Assessment of yield loss due to the millet head miner, Heliocheilus albipunctella (Lepidoptera: Noctuidae) using a damage rating scale and regression analysis in Niger

(*Keywords:* yield loss, millet head miner, *Heliocheilus albpunctella*, damage rating, West Africa)

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Abstract. Linear equations for five pearl millet varieties were established for yield losses due to damage by the millet head miner, *Heliocheilus albipunctella* De Joannis (Lepidoptera: Noctuidae), using a panicle damage rating scale. A very high positive correlation ($r > 0.90$; $P = 0.001$) was found between damage rating and percent yield loss, and also between observed and predicted yield loss. The low percent absolute deviation (% *ad*) and deviation ratios (*dr*) between observed and predicted yield loss demonstrated the reliability of the damage rating scale, and the established yield loss equations. In addition, the damage rating on farmers' fields by farmers and a team of technicians showed that the method can be used for quick on-farm assessment of yield loss by extension agents and farmers. In four farmer's fields, the estimated yield loss for the local variety (Sadore local) ranged from 11.7 to 41.9%. Implications in the use of the method in future crop loss assessment in pearl millet are presented and discussed.

1. Introduction

Pearl millet, *Pennisetum glaucum* (L.) R. Brown is a major source of food in the Sahelian zone of Africa. In West Africa alone, over 12 million ha of land are cultivated to millet (Nwanze, 1988). However, the crop is attacked by many insect pests including the millet head miner (MHM) *Heliocheilus albipunctella* De Joannis (Lepidoptera: Noctuidae). Data on pearl millet yield loss due to insect pests are sketchy. Nevertheless, an account of yield loss due to *H. albipunctella* as a percentage of grain mass in some locations in West Africa has been summarized by Krall *et al.* (1995). Most of the information available on millet yield loss has limited application concerning large-scale on-farm applications. This is because methodologies are too complex and time consuming for quick understanding and adoption by extension agents and farmers. This may explain the reason for the limited number of insect pests in West Africa for which accurate on-farm crop losses data are available (Nwanze, 1988).

Since 1983, ICRISAT has been using a special rating system (based on a 1–9 scale) to categorize millet damage due to insect pests and diseases (Youm and Kumar, 1995). This approach was classified under visual score analysis by Nwanze (1988) and gave an estimated grain loss of 0.8–14.9% due to *H. albipunctella*. The simplicity of the method makes it promising for quick on-farm estimation of yield losses. However, it is yet to be fully tested. This paper reports the results of about 3 years of studies to improve technology in pearl millet yield loss assessment using a 1–9 rating scale and correlating yield loss against damage.

2. Materials and methods

2.1. On-station experiments

Five pearl millet varieties, including Sadore local, 3/4HK, Chalakh, MBH110 and ICMV IS 89305 were sown in a randomized complete block design (10 replicates) in June, 1996. Standard weeding, thinning and fertilizer application was done as usual. At maturity, the damage rating 1–9 (1 = no damage, 9 = complete damage) (Youm and Kumar, 1995) was used to classify panicles. Panicles were selected based on average length and diameter for the variety. Selected panicles (2–5) for each of the ratings were then sun-dried before threshing. In selecting panicles, damage due to factors other than *H. albipunctella* were discarded. To compare the on-station derived equation with that of on-farm for the local variety (Sadore local), 100 panicles for each rating (900 panicles total) were selected from a farmer's field. These were then sun-dried, threshed, and data processed to establish loss equations as described below.

2.2. On-farm testing of the damage rating scale

The rating scale was tested using data collected from four farmers' fields planted with the local variety (Sadore local) to establish how best the equations could be used to assess on-farm losses. An area of 1 ha in the middle of a farmer's farm was selected and millet panicles were sampled across diagonals at 2 m intervals. This gave 100–300 panicles per sampled field on average. Five observers scored these panicles according to the 1–9 rating. To simplify yield loss assessment by farmers, the rating scale was modified as follows: 1–2 (very good panicles, nearly no damage); 3–5 (good panicles, very little to moderate damage); 6–8 (moderate to severe damage); 9 (very severe damage). Three farmers were then asked to classify samples based on the above modified ratings. For example, very good was assigned 2, good was assigned 4, moderate to severe damage was assigned 7 and very severe damage 9. The panicles were then sun-dried, threshed and weighed. The yield losses (with reference to our standard) were calculated and these were fitted into the equation to complete the predicted ratings (*Rt*) as shown in equation (3) below:

2.3. Analyses

Percent yield loss (%*YL*) in terms of grain weight was calculated as follows.

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$$\%YL = [(GW1 - GW_t)/GW1)] \times 100 \quad (1)$$

where $GW1$ represents grain weight for rating 1 and GWt represents grain weight for rating t.

