'</td>
<td>2+</td>
<td>13+3+</td>
<td>CPAN 1796/CPAN 1922</td>
<td>SR, LR, FS</td>
</tr>
<tr>
<td>111</td>
<td>'HUW 580'</td>
<td>2+</td>
<td>13+</td>
<td>CPAN1869/HIMIO-BA</td>
<td>LR, YR, MR to LB</td>
</tr>
<tr>
<td>112</td>
<td>'HUW 584'</td>
<td>-</td>
<td>-</td>
<td>HD2278/HUW234/DL230-16</td>
<td>SR, LR, FS</td>
</tr>
<tr>
<td>113</td>
<td>'HUW 700'</td>
<td>5+</td>
<td>13+</td>
<td>ATTTILA/RAJ 3765//HUW 280</td>
<td>Three rusts</td>
</tr>
<tr>
<td>114</td>
<td>'HUW 709'</td>
<td>5+</td>
<td>13+</td>
<td>RAJ 3879/HD 2733/HUW 395</td>
<td>SR, YR, FS, LB</td>
</tr>
<tr>
<td>115</td>
<td>'HUW 731'</td>
<td>2+</td>
<td>13+</td>
<td>CPAN 1869/HIMIO-BA</td>
<td>LR, YR, MR to LB</td>
</tr>
<tr>
<td>116</td>
<td>'HUW 795'</td>
<td>-</td>
<td>26+10+</td>
<td>KAUZ/ALTARB4/AOS/3/MILAN/KAUZ/4/HUIITE S</td>
<td>Three rusts</td>
</tr>
<tr>
<td>117</td>
<td>'HUW 820'</td>
<td>31+</td>
<td>26+10+</td>
<td>264#112K99-247</td>
<td>LR, YR, MR to LB</td>
</tr>
<tr>
<td>118</td>
<td>'HUW 826'</td>
<td>-</td>
<td>26+</td>
<td>GW291//PRL/VEE#10/3/WH542</td>
<td>Three rusts</td>
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<tr>
<td>119</td>
<td>'HUW 833'</td>
<td>5+</td>
<td>-</td>
<td>UKS//VER'S'</td>
<td>Three rusts, FS</td>
</tr>
<tr>
<td>ISN</td>
<td>Variety</td>
<td>Rating</td>
<td>Reaction</td>
<td>Disease</td>
<td>Source</td>
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<td>-------</td>
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<td>----------</td>
<td>---------</td>
<td>--------</td>
</tr>
<tr>
<td>127</td>
<td>'HW 3082'</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>128</td>
<td>'HS 240'</td>
<td>31+2+</td>
<td>26+34+</td>
<td>9+18+</td>
<td>AU/KAL/BB/WOP'S/PVN'S&quot;</td>
</tr>
<tr>
<td>129</td>
<td>'HS 295'</td>
<td>2+8b+</td>
<td>23+34+</td>
<td>3+18+</td>
<td>COT/\A/IAS 55/ALD'S/NAFN4/PIN'S/PEN SL 127</td>
</tr>
<tr>
<td>130</td>
<td>'HS 318'</td>
<td>31+</td>
<td>26+</td>
<td>9+</td>
<td>HUW206/HUW202</td>
</tr>
<tr>
<td>131</td>
<td>'HS 345'</td>
<td>31+</td>
<td>26+23+1+</td>
<td>9+</td>
<td>GH'S/SONO++ARI MR to LB 36.5</td>
</tr>
<tr>
<td>132</td>
<td>'HS 364'</td>
<td>2+8b+9b+11+</td>
<td>13+10+1+</td>
<td>2(KA)+</td>
<td>NA/C/S1/Y63/AGEL/ANZA/4/BOW'S/CEP778 0=ARA Three rusts, FS, 40.9</td>
</tr>
<tr>
<td>133</td>
<td>'HS 365'</td>
<td>31+2+</td>
<td>26+1+</td>
<td>9+</td>
<td>HS207/SKA</td>
</tr>
<tr>
<td>134</td>
<td>'HS 369'</td>
<td>9b+11+</td>
<td>13+1+</td>
<td>-</td>
<td>HD2385/BRSN27/HS208</td>
</tr>
<tr>
<td>135</td>
<td>'HS 375'</td>
<td>31+5+2+</td>
<td>26+34+</td>
<td>9+18+</td>
<td>BB/G11/CJ71/TAESI//KAL/BB Three rusts, KB, RA, MR to LB 45.5</td>
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<tr>
<td>136</td>
<td>'HS 420'</td>
<td>2+</td>
<td>13+</td>
<td>1+</td>
<td>LAJ 3302/CMH 73A-497/3*CN 079 Three rusts 40.9</td>
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<tr>
<td>137</td>
<td>'HS 424'</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>CPAN 3004//HPW(di) 30/HS286 Three rusts 13.6</td>
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<tr>
<td>138</td>
<td>'HS 431'</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>V81623//BUC/PVN</td>
</tr>
<tr>
<td>139</td>
<td>'HS 443'</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>MILAN/SHAT</td>
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<tr>
<td>140</td>
<td>'HS 455'</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>ALTAR 84/AC.SQUAROSSA219//2*SERI SR, LR, MR to LB 4.5</td>
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<tr>
<td>141</td>
<td>'HS 456'</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>CON 79/4/CS/TH.CN//CH.CEN/3/ALD/PVN/5/GISVZ</td>
</tr>
