AGRONOMIC EVALUATION OF THE HESSIAN FLY RESISTANT WHEAT CULTIVAR 'SAADA' IN MOROCCO

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INTRODUCTION

Hessian fly (**Mayetiola destructor** (Say)) has been identified since 1932 as a damaging insect to cereals in Morocco (DURANT, 1967). In bread wheat (**Triticum aestivum** em Thell.) a total loss of the crop can occur in late plantings of susceptible cultivars. The biology of the insect had been studied (JOURDAN, 1937; JOURDAN, 1938; DURANT, 1967) early in the thirties, and chemical control (DURANT, 1967; BENNANI, 1968) had been attempted with limited success late in the sixties. TEGYEY (1965) and DURANT (1967) were not successful in their search for genetic resistance. Recently, three resistance genes in wheat, **H5, H11,** and **H13** have been found effective against Moroccan biotypes (EL BOUHSSINI et al., 1986; EL BOUHSSINI et al., 1988). GALLAGHER et al. (1987) identified **H5** and **H13** as contributing resistance; **H11** was reported as being non-effective in the Tadla region. Several other genes have been reported later (AMRI, 1989). **Triticum tauschii** (Coss) Schmal., a wild relative of wheat which carries the D-genome of wheat appears to be a valuable source for additional resistance genes. Synthetic hexaploid wheats derived from this species produced in Japan (TANAKA, 1961) have been found resistant to biotype D in the States, with a single dominant gene of **T. tauschii**

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contributing resistance (HATCHETT et al., 1981). Some resistance genes derived from **T. tauschii** are now successfully being used to breed resistant wheat in Morocco. Triticale (**Triticosecale** Wittmack) appears to be resistant in Morocco indicating that the rye genome in triticale is also another source of resistance (EL BOUHSSINI et al., 1991). Resistance genes effective against US biotypes were identified in durum wheat (**T. durum L.**) (AMRI, 1989), and may also be used to improve bread wheat. Bread wheat may ultimately benefit from the substantial wealth preserved in the whole genus, **Triticum.**

Tolerance which is defined as the ability of the host to sustain damage in the presence of the parasite, has not been studied, although wheat cultivars that are Hessian fly tolerant have been identified in Morocco (JLIBENE, 1988). Mechanisms involved are under investigation.

To limit the losses caused by Hessian fly in Morocco, a resistant spring wheat cultivar carrying the **H5** gene, was introduced from Dr. Cholick's program in South Dakota (SD) under the number SD8036, and was later given the name 'Saada'. The name was chosen on the basis of a meaningful word (Happiness) which contains the two letters S and D to acknowledge the South Dakota program.

Saada was tested as one meter-single-row plot among 37 other germplasm lines sent by Dr. J. H. Hatchett, and identified as resistant in 1985 at Sidi El Aidi, Rabat, Marchouch, and Sidi Kacem, which represent a wide range of environments in Morocco (El BOUHSSINI et al., 1986, 1988). Dr. E. Smith (MIAC wheat cereal breeder, 1985-1987) judged Saada as agronomically acceptable and suggested to Dr. Darrel Watts, the MIAC team leader, that he get more seed from South Dakota State University for yield testing and seed multiplication plots (E. Smith, 1987, person. comm.). Four hundred kilograms (400 kg) of seed were received in October 1985. During 1986, M. Mergoum (person. comm., 1988) included Saada in yield trials. As Saada appeared to perform reasonably well in the arid environment compared to susceptible cultivars, it was introduced to the National Catalogue yield system in 1987 and 1988. It was later released in 1989 as the first Hessian fly resistant variety in Morocco. Its yield was higher than the yield of 'Nasma' or 'Jouda' under heavy Hessian fly infestation, but lower in favorable and irrigated conditions. Official seed increase started in 1988, although large quantities of seed were produced at the Settat regional research center. The line originated from the cross between Butte and the **H5**-carrying Arthur-71, backcrossed to Butte one more time. The pedigree is thus Butte*2/Arthur-71 (CHOLICK, et al. 1987).

Saada has, since its introduction to Morocco, been used in the bread wheat breeding program as a source of resistance. It was further used as check in trials of new improved lines in semi-arid areas. Saada has also been compared to all released varieties in six locations during the last four years. The present paper summaries the test results.