For each variety, $\%YL$ was regressed over ratings to establish a linear equation for the particular variety. For the local variety Sadore local:

$$Rt = (\%YL + 8.456)/10.075 \quad (2)$$

Substituting equation (1) in equation (2) gives

$$Rt = 10.85 - 10GWt/GW1 \quad (3)$$

The Rt values were then compared with what we and the farmers had previously observed.

Percent absolute deviation (%*ad*) was calculated by taking the absolute value of the difference between the observed percent yield loss and the predicted percent yield loss. Deviation ratio (*dr*) was then calculated by dividing the percent absolute deviation over the observed percent yield loss.

Table 1. Yield loss regression equations for five pearl millet varieties

Variety	Regression equation	r^2 (P=0.001)
Sadore local[a]	$\%YL=10.16Rt-9.70$	0.63
Sadore local[b]	$\%YL=10.08Rt-8.46$	0.99
3/4HK	$\%YL=8.52Rt-5.59$	0.91
Chalakh	$\%YL=9.17Rt-5.71$	0.94
ICMV IS 89305	$\%YL=10.65Rt-10.76$	0.98
MBH110	$\%YL=11.83Rt-2.96$	0.94

[a]Represents 900 millet panicles (100 for each rating) collected from farmer's field.

[b]Represents 2–5 millet panicles for each rating from our in-station experimental plot.

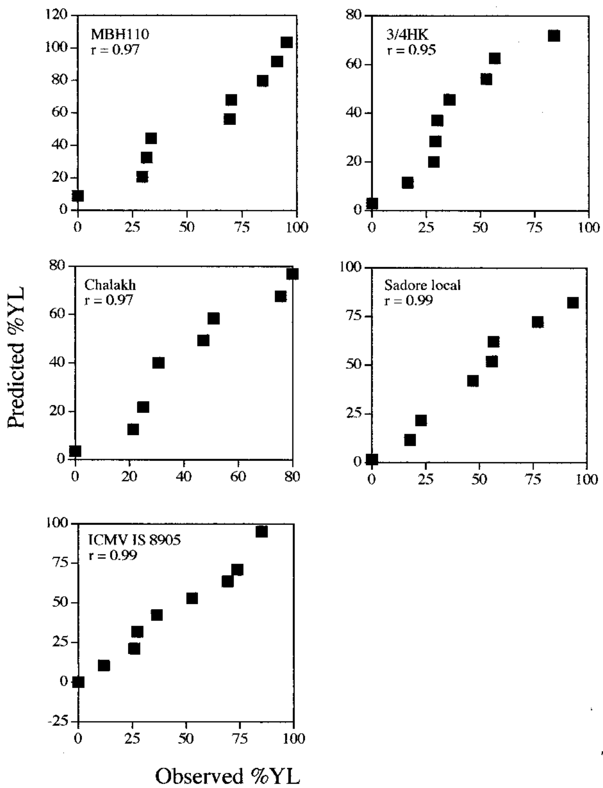

Figure 1. Relationship between observed and predicted percent yield loss (%YL) values for five millet varieties.

3. Results and discussion

Table 1 gives the yield loss equations for five millet varieties, including the cultivated land race (Sadore local). In all, a high degree of correlation (> 90%) was found between

Table 2. Percent absolute deviation (% ad) and deviation ratio (dr) values for damage rating scale (1–9) for five millet varieties

Variety	Rating	%*ad* [a]	*dr* [b]
Sadore local	1	1.62	∞
	2	6.04	0.34
	3	1.03	0.05
	4	[c]	[c]
	5	5.08	0.11
	6	3.85	0.07
	7	5.52	0.10
	8	4.99	0.07
	9	11.29	0.12
			Mean=0.12
3/4HK	1	2.93	∞
	2	4.94	0.30
	3	8.48	0.30
	4	0.77	0.03
	5	6.93	0.23
	6	9.84	0.28
	7	1.32	0.03
	8	5.98	0.11
	9	12.00	0.14
			Mean=0.18
Chalakh	1	3.36	∞
	2	8.62	0.41
	3	3.20	0.13
	4	[c]	[c]
	5	9.52	0.31
	6	2.30	0.05
	7	7.58	0.16
	8	7.87	0.10
	9	3.08	0.04
			Mean=0.17
ICMV IS 89305	1	0.11	∞
	2	1.21	0.10
	3	1.22	0.05
	4	4.52	0.17
	5	6.13	0.17
	6	0.27	0.01
	7	5.48	0.08
	8	0.59	0.01
	9	0.03	0.01
			Mean=0.07
MBH 110	1	8.87	∞
	2	8.84	0.30
	3	1.03	0.03
	4	10.90	0.33
	5	13.28	0.19
	6	2.02	0.03
	7	4.59	0.05
	8	0.69	0.01
	9	8.03	0.08
			Mean=0.13

[a]$\%ad = |\text{observed } \%YL - \text{predicted } \%YL|$.