<tr>
<td>142</td>
<td>'HS 459'</td>
<td>31+2+</td>
<td>26+23+1+</td>
<td>9+</td>
<td>MILAN/SHAT</td>
</tr>
<tr>
<td>143</td>
<td>'HS 460'</td>
<td>11+2+</td>
<td>13+</td>
<td>-</td>
<td>BOW//BUC//BUL//CLRP-6 Three rusts, LB, KB 24.0</td>
</tr>
<tr>
<td>144</td>
<td>'HS 461'</td>
<td>31+2+</td>
<td>26+23+1+</td>
<td>9+</td>
<td>NA/C/S1/Y63/AGEL/ANZA/4/BOW'S/CEP778 0=ARA Three rusts, FS, 40.9</td>
</tr>
<tr>
<td>145</td>
<td>'HS 468'</td>
<td>31+</td>
<td>26+</td>
<td>9+</td>
<td>HS 435/HS 277</td>
</tr>
<tr>
<td>146</td>
<td>'HS 471'</td>
<td>-</td>
<td>23+1+</td>
<td>2+</td>
<td>MUNIA/MILAN</td>
</tr>
<tr>
<td>147</td>
<td>'HS 472'</td>
<td>31+2+</td>
<td>-</td>
<td>9+</td>
<td>WRM/4/FN/3'TH/K58/2*N3/AUS6889/5PEL/2380/1ATR/1/6/SHA/SERI/SHA4/LRIA Three rusts, LB, KB 31.8</td>
</tr>
<tr>
<td>148</td>
<td>'HS 473'</td>
<td>5+</td>
<td>3+</td>
<td>-</td>
<td>ZIDANE 89/3/PEG'S'/HD 2206/HORK'S Three rusts, FS 22.7</td>
</tr>
<tr>
<td>149</td>
<td>'HS 484'</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>CNO79/4/CS/TH.CN//GLEN/3/ALD/PVN/5/GIS</td>
</tr>
<tr>
<td>150</td>
<td>'HS 485'</td>
<td>31+2+</td>
<td>26+23+1+</td>
<td>9+</td>
<td>HD 2380/HS 364</td>
</tr>
<tr>
<td>151</td>
<td>'HS 490'</td>
<td>-</td>
<td>23+</td>
<td>-</td>
<td>HS 364/HPW 114//HS 240/HS 346</td>
</tr>
<tr>
<td>152</td>
<td>'HS 493'</td>
<td>31+</td>
<td>26+23+1+</td>
<td>9+</td>
<td>HPW42/VL755</td>
</tr>
<tr>
<td>154</td>
<td>'HS 507'</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>KAUZ/MYANA/VUL//BUC/FLK/4/MILAN</td>
</tr>
<tr>
<td>155</td>
<td>'HS 510'</td>
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<td>31+</td>
<td>26+</td>
<td>9+</td>
<td>F6KB 90//PBW 343</td>
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<tr>
<td>250</td>
<td>'PBW 568'</td>
<td>31+</td>
<td>26+</td>
<td>9+</td>
<td>W 485//PBW 343//HD 2160</td>
</tr>
<tr>
<td>251</td>
<td>'PBW 570'</td>
<td>31+</td>
<td>26+</td>
<td>9+</td>
<td>PBW 457//W 9217</td>
</tr>
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<tr>
<td>252</td>
<td>'PBW 573'</td>
<td>31+2+</td>
<td>26+</td>
<td>9+</td>
<td>WH 594/RAJ 3814</td>
</tr>
<tr>
<td>253</td>
<td>'PBW 574'</td>
<td>31+</td>
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<td>9+</td>
<td>HD 2643/CS/AE, Sq.</td>
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<tr>
<td>254</td>
<td>'PBW 580'</td>
<td>31+</td>
<td>26+23+1+</td>
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<tr>
<td>255</td>
<td>'PBW 582'</td>
<td>31+5+</td>
<td>26+</td>
<td>9+</td>
<td>PBW 343/PBW 346</td>
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<tr>
<td>256</td>
<td>'PBW 583'</td>
<td>31+5+</td>
<td>26+23+</td>
<td>9+</td>
<td>CPAN 3048/DL 788-2</td>
</tr>
<tr>
<td>257</td>
<td>'PBW 585'</td>
<td>31+5+1+</td>
<td>26+23+</td>
<td>9+</td>
<td>PBW 342/HD 2652</td>
</tr>
<tr>
<td>258</td>
<td>'PBW 586'</td>
<td>31+5+</td>
<td>26+23+</td>
<td>9+</td>
<td>PBW 443/PBW 470</td>
</tr>
<tr>
<td>259</td>
<td>'PBW 588'</td>
<td>31+5+</td>
<td>26+23+1+</td>
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<td>RL0543/RAJ 3765</td>
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<tr>
<td>260</td>
<td>'PBW 590'</td>
<td>31+5+</td>
<td>26+23+</td>
<td>9+</td>
<td>WH581/PBW346//CC527</td>
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<tr>
<td>261</td>
<td>'PBW 599'</td>
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<td>HD 2643//CS/AE. Sq. SR, LR 20.0</td>
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<tr>
<td>262</td>
<td>'PBW 610'</td>
<td>31+5+</td>
<td>26+23+1+</td>
<td>9+</td>
<td>WH 581/PBW 346//CC527</td>
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<td>263</td>
