Genetic Purity Solutions and Associated. Algorithms for Conforming Seed Lots or (Any Industrial Blend) To Stipulated Certification Standards of Quality.

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Abstract

Seed Certification prerequisites trade and marketing of crop seed varieties within and across countries or Global Regions. A Seed Lot can only be certified if it meets minimum quality of genetic and physical purity standards as enshrined in Certification Schemes of Certifying Authority or Agency of respective Organisations, Countries, or Regions. The quality standards set may vary considerably across Seed Certification Schemes. Meeting of genetic purity standards in maize seed production requires Distance and Time Isolation husbandry techniques in the separation of seed production fields from sources of foreign pollen in neighbouring contaminant maize fields. These two Seed field Isolation techniques however require minimisation in response to ever rising pressure on land and tight turn around cropping schedules in farms. Essias Michael Kok (1985), with help of Ephrame Kudzaishe Havazvidi, showed that minimum Distance Isolation set for Certification of maize seed crops could be reduced to 122 metres provided that the protected maize seed crop is planted on the leeward side of the potential contaminant maize crop and that the synchronisation (or nicking) of pollen shed in the male parent of the seed maize crop with silking period in the female parent of the protected seed maize crop is perfect. Time Isolation technique obviates distance separation of seed fields from potential contaminant maize crops and furthermore removes wind current challenges which may reduce effectiveness of Distance Isolation. Ephrame Kudzaishe Havazvidi (1989) derived Time Isolation Formulae and quantified Safety Factors in the formulae to ensure reliability in their effectiveness. He derived Time Isolation Constants specific to the genetic constitution of female parents of the different seed maize crops i.e. inbred females, sisterline cross females and single cross females, respectively. Corrective measures to conform excessive genetic contamination of seed maize to certification standards set can be taken using algorithms derived by the Author (unpublished). The principle behind Ephrame Kudzaishe Havazvidi's algorithms lies in the mixing or blending of inferior quantities of seed lots with specified quantities of seed lots containing much higher genetic or physical quantity fractions than those stipulated in Seed Certification Schemes in question. These algorithms can also be applied in other Industrial Blending or Stoichiometric formulations.

Keywords

1.Certifiation , 2. Isolation , 3. Contamination , 4. Blending , 5. Algorithm

1. Introduction

Maize (*Zea mays L.)* derives high agronomic performance from heterotic mating or hybrid vigour. Any genetic recombination towards homozygosis will lead to inbreeding depression in traits of economic importance such as grain yield. Undesirable pollination arising from maize fields bordering hybrid seed maize production fields breaks down heterotic genetic recombinations resulting in low yield performance of the hybrid seed produced. Furthermore, uniformity in expression of pertinent traits is lost when seed maize crops are pollinated by foreign pollen. Seed

Certification Schemes of Countries, Regions or Organisations insist on minimum genetic purity standards to be met by hybrid seed maize Producers. Husbandry techniques used by Seed Maize Producers to minimise genetic contamination of seed maize crops to Certification Standards are; Distance Isolation and Time Isolation. We have attempted to measure and validate effectiveness of Distance and Time Isolations in the minimisation of genetic contamination of hybrid seed maize crops by foreign pollen flowing from adjacent untrue to type maize crops. Hybrid Maize Seed Lots containing excessive genetic impurities can be blended or mixed with Seed Lots of the same hybrid which carry lower genetic impurities than the minimum amount stipulated in Seed Certification standards. Algorithms applicable in the calculation of seed blending ratios towards performing non compliant Seed dots to Certification standards are presented in this paper.