MATERIALS AND METHODS

Saada has been tested in replicated yield trials in six locations across Morocco, Marchouch (M), Fes-Douyet (F), Sidi El Aidi (S), Jemaa Shaim (J), Tassaout (T), and Deroua (D) since 1987. Marchouch and Fes-Douyet represent high rainfall areas, while Sidi El Aidi and Jemaa Shaim represent low rainfall areas. Tassaout and Deroua represent the irrigated areas. Randomized complete bloc was the experimental design used. Yield trials were of 5 types (Tables 1 and 2), demonstration (PG and EX), national-catalogue (NC), advanced (A1 and A2) intermediate (I1 and I2), and preliminary (P1 to P6) yield trials. Demonstration trials included all released varieties and promising lines (1 or 2 reps). National-catalogue yield trials (4-6 reps) included cultivars which were immediate candidates for release. Advanced yield trials (4 reps) were made of selected lines from the less advanced yield trials, intermediate yield trials (3 reps) which in turn were made of selected lines from preliminary yield trials (2 reps). For commodity the name of each trial is made of initials representing the species (BT for bread wheat), year of test (87, 88, 89 or 90), the name of the test (EX, NC, PG, A1, A2, I1, I2, P1...), and the location (M, F, S, J, T, or D). For example BT88NCJ is the name of the National-catalogue yield trial of bread wheat conducted at Jemaa Shaim during the 1987-88 growing season.

Dates of planting ranged from the first week of December to the first week of January. Plots were planted with six rows 5 m long and 0.30 m apart using a seed drill. Sowings were usually delayed by the rain which made entrance to the field difficult. All trials received recommended applications of fertilizer and manual weed control. The four central rows in each plot were harvested in June by an experimental plot combine to estimate grain yield.

Data on days to heading, days to maturity, plant height, and reaction to pests were collected from each plot. Levels of infestation of fields by the Hessian fly ranged from light to very heavy. Under very heavy infestation susceptible cultivars could not produce harvestable crop. Under heavy infestation harvest of susceptible cultivars was possible, but, large numbers of broken tillers were observed. Medium infestations were characterized by the presence of broken

tillers at maturity in a lesser extent. The presence of larvae or pupae of the fly were noted in light infestations, but, damages could not be visually estimated.

RESULTS

Description of Saada

Saada is a spring wheat with hard red colored grain. Compared to Nasma, Jouda, or Marchouch, the major cultivated wheat varieties in Morocco, Saada has a higher tillering capacity, a higher tillering mortality, and a better early growth. It has taller stature but a weaker straw. The stems are hallow and fragile. It has a longer grain filling period since it heads a few days earlier but matures one week later than Nasma. It produces more heads per plant than standard varieties. The spike is white, fusiform, semi-compact, and small carrying at most three kernels per spikelet and 16 spikelets. The grain is darker in color and smaller in shape compared to the kernel of Nasma and Jouda. Saada grain is the smallest of all released wheat varieties.

Saada is susceptible to Yellow rust (**Puccinia striiformis**) as is Nasma, sesceptible to Tan spot, (**Pyrenophora tritici repentis**) and to Barley Yellow Dwarf Virus (**BYDV**). Saada is as resistant to Brown rust (**Puccinia recondita**) as Jouda, but has better resistance to Septoria tritici blotch (**Septoria tritici**), and definite resistance to Hessian fly.

Yield performance

Performances of the variety Saada under light and intermediate infestations are given in Table 1, and the results under heavy infestations are presented in Table 2. In general, heavy infestations seemed to be common in late sowings except when an insecticide, Furadan 5Gwas applied (Table 2) as it was the case at Sidi El Aidi in 1990. Heavy infestations of Hessian fly were common at Sidi El Aidi and Jemaa Shaim, but were less common in other locations. However, late sowing in Fes-Douyet in 1990 resulted in heavy infestation (Table 1), particulary in demonstration plots where Saada was the only Hessian fly resistant cultivar. Nevertheless, it is worth noting that wheat varieties Potam, Achtar, and Pynite produced grain despite the heavy pressure of the fly. In four other trials (data not presented), new Hessian fly resistant cultivars performed better than Saada. Under very heavy infestations, Saada was the only variety among susceptible cultivars that survived. No grain yield could be harvested from the other varieties in 12 trials planted at Sidi El Aidi and Jemma Shaim (Table 1). Saada ranked first in these conditions. When Hessian fly infestations

were less important, Saada lagged behind the other cultivars. In some trials, the ranking of Saada was not as good, due to the presence in the test of new high yielding cultivars. Under light or medium infestations, Saada ranked among the last group in 22 cases out of 24.

