EVALUATION OF BREAD WHEAT GENOTYPES FOR STRIPE RUST RESISTANCE

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ABSTRACT

Stripe rust disease is a major problem for wheat production in the hills of Nepal. To find resistance sources against this disease, 444 and 457 wheat genotypes received from National Wheat Research Program, Bhairahawa in 2018 and 2019 respectively were evaluated at Khumaltar under inoculated high disease pressure field condition. Disease was evaluated at both seedling and adult stages. In 2018, 315 genotypes showed resistance at seedling stage while 89 genotypes were having adult plant resistance (APR). Also, 71 entries showed immune response and 191 were resistant at both stages. Similarly in 2019, 233 genotypes were resistant at seedling stage and 201 were showing APR. Likewise, 35 entries were immune and 208 were resistant at both stages. Wheat genotypes with APR gene(s) can be utilized for developing durable stripe rust resistant varieties in the future. In addition, the genotypes having both stages resistant could also be used as sources of major and minor gene(s) for stripe rust resistance genotypes development in future breeding purposes.

Key-words: Adult, resistance, seedling, stripe rust, wheat

INTRODUCTION

Wheat is the third most important cereal crop in Nepal after rice and maize. It occupied 703,992 ha areas and produced 2,005,665 tons of wheat with productivity 2.85 t/ha (MoALD, 2019) during 2018/19. The average productivity of wheat is lower than the potential yield. There are several biotic constraints for wheat production and rust diseases are the most important ones in the country. Among them, stripe rust also known as yellow rust caused by the fungus *Puccinia striiformis* f.sp. *tritici* is considered as the most important threat on wheat cultivation in the hills of Nepal. The incidence and severity of stripe rust disease varied according to the climatic condition, management practices and wheat varieties. Losses due to stripe rust was estimated to be 27% in Nepal 297 variety (Sharma *et al.*, 2013). Likewise, Upreti and Karki (1988) recorded 30% in grain yield production in a field experiment on RR21 at Kavre, Dolakha due to stripe rust disease.

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Several resistant varieties have been developed since the last many years but due to the year round evolution of new virulent pathotypes, they become susceptible. Management by growing resistant wheat cultivars is the best method in terms of economic and environmental concern. Also, due to the evolution of new races/pathotypes of stripe rust pathogen, searching for new sources of resistance is a never ending process. This study also provides genetic materials to the breeders for developing resistance wheat cultivars against the new pathotypes in the future. So, in this experiment, we were looking for new sources of resistance against stripe rust disease against the prevailing pathotypes in the country.

MATERIALS AND METHODS

Various wheat genotypes advanced to different stages of selection viz. advanced lines, NRN, IETs and CVTs (444 genotypes in 2018 and 457 in 2019) were received from National Wheat Research Program, Bhairahawa as National Wheat Disease Screening Nursery (NWDSN) for the evaluation of stripe rust resistance level at Khumaltar, Lalitpur. They were planted in the field in a 1 m long rod row design. Fertilizer dose 100:60:40 NPK kg/ha was applied with nitrogen as two split doses, one at the time of planting and another was applied during first irrigation. First Irrigation was done at crown root initiation (CRI) i.e. 21 days after sowing. Timely weeding was also done during the crop period viz. one at tillering stage and second at booting stage. Three weeks old seedlings of Morocco (susceptible variety) grown in earthen pots were inoculated with viable rust spores for multiplication of pathogen. The spores multiplied in the earthen pots were also spread uniformly in the field for congenial environment to maintain inoculum density in the field. In the meantime, the rust spores were also sprayed in the field using ULVA sprayer in the seedlings. Border rows of susceptible variety, Morocco, were also planted around each nursery and infected pots were placed in the border rows at a distance of 10 m each for a conducive environment for rust development.

Disease scoring at seedling stage was done using the 0 – 4 scale as described in the below table.