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<td>-</td>
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<td>W 9931/PBW 373/PBW 495</td>
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<td>265</td>
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<td>NIW 34/BAU/KAUZ</td>
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<td>266</td>
<td>'PBW 622'</td>
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<td>27+</td>
<td>KAUZ/ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES</td>
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<td>267</td>
<td>'PBW 629'</td>
<td>31+</td>
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<td>CHIL/ALD//JUP/COC/3/PVN/4/GEN/5 /KAUZ/CHO//BUC</td>
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<td>268</td>
<td>'RAJ 3765'</td>
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<td>13+10+</td>
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<td>269</td>
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<td>271</td>
<td>'RAJ 4012'</td>
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<td>272</td>
<td>'RAJ 4027'</td>
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<td>273</td>
<td>'RAJ 4028'</td>
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<td>274</td>
<td>'RAJ 4083'</td>
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<td>RAJ 3777/WR 413</td>
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<td>275</td>
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<td>276</td>
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<td>279</td>
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<td>-</td>
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<tr>
<td>280</td>
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<td>2+</td>
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<td>-</td>
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<tr>
<td>281</td>
<td>'RAJ 4132'</td>
<td>24+</td>
<td>24+</td>
<td>-</td>
<td>RAJ 3777/WH 671</td>
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<td>282</td>
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<td>23+</td>
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<td>284</td>
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<td>26+23+1+</td>
<td>9+</td>
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<td>286</td>
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<td>-</td>
<td>PBW 352/CPAN 4020</td>
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<td>DL 802-1/RAJ 3077</td>
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<tr>
<td>289</td>
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<td>-</td>
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<td>'UP 2600'</td>
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<td>23+</td>
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<tr>
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<tr>
<td>No.</td>
<td>Variety</td>
<td>Symbol</td>
<td>Hybrid(s)</td>
<td>Crosses</td>
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<td>296</td>
<td>'UP 2632'</td>
<td>31+26+23+1+9+</td>
<td>TR 380/UP 2435</td>
<td>LB, KB, FS</td>
<td>32.0</td>
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<tr>
<td>297</td>
<td>'UP 2642'</td>
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<td>PBW 352/WH 592</td>
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<td>22.6</td>
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<td>298</td>
<td>'UP 2687'</td>
<td>11+13</td>
<td>[NAC3/STW163/AGEL/ANZA/4/-BOW &quot;S&quot; /CEP 7786/HPW 42</td>
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<td>299</td>
<td>'UP 2691'</td>
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<td>UP 2377/WH 11085</td>