DISCUSSION

What makes Saada not a good yielder can be deduced from observing its vegetative and reproductive behaviors. Saada develops many tillers of which many die prior to seed set, wasting valuable inputs particularly water and nitrogen. Spike fertility is low, due to small spike, low number of spikelets per spike, low number of kernels per spikelet, and small seed size. In Morocco the cultivated wheat is of spring type. Winter season is mild and moist, which allows sowing in the fall to take advantage of the winter moisture. Wheat has the whole period of fall-winter to develop its yield components. For these yield components to be fully expressed, the genetic potential must be high. All high yielding varieties developed in Morocco have a large number of kernels per spikelet (up to 8), and large number of spikelets per spike (up to 24). The seed size is often high. Varieties with genetic limitations may not be fit to this environment. Most of the biomass produced in Saada can not be converted to grain yield because of the genetic limitations of the yield components. Hence, more straw than grain is produced, showing a low harvest index. On the other hand, the straw should be of a good quality because of the non-translocated carbohydrates. Saada lodges under high inputs due to its tall stature and weak straw. It is also susceptible to sawfly due to its hallow stems. Its tillering capacity and fast early growth make Saada a better weed competitor than Nasma (TANJI and JLIBENE, 1988).

The grain filling period is sensitive to drought and heat. Therefore it should not be long exposed to these stresses. The length of this period is a disadvantage to Saada in environments with late drought which is common, often resulting in shrivelled seed.

Saada is susceptible to **Pyrenophora** Tan spot which has probably been conspicuous due to the absence of a competitor Septoria tritici bloth. Susceptibility to BYDV is another disadvantage to Saada. EL YAMANI and HILL (1990) quantified the loss due to BYDV on Saada and other wheat varieties including Nasma under artificial and natural inoculations, and found that Saada was the most susceptible.

CONCLUSION

Three main attributes make Saada perform reasonably well, resistance to Hessian fly, resistance to rust and resistance to Septoria. The three pests cause the most important damages to wheat in Morocco. When all of them are present, a complete loss of the crop can be expected. In the absence of any of these, Saada is not yielding as good as released cultivars, which seem to limit its spread to other regions. Saada may be wisely used as a temporary solution in situations where the pests are present. It is now being adopted by farmers in the Abda region. Saada possesses a lower harvest index than that of most released varieties, as low as the harvest index of barley cultivars.

Saada would also make a good source of multiple resistance to use in the breeding program. Some backcrosses to adapted parents are necessary to increase yield level. However, one should be careful in choosing the reccurrent parent, because Saada is susceptible to **Pyrenophora** Tan spot disease which has not been a problem in Morocco so far. Susceptible progenies should immediately be discarded. Saada is also susceptible to the BYD-virus and to stripe rust.

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Table 1 : **Ranking and yield of Saada under high levels of Hessian fly infestation in several years and several locations**

Trial*	Furadan	Date of planting	Level of infestation	Number of entries	Saada rank	Average yield (kg / ha) Saada	Trial	Maximum
BT88A1J	No	Dec.	Very high	24	1	-	-	-
BT88A2J	No	Dec.	Very high	24	1	-	-	-
BT88I1J	No	Dec.	Very high	24	1	-	-	-
BT88I2J	No	Dec.	Very high	24	1	-	-	-
BT88A2S	No	30 Dec.	Very high	24	1	-	-	-
BT88I2S	No	30 Dec.	Very high	24	1	-	-	-
BT88P3S	No	30 Dec.	Very high	24	1	-	-	-
BT88P4S	No	30 Dec.	Very high	24	1	-	-	-
BT88PGS	No	30 Dec.	Very high	20	1	-	-	-
BT90EXF	No	9 Jan.	Very high	26	1	-	-	-
BT88P2S	No	2 Dec.	High	24	1	4042	2459	4042
BT89PGS	No	9 Dec.	High	20	1	1829	1077	1829
BT87P1J	No	21 Nov.	High	24	2	700	510	720
BT89A2S	No	9 Dec.	High	25	3	1299	1022	1314
BT89I2S	No	9 Dec.	High	25	5	1456	1230	1720
BT89P1S	No	9 Dec.	High	25	5	1202	1011	1275
BT87P2J	No	21 Nov.	High	24	5	610	490	760
BT89A1S	No	9 Dec.	High	25	9	1134	1058	1455
BT88P1S	No	2 Dec.	High	24	11	3989	3730	4570
BT88A1S	No	2 Dec.	High	24	19	3396	3595	4392
BT88I1S	No	2 Dec.	High	24	17	3216	3462	4249
BT89I1S	No	9 Dec.	High	25	20	1077	1335	1821