Infection Type (IT)	Description
0	*No visible symptoms*
;	*Hypersensitive flecks*
1	*Small uredinia with necrosis*
2	*Small to medium uredinia with green islands & surrounded by necrosis or chlorosis*
3	*Medium to large sized uredinia with chlorosis*
4	*Large uredinia without chlorosis*
X	*Heterogenous ITs*

+	*Uredinia somewhat larger than normal*
-	*Uredinia somewhat smaller than normal*
C	*More than normal chlorosis*
N	*More than normal necrosis*

Source: McIntosh et al. 1995

Adult plant resistance in the field was evaluated on the basis of host response to infection (pustule type and size) (Roelfs *et al.,* 1992) and disease severity – the proportion of the possible tissue surface (%) area infected by rust following to the modified Cobb's scale (Peterson *et al.,* 1948). Field response was recorded using following letters:

Field response	Description
0	Immune; *No visible infection on plants.*
R	Resistant; *visible chlorosis or necrosis, no uredia are present.*
MR	Moderately resistant; *small uredia* are present and surrounded by either chlorotic or necrotic areas.
M	Intermediate; *variable sized uredia* are present, some with chlorosis, necrosis or both.
MS	Moderately susceptible; *medium sized uredia* are present and possibly surrounded by chlorotic areas.
S	Susceptible; *large uredia* are present, generally with little or no chlorosis and no necrosis.

Based on the disease score, wheat genotypes were categorized under different levels of resistance and genotypes which showed susceptibility at seedling stage (3 or more) and resistant reactions during the adult stage were characterized as adult plant resistance (APR).

RESULTS

In 2018, most of the wheat genotypes (#315) were resistant to stripe rust disease at seedling stage. Seventy one entries showed an immune response to the disease while only 7 genotypes were resistant at adult stage. Similarly, 162 genotypes were found moderately resistant whereas 10 were recorded to have susceptible reactions. Eighty nine genotypes showed APR to stripe rust and 191 genotypes were resistant at both stages (Figure 1). The immune reaction genotypes were BL 4812, BL 4868, BL 4908, BL 4916, BL 4945, BL 4951, BL 4952, BL 4955, NL 1307, NL 1340, NL 1311, NL 1352, NL 1364, NL 1369, WK 1204, WK 2582, Bhrikuti, Kanti, PasangLhamu, Gautam, Danphe, Bandganga, Chyakhura, Dhaulagiri etc. Likewise, seven genotypes such as NL 1343, LIVINGSTON/5/2*W15.92/4/ PASTOR//HXL7573/2*BAU/3/WBLL1, PBW65/2*PASTOR, FRANCOLIN#1//WBLL1*2/BRAMBLING, WBLL1*2/4/YACO/ PBW65/3/KAUZ*2/TRAP//KAUZ/5/KACHU#1/6/MARCHOUCH*4/SAADA/3/2*FR ET2/KUKUNA//FRET2/7/WBLL1*2/4/YACO/PBW65/3/KAUZ*2/TRAP//KAUZ/5/ KACHU#1, WBLL1*2/4/ YACO/PBW65/3/KAUZ*2/TRAP//KAUZ/5/KACHU

#1/6/MARCHOUCH*4/SAADA/3/2*FRET2/KUKUNA//FRET2/7/WBLL1*2/4/YACO /PBW65/3/KAUZ*2/TRAP//KAUZ/5/KACHU#1 and NELOKI/4/MARCHOUCH *4/SAADA/3/2*FRET2/KUKUNA//FRET2/5/PBW343*2/KUKUNA*2//FRTL/PIFED were resistant to stripe rust at adult stage. Similarly, the genotypes like BL 4708, BL 4870, BL 4871, BL 4872, BL 4875, BL 4876, BL 4905, BL 4906, BL 4863, NL 1278, NL 1288, NL 1290, NL 1298, NL 1335, NL 1337, NL 1341, NL 1342, NL 1346, NL 1347, WK 2654, WK 2787, WK 2820, WK 2550, Vinayak, Siddhartha, Nepal 251, Munal etc. were moderately resistant at Khumaltar. Some of the genotypes having APR and resistant at both seedling and adult stages in 2018 were presented in Table 1 and 2 respectively.