[b]$dr = \%ad \div \text{observed } \%YL$.

[c]Missing value.

percent yield loss and damage rating, and also between observed and predicted yield loss (figure 1). Almost the same linear equations were obtained for Sadore local for both on-station and on-farm. The lower r^2 value obtained for on-farm however could be due to variability in farmer's field, differences in plant growth conditions due to soil heterogeneity, as well as sample size. Nonetheless, the rating system used and tested and equations established could be easily applied in farmer's fields for assessment of yield loss due to *H. albipunctella*. This is further supported by the rather low values for the percent absolute deviation (difference between observed and predicted values) and deviation ratios obtained for all ratings for the five varieties (table 2). The deviation ratio gives an indication of how close the observed value is to the predicted one. Generally, the closer the ratio is to zero, the better it is. Thus, a range of 0 to 0.5 should be acceptable. Since most deviation ratios were less than 0.3, the rating scale can be conveniently used to establish on-farm losses.

Table 3. Observed rating, predicted rating and estimated yield loss for millet panicles (Sadore local) sampled from farmers' fields in Sadore, Niger (October, 1996)

Farm	Observer	Observed rating	Predicted rating	Remarks (rating fit)[a]	% yield loss
A	1	2		P	
	2	2		P	
	3	2		P	
	4	2		P	11.69
			2		
	5	2		P	
	Farmer 1	Very good (1–2)		P	
	Farmer 2	Very good (1–2)		P	
	Farmer 3	Good (3–5)		B	
B	1	4		P	
	2	3		A	
	3	2		B	
	4	2		B	31.84
			4		
	Farmer 1	Good (3–5)		P	
	Farmer 2	Good (3–5)		P	
	Farmer 3	Good (3–5)		P	
C	1	3		A	
	2	3		A	
	3	3		A	
	4	2		B	31.84
			4		
	5	2		B	
	Farmer 1	Good (3–5)		P	
	Farmer 2	Good (3–5)		P	
	Farmer 3	Good (3–5)		P	
D	1	5		P	
	2	4		A	
	3	4		A	
	4	4		A	41.92
			5		
	5	4		A	
	Farmer 1	Good (3–5)		A	
	Farmer 2	Good (3–5)		A	
	Farmer 3	Good (3–5)		A	

[a]A, acceptable; B, bad; P, perfect.

Actual use of the rating scale to establish on-farm losses was however tested by first rating damage on panicles collected from farmer's fields, calculating the yield loss, and fitting the yield loss back into our established equation to get the calculated rating (table 3). For the purpose of farmers and on-farm use, the rating scale was narrowed. In all cases established however, the observed rating matched well with the predicted rating with only a few instances where the rating fit was considered bad.

Before any effective pest management decision can be taken in any cropping system, it is imperative to assess the extent of crop loss. Unfortunately, very little progress has been previously made on crop loss assessment methods for pearl millet (Nwanze, 1988, Jago, 1995). Reasons for estimating yield loss include attempts to define a plan of action or strategy for future research priorities, preferences and allocation of resources, as well as to define the pest status of a particular insect and establish economic thresholds and economic injury levels. Thus, there is a need to use simple methods that can be adopted over wider areas. Since yield is a varietal characteristic, it will not be appropriate to use a single equation for all millet varieties. This methodology can be extended for many varieties and across locations.

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References

JAGO, N. D., 1995. Population monitoring and crop loss assessment in integrated pest management of panicle pests of sorghum and pearl millet. In K.F. Nwanze and O. Youm. (eds) *Panicle Insect Pests of Sorghum and Pearl Millet: Proceedings of an International Consultative Workshop* 4-7 October, ICRISAT Sahelian Center, Niamey, Niger, pp. 103 – 113.

KRALL, S., YOUM, O. and KOGO, S. A., 1995. Panicle insect pest damage and yield loss in pearl millet. In K.F. Nwanze and O. Youm. (eds) *Panicle Insect Pests of Sorghum and Pearl Millet: Proceedings of an International Consultative Workshop*, 4-7 October, ICRISAT Sahelian Center, Niamey, Niger, pp. 135 – 145.

NWANZE, K. F., 1988. Assessment of on-farm losses in millet due to insect pests. *Insect Science and its Application*, **9**, 673 – 677.

YOUM, O. and KUMAR, A. K., 1995. Screening and breeding for resistance to millet head miner. In K.F. Nwanze and O. Youm. (eds) *Panicle Insect Pests of Sorghum and Pearl Millet: Proceedings of an International Consultative Workshop*, 4-7 October, ICRISAT Sahelian Center, Niamey, Niger, pp. 201 – 209.