* The first two letters refer to bread wheat, the next two digits refer to the year of test, the next two refer to the trial, and the last letter refers to the site of the test, J for Jemma Shaim, S for Sidi El Aidi, F for Fes-Douyet.

- Plots were not harvested because they were heavily damaged by the insect.

Table 2 : **Ranking and yield of Saada under light levels of Hessian fly infestation in several years and several locations**

Trial*	Furadan	Date of planting	Level of infestation	Number of entries	Saada rank	Average yield (kg / ha) Saada	Trial	Maximum
BT90A1S	Yes	15 Dec.	Medium	24	24	2714	3508	3972
BT90A2S	Yes	15 Dec.	Medium	24	24	2874	3559	4212
BT90I1S	Yes	15 Dec.	Medium	24	23	2815	3610	4543
BT90I2S	Yes	15 Dec.	Medium	24	21	3068	3527	4545
BT90P1S	Yes	15 Dec.	Medium	24	18	2814	3032	4087
BT90P2S	Yes	15 Dec.	Medium	24	21	2758	3582	4585
BT90P3S	Yes	15 Dec.	Medium	24	10	3288	2952	3721
BT90P4S	Yes	15 Dec.	Medium	24	17	3696	3912	4516
BT90P5S	Yes	15 Dec.	Medium	24	20	3157	3554	4894
BT90P6S	Yes	15 Dec.	Medium	24	16	3582	3769	4815
BT90EXS	Yes	15 Jan.	Medium	28	27	2104	3233	5200
BT90EXM	No		Medium	26	6	4167	3808	5167
BT90EXT	No		low	26	25	3700	4754	6100
BT89PGM	No		Medium	20	6	2000	1849	2229
BT89PGF	No		Medium	20	20	1208	1843	2229
BT89PGT	No		Low	20	13	4167	4282	4896
BT88PGD	No		Low	20	16	3830	3830	4680
BT88PGT	No		Low	20	16	3863	4240	5896
BT88PGM	No		Low	20	20	5915	6862	8585
BT88PGF	No		Low	20	23	3900	4525	5900
BT88NCJ	No	Nov.	Medium	16	14	3543	4102	5502
BT87P1S	No	11 Nov.	Medium	24	20	950	1050	1450
BT87P2S	No	11 Nov.	Medium	24	10	1160	1050	1500
BT87NCJ	No	25 Nov.	Medium	8	7	3543	3783	4965
BT87P2S	No	11 Nov.	Medium	24	10	1160	1050	1500
BT88NCS	No	21 Nov.	Medium	16	1	4647	3688	4647

* The first two letters refer to bread wheat, the next two digits refer to the year of test, the next two refer to the trial, and the last letter refers to the site of the test, M for Marchouch, D for Deroua, F for Fes-Douyet, J. for Jemaa Shaim, S. for Sidi El Aidi, and T for Tassaout. - Plots were not harvested because they were heavily damaged by the insect.

ABSTRACT

Hessian fly (**Mayetiola destructor** (Say)) is a damaging insect to cereals in Morocco, inflecting up to 90% yield loss in bread wheat (**Triticum aestivum** em Thell.). A resistant spring wheat cultivar carrying the **H5** gene, was introduced from South Dakota (SD), named 'Saada', and released in 1989 as a temporary solution to control the fly. Its spread has been rapid in the highly infested Abda region, but was limited in other regions. While ranking first for yield among other varieties under heavy infestations of Hessian fly, it ranked among the last group under light or medium infestations. Small spike, low number of spikelets per spike, low number of kernels per spikelet, and small seed size limit its grain yield potential. Among large number of tillers produced, many are lost, wasting valuable inputs. It has tall, hallow and fragile stems, making it susceptible to lodging and sawfly. It is susceptible to Yellow rust (**Puccinia striiformis**), Tan spot, (**Pyrenophora tritici repentis**) and Barley Yellow Dwarf Virus (BYDV). The grain filling period is long, often resulting in shrivelled seed when late drought occurs. Its multiple resistance to Hessian fly, leaf rust (**Puccinia recondita**) and Septoria (**Septoria tritici**), and the fast early growth, are being exploited in the wheat breeding program.