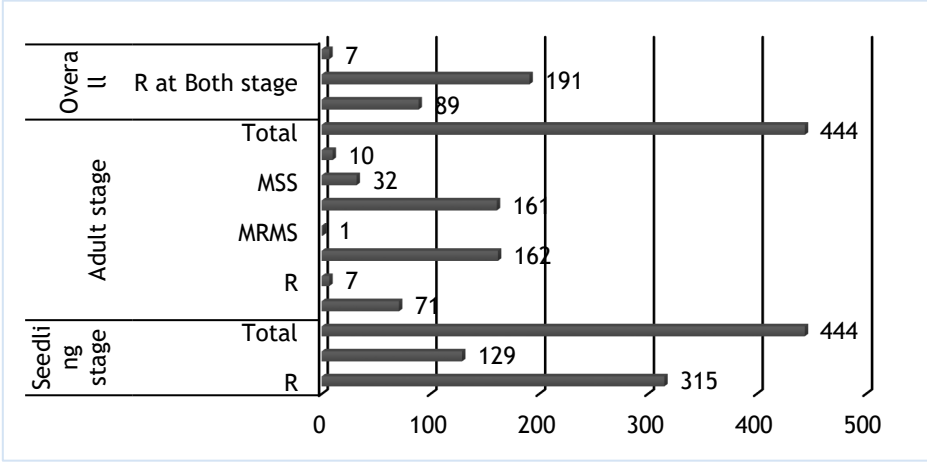

Figure 1. Wheat genotypes response to stripe rust in 2018 at Khumaltar, Lalitpur

Table 1. List of some APR genotypes from NWDSN tested at Khumaltar, Lalitpur in 2018

SN	Genotypes	Source	Seedling score	Adult score
1	BL 4872	NRN 2017-18	3	10MR
2	BL 4883	NRN 2017-18	33+	20MS
3	BL 4889	NRN 2017-18	3	20MR
4	BL 4894	NRN 2017-18	3	30MR
5	FRANCOLIN #1//WBLL1*2/BRAMBLING	NRN 2017-18	3	TR
6	HUW234+LR34/PRINIA*2//SNLG/3/BO KOTA	NRN 2017-18	33+	20MR
7	ROLF07*2/KIRITATI*2//PICAFLOR #1	NRN 2017-18	33+	10MR
8	BL 4909	NAL 2017-18	3	30MR
9	BL 4913	NAL 2017-18	33+	20MR
10	BL 4914	NAL 2017-18	33+	20MS
11	NL 1335	IET-MHH(2017-18)	33+	20MR
12	NL 1336	IET-MHH(2017-18)	3	20MS

13	NL 1347	IET-TTL(2017-18)	3	20MR
14	NL 1362	IET-TTL(2017-18)	33+	10MR
15	NL 1363	IET-TTL(2017-18)	3	10MR
16	NL 1202	CVT-TTL(2017-18)	33+	30MS
17	NL 1307	CVT-TTL(2017-18)	33+	20MS
18	NL 1298	CVT-TTL(2017-18)	33+	10MR

Table 2. List of some genotypes resistant at both seedling and adult stage in 2018 at Khumaltar, Lalitpur

SN	Genotypes	Source	Seedling score	Adult score
1	BL 4870	NRN 2017-18	2	20MR
2	BL 4904	NRN 2017-18	2	10MR
3	PBW65/2*PASTOR	NRN 2017-18	2	TR
4	BECARD #1/BAVIS	NRN 2017-18	2	10MR
5	BL 4905	NAL 2017-18	0;	10MR
6	BL 4952	NAL 2017-18	0;	0
7	BL 4953	NAL 2017-18	2	20MR
8	BL 4955	NAL 2017-18	2	0
9	PUB94.15.1.12/WBLL1	NAL 2017-18	2	10MR
10	KACHU/SAUAL*2//KINGBIRD #1	NAL 2017-18	0;	0
11	KACHU*2/CIRNO C 2008	NAL 2017-18	0;	20MR
12	WK 2820	IET-MHH(2017-18)	2	10 MR
13	WK 1204	IET-MHH(2017-18)	2	0
14	WK 2550	CVT-MHH(2017-18)	0;	10 MR
15	WK 1204	CVT-MHH(2017-18)	0;	0
16	NL 1343	IET-TTL(2017-18)	0;	TR
17	NL 1354	IET-TTL(2017-18)	2	10 MR
18	BL 4708	CVT-TTL(2017-18)	2	20 MR
19	NL 1311	CVT-TTL(2017-18)	2	0
20	NL 1317	CVT-TTL(2017-18)	2	10 MR