<td>SR, LR, FS, KB, LB</td>
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<tr>
<td>300</td>
<td>'UP 2696'</td>
<td>31+26+23+1+9+</td>
<td>CDWR 9510/NW 1027</td>
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<td>301</td>
<td>'UP 2719'</td>
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<td>CPAN 3048/RH 3766</td>
<td>Three rusts, KB, FS</td>
<td>37.0</td>
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<tr>
<td>302</td>
<td>'UP 2747'</td>
<td>13+13+</td>
<td>MILAN/KAUZ/PRINIA/S/BABAX</td>
<td>Three rusts, PM</td>
<td>15.0</td>
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<tr>
<td>303</td>
<td>'UAS 295'</td>
<td>-</td>
<td>SNITRAP^3/SEV 92</td>
<td>Three rusts, KB, SF</td>
<td>17.3</td>
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<tr>
<td>304</td>
<td>'UAS 305'</td>
<td>31+26+23+9+</td>
<td>CMH 9483379/CMH 78578/MILAN/HD 2189</td>
<td>Three rusts, KB, FS</td>
<td>20.0</td>
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<tr>
<td>305</td>
<td>'UAS 419'</td>
<td>9+23+</td>
<td>GAL 31/BOOMER-20/BANSI/DWR1006</td>
<td>LR to YR, H to SR, LR</td>
<td>10.0</td>
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<tr>
<td>306</td>
<td>'VL 738'</td>
<td>-</td>
<td>NS 12.07/LIRA &quot;S&quot;/REE &quot;S&quot;</td>
<td>LR, YR, FS, MR to LB</td>
<td>27.3</td>
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<tr>
<td>307</td>
<td>'VL 796'</td>
<td>11+13+34+</td>
<td>WEMBABLY/V 404</td>
<td>Three rusts, LB, PM, KB, FS</td>
<td>22.0</td>
</tr>
<tr>
<td>308</td>
<td>'VL 796'</td>
<td>-</td>
<td>WEMBABLY/VL 404</td>
<td>SR, LR, LB, PM, KB, FS</td>
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<tr>
<td>309</td>
<td>'VL 801'</td>
<td>-</td>
<td>HS 240/CPAN 3031</td>
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<td>310</td>
<td>'VL 803'</td>
<td>2+31+2+6+34+</td>
<td>SERI/CPAN 2099</td>
<td>Three rusts, FS</td>
<td>18.1</td>
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<td>311</td>
<td>'VL 804'</td>
<td>5+31+2+6+34+</td>
<td>CPAN 3018/CPAN 3034/WH 11085</td>
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<td>312</td>
<td>'VL 809'</td>
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<td>313</td>
<td>'VL 818'</td>
<td>5+2+13+1+34+</td>
<td>SPINEBILL &quot;S&quot;/CPAN 2045</td>
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<td>314</td>
<td>'VL 824'</td>
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<td>Raj 3302/TURACO/TURACO</td>
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<td>316</td>
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<td>8b+9b+11+2+13+34+</td>
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<td>317</td>
<td>'VL 852'</td>
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<td>318</td>
<td>'VL 864'</td>
<td>31+5+2+26+3+9+</td>
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<tr>
<td>319</td>
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<td>31+2+26+9+</td>
<td>ALFROG#4/HD 30/CPAN 3031</td>
<td>LB, KB, LS</td>
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<tr>
<td>320</td>
<td>'VL 867'</td>
<td>31+5+2+26+9+</td>
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<td>321</td>
<td>'VL 868'</td>
<td>31+2+26+23+1+9+</td>
<td>RAJ 37/4/CPAN 2051/PBW 65</td>
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<tr>
<td>322</td>
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<td>328</td>
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<td>'VL 913'</td>
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<td>20 + 23+</td>
<td>9+</td>
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**T. dicoccum**

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