KEY WORDS : Bread wheat, **Triticum aestivum, Mayetiola destructor, Septoria tritici**

RESUME

La mouche de Hesse (**Mayetiola destructor** (Say)) est un insecte qui cause des dégats considérables sur blé qui peuvent être de l'ordre de 90% chez le blé tendre (**Triticum aestivum** em Thell.). Une variété résistante à cet insecte a été introduite des Etats Unis, South Dakota, et lancée aux agriculteurs sous le nom de 'Saada' comme solution temporaire à ce problème. Son adoption a été facile dans la région de Abda où le degré d'infestation est très élevé. Quand l'infestation est forte, 'Saada' se classe en tête parmi les variétés testées. Mais quand le niveau d'infestation est faible ou moyen, elle se classe souvent derrière. La petitesse de l'épi, le faible nombre d'épillets et de grains par épillet, et lá petitesse des grains limitent son potentiel de production. Elle produit beaucoup de talles mais en perd beaucoup, valorisant moins l'eau et l'azote. Elle a une tige haute, creuse et fragile; ce qui la rend sensible à la verse et au cèphe. Elle est sensible à la rouille jaune (**Puccinia striiformis**), à l'helmintosporiose (**Pyrenophora tritici** repentis), et au virus de la jaunisse nanisante. La période de remplissage de grain est longue résultant le plus souvent en des grains échaudés. Ses résistances multiples à la cécidomyie (**M. destructor**), septoriose (**Septoria tritici**) et rouille brune (**Puccinia recondita**) sont utilisées dans le programme de sélection.

MOTS CLES : Blé tendre, **Triticum aestivum, Mayetiola destructor, Septoria tritici**

ملخص

دودة"هس"(Mayetiola destructor) تسبب في تلف كمية هامة من محصول الحبوب الخريفية بالمغرب قد تصل إلى 90٪ من محصول القمح الطري (Triticum aestivum) في بعض الحالات . لمكافحتها قام المعهد الوطني للبحث الزراعي بإدخال صنف من الولايات المتحدة تمت تجربته والتأكيد من مقاومته في ظروف انتاجية مغربية . يحتوي هذا النوع على جين المقاومة ضد هذه الحشرة H5.وقد سمي هذا الصنف بالسعادة تذكيرا بولاية داكوتا الجنوبية "SOUTH DAKOTA"التي أنتج فيها هذا الصنف والتي تحمل حرفي السين والدال .

كان إقبال المزارعين على هذا الصنف عاليا في منطقة عبدة حيث ضخامة الأضرار الناتجة عن هذه الحشرة . لكن الإقبال عليه كان محدودا بالنسبة لمناطق أخرى. بينما تنفرد السعادة بالصف الأول في الإنتاج بين أنواع أخرى، عندما تكون الظروف ملائمة لتكاثر الحشرة، تنزل إلى الصف الأخير عندما تكون الإصابة أقل خطورة. صغر حجم السنبلة وعدد السنيبلات في كل سنبلة، وعدد الحبات في كل سنيبلة، وصغر حجم الحبة عند هذا الصنف يكونون أحد العوامل لضعف مردوديته .

إضافة إلى هذا تمتاز السعادة باشطاء جيد جله لايصل إلى مرحلة التسنبل .للسعادة ساق طويل أجوف مما يجعلها معرضة للرقاد وللدودة المنشرية (Sawfly).للسعادة حساسية لأمراض الصدأ الأصفر (Puccinia striiformis) والتبقع البني(Pyrenophora tritici repentis) وفيروس BYDV .

مدة استكمال نضج الحب يستغرق أطول من الازم مما يجعلها معرضة لجفاف آخر الموسم. لكن مقاومتها لأمراض السبتوريا(Septoria tritici) والصدأ البني-(Puccinia recondi-ta)، وأشطاؤ ها المبكر هم أهم المميزات التي يتم استغلالها بالبرنامج الوطني لتربية القمح الطري بالمغرب .

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