Out of 457 wheat genotypes, 233 were resistant and the rest were susceptible to stripe rust at seedling stage in 2019. Meanwhile, thirty five genotypes/crosses were found immune in the adult stage that means they were free from this disease. Three hundred eleven genotypes were moderately resistant to stripe rust. Similarly, 7 were resistant, 26 were moderately resistant to moderately susceptible, 62 were moderately susceptible and 16 were found susceptible to the disease. Out of 457 wheat genotypes, 201 genotypes showed APR against stripe rust disease. Two

hundred eight genotypes were resistant and only twelve genotypes were susceptible in both stages (Figure 2). Likewise, some genotypes such as Pitik 62, Annapurna-1, Annapurna-3, Bhrikuti, Kanti, Pasang Lhamu, Gautam, WK 1204, NL 971, Gaura, Dhaulagiri, Tilottoma, Chyakhura, BL 4407, NL 1307, NL 1327, NL 1179, Khajura durum 1 and Khajura durum 2 from WVD (Wheat Varietal Display) showed moderately resistant reaction to stripe rust. Some moderately resistant genotypes from NRN and advanced lines were BL3623/NL1070, BECARD/NL1128, VIJAY/NL1095, ADITYA/NL1140, BECARD/NL1128, NL1042/BL4282, BL3530/NL1129 etc. Similarly, genotypes like NL 1278, NL 1288, NL 1318, NL 1322, WK 2748, WK 2820, WK 2832, WK 2602, WK 2582, BL 4837, BL4863, BL 4879, BL 4880, NL 1330, NL 1334, NL 1335, NL 1340, NL 1342, NL 1350, NL 1362, NL 1367 etc. showed moderately resistance to yellow rust disease at Khumaltar. Some genotypes having APR and resistant at both stages in 2019 were presented in Table 3 and 4 respectively.

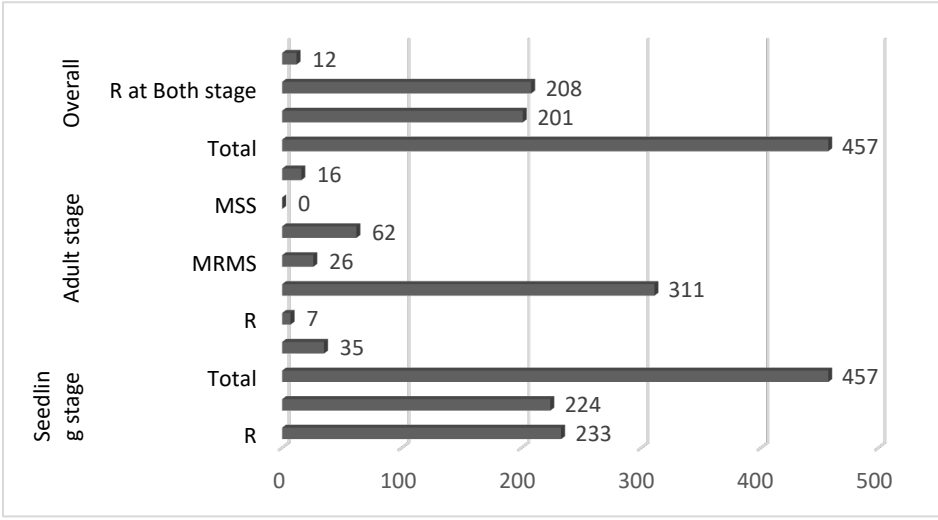

Figure 2. Wheat genotypes response to stripe rust in 2019 at Khumaltar, Lalitpur

Table 3. List of some APR genotypes from NWDSN tested at Khumaltar, Lalitpur in 2019

SN	Genotypes	Source	Seedling score	Adult score
1	VIJAY/NL1095	NRN 7	33+	20MR
2	ADITYA/NL1140	NRN 8	33+	20MR
3	UP262/KIRITATI//PRL/2*PASTOR	NRN 16	33+	TR
4	ADITYA/WAXWING/CIRCUS	NRN 21	3	20MR
5	ZINCOL/VALI	NRN 79	3	10MR
6	MUNAL*2/WESTONIA	NRN 86	33+	30MR