2. Literature Review

Development of maize hybrids involves crossing of unrelated genotypes which express high hybrid vigour or heterosis in traits of economic importance (Derera 2005). Maize hybrids generally outperform maize Open Pollinated Varieties (OPVs) (Muungani et al. 2007) though the latter are easier and less costly to produce due to unlimited pollination in the seed production field (Thomson 1979). Maize hybrid types vary in the number of parents constituting them (Beck 2002). A genotype is defined as an individual's genetic structure (Chikarate 2018). Maize inbred is a true breeding line which is homozygous at all loci. A maize single cross is constituted by crossing two maize inbreeds and a 3-way maize hybrid is constituted by crossing a single hybrid with an inbred, while crossing two single crosses will produce a double cross (Jugenheimer 1958). A top cross can be produced by crossing an OPV with either an inbred or a single cross. Amount of pollen production and seed produce ability decrease in the order: OPV or inbred bulk > Double Cross > 3-Way cross > Single Cross (MacRobert et al. 2014), albeit being in reverse order to grain yield potential of the respective maize types (Caulfield and Havazvidi 1989). It is important to isolate seed maize crops from cross pollination by neighbouring maize to maintain genetic purity of the hybrid seed under production (Kok 1985). Thomson (1979) outlined methods of protecting maize seed crops from foreign pollination and later on Caulfield and Havazvidi (1989) described the appropriation of Distance and Time Isolation in the prevention of genetic contamination of maize hybrid seed produced by maize seed Growers. Distance Isolation requirements for seed maize production vary considerably across Seed Certification Schemes of Different Countries, Regions and Institutions (Kok 1985). Scope of minimising Distance Isolation in the face of increasing pressure on land space was investigated by Kok (1985), while safety parameters in the effective use of Time Isolation were evaluated by Havazvidi (1989). In the event that maize hybrid seed produced does not meet minimum standards stipulated in Seed Certifying Schemes e.g. Government of Zimbabwe Statutory Instrument 213, Seed Certification Scheme notice 2000, Seed Act 40/65, blending of maize hybrid Seed Lots containing excessive genetic impurities with Seed Lots of the same hybrid seed carrying lower genetic impurities relative to Certification Standards will considerably save Seed Production loses (Havazvidi 2019). Conditions for blending are that the contaminating off-type or off-quality seed does not corrupt the resultant seed blend and that the size and shape of the off type seed is within the same grade and seed aleurone colour as the bulk of the final Seed Blend, for ease of machine planting and seed sorting (MacRobert et al.2014).

3. Materials and Methods

3.1 Scope for minimisation of Distance Isolation in maize seed production.

Kok (1985) measured genetic contamination in an SR52 white aleurone maize hybrid seed production covering a square field (250m x 250m). This test area was uniformly closely surrounded by a yellow aleurone maize single hybrid R90 intended to release seed contaminating pollen into the SR52 seed production field. This trial was conducted at Rattray Arnold Research Station (RARS) $17^0$40'S, $31^0$14' E at 1300m above sea level, during 1980/81, 1982/83and 983/84 seasons. Mass of yellow coloured off-type seed resulting from R90 foreign pollination in the SR52 seed crop, was subsequently measured and per cent seed contamination by mass was calculated in 700 sub divisions of the entire 250 m square seed field. Penetration distances of yellow seed contamination in the North, South, East and West quadrants of the SR52 seed production field were mapped at 5 % and 10% degrees of yellow contamination to inform on the scope of revision of Distance Isolation in maize seed production.

3.2 Derivation of Time Isolation Formulae and ascertainment of safety parameters for its effective prevention of genetic contamination in maize seed production.

Two Time Isolation Formulae ; first one applicable when a contaminant maize crop is planted first, followed by a maize seed crop and second one when a maize seed crop is planted first followed by a contaminant maize crop, were derived by Havazvidi (1989). The two Time Isolation Formulae are presented in Table 3.2.1 and Table 3.2.2 below:

Table 3.2.1. Havazvidi 1983 Time Isolation Formula 1: Contaminant maize crop planted first followed by seed crop

D.B.P = CI + ($DP_{95} – DS_5$) + Altitude effect + season effect + Soil effect + UV
Where
D.B.P = Day between plantings
CI = Time Isolation Constant 1 (days required to separate DP_{95} from DS_5)
DP_{95} = Days to 95% pollen shed of contaminant
DS_5 = Days to 5% silking of seed female parent
UV = Constant for unaccounted variation (99.9% confidence interval of ($DP_{95} – DS_5$) estimate

Table 3.2.2. Havazvidi 1983 Time Isolation Formula 2: Seed maize crop planted first followed by contaminant maize crop

D.B.P = C2 + ($DS_{95} – DP_5$) + Altitude effect + season effect + Soil effect + UV
Where:
D.B.P = Day between plantings
C2 = Time Isolation Constant 2 (days required to separate DS_{95} from DP_5)
DS_{95} = Days to 95% silking of the seed female parent
DP_5 = Days to 5% pollen shed of contaminant
UV = Constant for unaccounted variation. 99.9% confidence interval of ($DS_{95} – DP_5$) estimate

3.2.1. Evaluation of Havazvidi (1983) Time Isolation Safety Terms

3.2.1.1 .Evaluation of Time Isolation Constant C1

Time Isolation Constant C1 is defined as ($DP_{95} – DS_5$) the separation of terminal pollen shed (DP_{95}) in a contaminant maize pollen source from the initial silking (DS_5) of a female parent of a seed crop. This situation is presented pictorially in Figure 3.2.1.1 below:

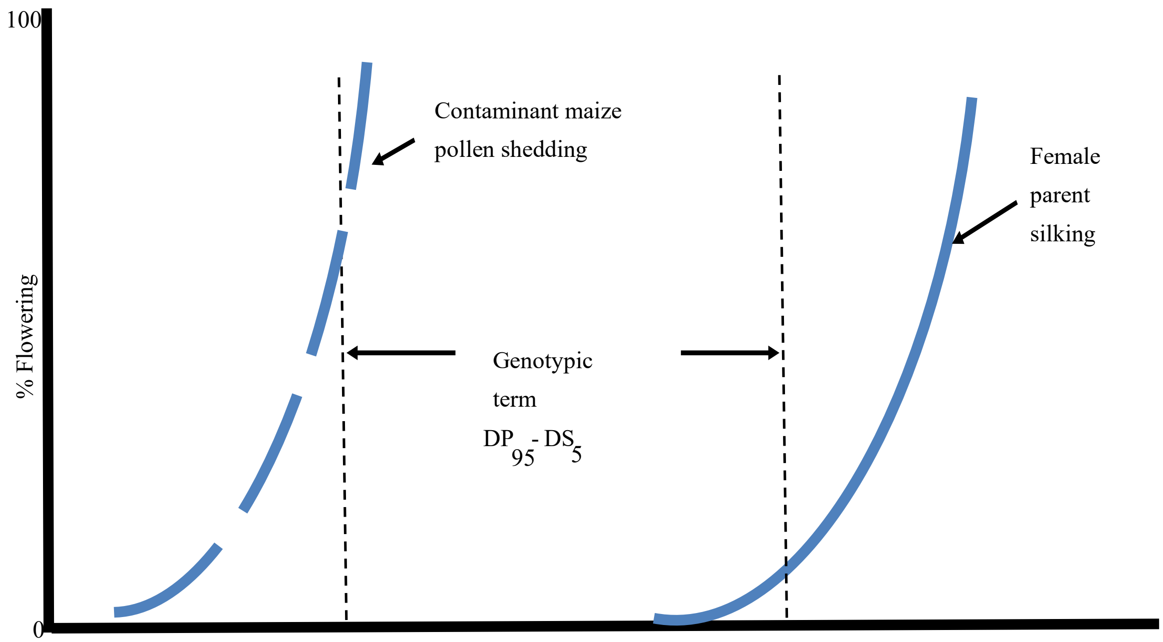

Fig 3.2.1.1: Time Isolation Constant C1 ($DP_{95} – DS_5$): Terminal pollen shed (DP_{95}) in maize contaminant source isolated by Time from initial silking (DS_5) in the female parent of a maize seed crop to maintain seed contamination levels within certification standards.

SR52 seed production plots were planted in a 2 Male: 6 Female: 2 Male pattern, uniformly surrounded by ZS206 yellow aleurone maize single hybrid. The SR52 seed production plots were laid in a 5 x 5 Latin Square design to remove residual variation in two directions. The first date of planting SR52 seed production coincided with time of planting ZS206. Subsequent plantings were carried out at seven day intervals up to 28 days after planting ZS206. Flowering progression records were taken in both SR52 seed production plots and ZS206 contaminant maize. Trials were conducted during 19/83/84, 1984/85 and1985/86 seasons at RARS. Percentage yellow contaminated grain in each SR52 seed production plot was measured and achieved Time Isolation ($DP_{95} – DS_5$), was calculated per date of planting SR52 seed crop. Percent contamination in SR52 seed was regressed on achieved Time Isolation with subsequent Student Newman Keuls Test of heterogeneity of the regression parameters and also comparison of the regression lines after Mead and Curnow (1983).

3.2.1.2 Evaluation of Havazvidi Time Isolation Constant C2

Time Isolation Constant C2 is defined as (DS_{95}-DP_5), the separation of terminal silking (DS_{95}) of a female parent of a seed crop from the initial pollen shed (DP_5) of a contaminant maize pollen source. This situation is presented pictorially in Figure 3.2.1.2 below:

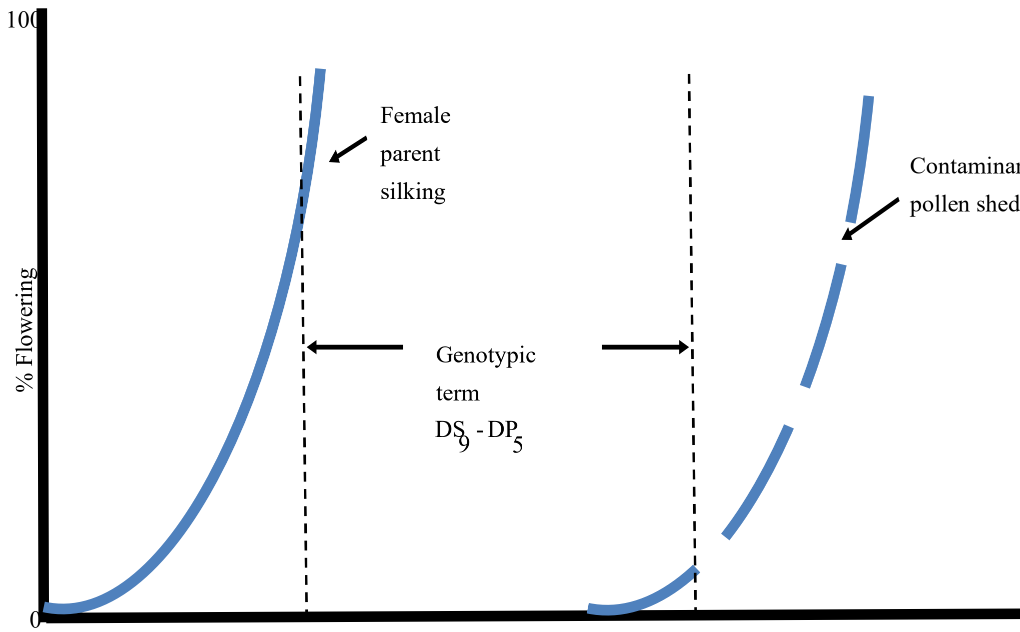

Fig 3.2.1.2: Time Isolation Constant C2 ($DS_{95} – DP_5$): Terminal silking (DS_5) in female parent of a maize seed isolated by Time from initial pollen shed (DP5) in maize contaminant source to maintain seed contamination within certification standards.

Time Isolation C2 was evaluated by planting SR52 seed production plots and also R201 3-way white aleurone maize hybrid in separate blocks, uniformly surrounded by ZS206 yellow aleurone single hybrid contaminant at RARS. SR52 seed production plots were laid down in a 6 x 6 Latin Square Design during 1986/87. SR52 and R201 seed production plots were laid in separate blocks using randomized complete block design with four replicates, in each hybrid trial.SR52 Seed Production plots were planted at 35 days and at 49 days before planting the ZS206 contaminant maize in 1986/87 and 1987/88, respectively. There after SR52 seed production plots were planted at seven day intervals down to the date of planting ZS206. Date of planting R201 parents was similar to those of planting SR52 parents during 1987/88. Flowering progression records were taken in SR52 and R201 parents as well as in ZS206 contaminant maize. Per cent contaminated yellow seed in the seed production plots was measured and achieved. Time Isolation (DS_{95}-DP_5) was calculated per date of planting of seed crops. Regression of per cent contamination on achieved Time Isolations was conducted, with subsequent testing of regression fits as in the foregoing evaluation of C1(DP_{95}-DS_5).

3.2.2 Evaluation of Environmental Terms in Time Isolation Formula 1 and 2.

Times from planting to initial and terminal flowering of a representative group of maize cultivars were recorded at different altitudes, different seasons and different soil conditions. The Time Isolation safety terms associated with genotypic and environmental causes of variation were evaluated and substituted in the Time Isolation formulae upon which the Time Isolation recommendations would be based. The genotypic Terms (DP_{95}-DS_5) and (DS_{95}-DP_5) were derived from meticulous flowering progression records taken in parents of maize hybrids and similar phonological records from commercial hybrid entries grown yearly for this purpose at RARS. Adjustment for unaccounted variation was taken as the 99.9% upper confidence interval (in days) in the estimation of C1 and C2. Analysis of variance of flowering data after testing for normality, additivity and homogeneity of variances following Little and Hills (1978) and Gomez and Gomez (1984).

3.3 Derivation of Blending Algorithms

Given a Seed Lot 'A' of quantity M1 and genetic purity α%, which is lower than Seed Certification requirements, algorithms were developed, to determine the quantity M2 of Seed Lot 'B' with genetic purity β% which exceeds Seed Certification Standards, to be thoroughly mixed with Seed Lot 'A' to yield a resultant 'Blend' (M1+M2) with Ω % genetic purity which meets Seed Certification Standards.