7	BAV92/SERI	NAL 187	33+	20MS
8	NADI/COPIO//NADI	NAL 225	33+	20MR
9	WK2832	CVTMH 18	33+	20MR-MS
10	BL4782	CVTMH 1	33+	20MS
11	WK2748	CVTMH 5	33+	20MR
12	WBLL4//OAX93.24.35/WBL L1 =NL1397	IETMH 15	3	20MR
13	WK3164	IETMH 25	33+	20MR-MS
14	WK3165	IETMH 26	3	10MR
15	BL 4928	IETTTL 2	33+	20MR
16	BL 4946	IETTTL 3	33+	30MS
17	BL 4947	IETTTL 4	33+	20MR-MS
18	BL4820	CVTTTLI 2	33+	20MR
19	NL1318	CVTTTLI 4	3	20MR
20	NL1349	CVTTTLI 12	33+	30MS

Table 4. List of some genotypes resistant at both seedling and adult stage in 2019 at Khumaltar, Lalitpur

SN	Genotypes	Source	Seedling score	Adult score
1	BL3635/NL1160	NRN 9	1	10MR
2	BL3635/NL1160	NRN 10	0	TR
3	WK1204/KINGBIRD	NRN-19	0	0
4	NL 297/NL1133	NAL 1	0	0
5	NL1055/WK2163	NAL 2	1	20MR
6	NL1097/NL971	NAL 7	2	10MR
7	BL4343/KAMB//BL4424	NAL 42	0	10MR
8	NL1340	CVTMH 13	2	10MR
9	NL1341	CVTMH 14	2	0
10	BL 4880	IETMH 3	2	10MR
11	WK2891	IETMH 21	2	10MR
12	WK3166	IETMH 27	2	10MR
13	BL 4952	IETTTL 5	1	10MR
14	NL1322	CVTTTLI 5	2	20MR
15	NL1344	CVTTTLI 10	1	20MR
16	NL1350	CVTTTLI 13	0	10MR
17	NL1362	CVTTTLI 16	2	10MR
18	NL1367	CVTTTLI 17	2	10MR

DISCUSSION

Wheat diseases commonly, leaf rust and stripe rust, foliar blight, powdery mildew, loose smut and hill bunt are the major threats to wheat production in Nepal. Various methods like chemical, cultural and resistant varieties have been used to manage these diseases. Several resistant genotypes against stripe rust disease have been developed and released during the last couple of decades. But due to the year round evolution of new races of the pathogen, those resistant genotypes became susceptible after years of adaptation like WK 1204, Dhaulagiri and Danphe which were released in 2007, 2012 and 2015 respectively now become susceptible to stripe rust in mid and far western hills of Nepal (Thapa, 2020). Both the years were favorable from a disease point of view since there was winter rain time and again. Stripe rust was very much severe in both the years. Karki and Karki (1996) also mentioned that stripe rust disease of wheat is very sensitive to environmental changes and its occurrence is not very regular. A disease becomes epidemic when susceptible variety is favored by suitable weather conditions along with virulent pathogen at specific location and time. So, regular screening of wheat genotypes against stripe rust under field conditions in different locations over the country should be given priority before releasing any varieties. Several scientists have done regular screening activities and they found some resistant lines against stripe rust disease. Two hundred ninety five entries were found resistant to stripe rust (Bhandari *et al.,* 2003). Similarly, Basnet *et al.,* 2016 revealed that 223 genotypes were resistant to stripe rust disease at Dailekh.

Genotypes such as WK 1204, Pasang Lhamu, Dhaulagiri, Bandganga, BL 4880, BL 4952, NL 1340, NL 1341, NL 1342, NL 1350, NL 1362 and WK 2787 were found resistant in both years against stripe rust disease at Khumaltar. But WK 1204 and Dhaulagiri became susceptible to stripe rust in 2020 at mid and far western hills. This might be due to the evolution of new races or prevalence of different races according to locations. Currently, we have had 4 stripe rust pathogen races viz. 46S119, 47S103, 78S84 and 110S119 prevailing in different parts of the country (PPD 2019 and NPPRC 2020) which were also used for the evaluation of wheat genotypes against this disease at Khumaltar. So, wheat genotypes showing APR and resistant at both seedling and adult stage at Khumaltar can represent the same resistance level across the country. So, we suppose that they may perform well anywhere in the country and recommend them for further varietal development processes. Also, we recorded some wheat genotypes immune at seedling stage and became susceptible at adult stage. This happens when more than one rust race was present at the same site where genotypes showed resistant reactions at seedling to one race which might become susceptible to another race at adult stage. So, wheat genotypes having APR to stripe rust can be utilized as resistant donors in

wheat breeding programs for the development of durable stripe rust resistant varieties. Similarly, we found a large number of wheat genotypes showing resistant at both stages might be the good sources of major and minor gene(s) against stripe rust disease and can be used for resistance breeding purposes.

CONCLUSION

There were abundant wheat genotypes having APR (#89 in 2018 and #201 in 2019) which can be utilized for developing durable stripe rust resistance varieties in the future. And for confirmation, those APR gene(s) should be identified by marker assisted selection (MAS). Also, genotypes which were resistant at both seedling and adult stages (#191 in 2018 and 201 in 2019) could be the source of major and minor gene(s) for stripe rust resistance and they can be used as resistant donors for breeding purposes. Similarly, genotypes like BL 4880, BL 4952, NL 1340, NL 1341, NL 1342, NL 1350, NL 1362 and WK 2787 which were resistant in both years against stripe rust disease can be selected for the varietal development process.

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REFERENCES

Basnet, R., Sharma, S., Mahato, B.N., Khadka, R.B., Dangal, N.K., Yadav, R.P., Rijal, T.R., Joshi, P. and GC C.B., 2016. Evaluation of wheat genotypes for multiple disease resistance. *In*: Proceedings of the 29th National Winter Crops Workshop, held on 11-12 June, 2014 at Regional Agriculture Research Station, Lumle, and Kaski. Nepal Agricultural Research Council.

Bhandari, D., Bhatta, M.R., Mahato, B.N., Chaurasia, P.C.P., Paudyal, D.C., Gharti, D.B. Malla, S. and Neupane, R.B., 2003. Screening of wheat genotypes against major diseases 2000-2001. *In*: Proceedings of wheat research papers presented at 25th National Winter Crops Research Workshop held at NARC, Khumaltar from 11-12 September 2002. National Wheat Research Program, Bhairahawa, Nepal.

Karki, C.B. and Karki, P.B., 1996. Wheat disease report 1994-1951. *In*: Proceedings of wheat research reports, National Wheat Research Program, Siddhartha Nagar (Bhairawa).

McIntosh R.A., Wellings C.R. and Park R.F., 1995. Wheat rusts: an atlas of resistance genes. CSIRO Publishing, East Melbourne.

MoALD, 2019. Statistical information on Nepalese Agriculture 2075/76 (2018/19). Planning and Development Cooperation Coordination Division. Ministry of Agriculture and Livestock Development. Government of Nepal. Singhadurbar, Kathmandu, Nepal. pp.435.

NPPRC, 2020. Annual Report 2019/20. National Plant Pathology Research Centre (NPPRC), NARC (S Baidya and S Manandhar eds.), Khumaltar, Lalitpur, Nepal

Peterson, R.F., Campbell, A.B. and Hannah, A.E., 1948. A diagrammatic scale for estimating rust intensity on leaves and stems of cereals. Canadian Journal of Research, **26**, 496-500.

PPD, 2019. Annual Report 2018/19. Plant Pathology Division (PPD), NARC (S Baidya, PB Magar and S Manandhar eds.), Khumaltar, Lalitpur, Nepal

Roelfs, A.P., Singh, R.P. and Saari, E.E., 1992. Rust Diseases of Wheat. Concepts and methods of Disease Management, Mexico, P.F.CIMMYT, pp.81.

Sharma, S., Mudwari, A., Thapa, D.B., Bhatta, M.R., Bhandari, D., Joshi, S., Baidhya, S. and Joshi, A.K., 2013. Major achievement of stem rust research on wheat in hills of Nepal. *In* Proceedings of 28th National Winter Crops Workshop. Nepal Agricultural Research Council.

Thapa, D.B., 2020. Stripe rust hits wheat crops in Nepal. BGRI Newsletter. May 2020. Cornell University. New York. USA. Accessed in 14 August 2020 from https://globalrust.org/blog/stripe-rust-hits-wheat-crop-nepal?utm_source=May++2020+BGRI+Newsletter&utm_campaign= BGRI+May+2020&utm_medium= email

Upreti, R.P. and Karki, C.B., 1988. Effects of yellow rust on grain yield and 1000-kernel weight of wheat at Kabre. Paper presented at the third working group meeting, Bhairahawa Agriculture Farm, Bhairahawa, Nepal.