4. Results

4.1 Scope for minimising Distance Isolation.

Five and ten percent yellow contamination penetrations distances into SR52 seed production are presented for the three year data in Tables 4.1.1 and Table 4.1.2 below :

Table 4.1.1 Summary of measured penetration distances inclusive of 10m barrier for 5% of contamination (m)

Year	Cob	North	South	East	West	Mean (m)
1980-81	Top-cob	112.4	60.60	66.00	108.00	86.83
	Second-cob	119.2	59.50	72.50	105.80	89.30
1981-82	Top-cob	31.00	56.00	31.00	56.00	43.65
	Second-cob	34.80	61.50	30.00	65.00	48.03
Standard Deviation	:	47.96	2.41	22.53	27.05	24.46
Mean	:	74.35	59.40	49.88	83.70	66.95
n	:	4	4	4	4	4

Table 4.1.2 Summary of measured penetration distances inclusive of 10m barrier for 10% of contamination (m)

Year	Cob	North	South	East	West	Mean (m)
1980-81	Top-cob	74.25	26.00	34.00	67.00	52.50
	Second-cob	56.00	44.00	35.50	64.60	54.42
1981-82	Top-cob	13.00	28.00	14.25	27.25	20.07
	Second-cob	14.00	34.00	16.00	32.10	23.30
1982-83	Top-cob	140.00	103.00	146.00	97.25	121.60
Standard Deviation	:	52.30	32.08	55.02	28.64	
Mean	:	59.45	47.00	19.15	57.64	
n	:	5	5	5	5	

In Table 4.1.1, 5% penetration was greatest (119,2m) in the Northern quadrant in 1980/81 and the mean penetration over all quadrants was 66, 95 m. Penetration distance for the 10% level of contamination was greatest in the Eastern quadrant of the test area in 1982/83 dry season, which was considered for drawing up recommendations. Mean penetration for the 1982/83 was 121, 6 m and the overall mean of the four quadrants across years was 54, 38 m (Table 4.1.2).

4.2 Evaluation of Time Isolation Safety Parameters in Field Experiments

Yellow genetic contamination in SR52 and R201 seed crops at different dates of staggering planting SR52 and R201 parents after and before planting ZS206 yellow aleurone contaminant is presented in Tables 4.2.1 and Table 4.2.2 below.

Table 4.2.1: Mean percent contaminated seed mass and achieved Time Isolation (days) against gaps in days between planting contaminant maize ZS206 before planting SR52 seed crop in C1 evaluation.

Days delay in planting SR52 parents after planting ZS206	1983/84		1984/85		1985/86	
	% SR52 seed contamination	Days' Time Isolation	% SR52 seed contamination	Days' Time Isolation	% SR52 seed contamination	Days' Time Isolation
0	76.94	-1.2	87.64	3.0	86.21	0.0
7	17.66	2.4	48.72	0.8	61.36	4.4
14	0.03	11.4	10.14	7.4	3.80	9.2
21	0.03	20.2	0.14	14.8	0.03	12.6
28	0.02	24.2	0.03	21.8	0.03	19.0

Table 4.2.2 : Mean of percent contaminated seed mass and achieved Time Isolation (days) against delay in days between planting the contaminant maize ZS206 after planting SR52 and R201 seed crops in C2 evaluation.

Days delay in planting ZS206 parents after planting SR52 parents	1986/87		1987/88			
	% SR52 seed contamination	Days' Time Isolation	% SR52 seed contamination	Days' Time Isolation	% R201 seed contamination	Days' Time Isolation
49			0.00	37.3	0.07	43.5
42			1.10	29.8	0.07	35.0
35	2.28	17.0	0.58	22.0	0.18	27.5
28	2.38	10.3	2.89	14.3	1.95	20.8
21	3.17	13.8	15.34	-2.0	8.57	7.8
14	10.50	10.5	32.20	-2.2	18.02	5.8
7	90.91	5.4	81.33	-9.0	76.59	-3.2
0	49.02	7.2	76.52	-15.8	96.49	-8.0

Inadequate achieved Time Isolations resulted in higher genetic contamination during 1984/85 wet season as shown in Table 4.2.1. Time Isolation Constant C1 was determined from the results of this season. Determination of Time Isolation Constant C2 was based on 1987/88 results presented in Table 4.2.2. Very low levels of contamination were recorded at 42 days of planting SR52 and R201 seed crops before planting ZS206 yellow contaminant. Linear regression models of per cent yellow contamination on achieved Time Isolation fitted the data well when ZS206 yellow contaminant was planted before planting SR52 seed production plots. The 1984/85 regression model presented in Figure 4.2.1 below , was considered for determining Time Isolation Constant C1 because it was the most vulnerable to contaminating; being a rainy season encourages fast development of the female parent of SR52 and late pollen shedding in ZS206 contaminant source.

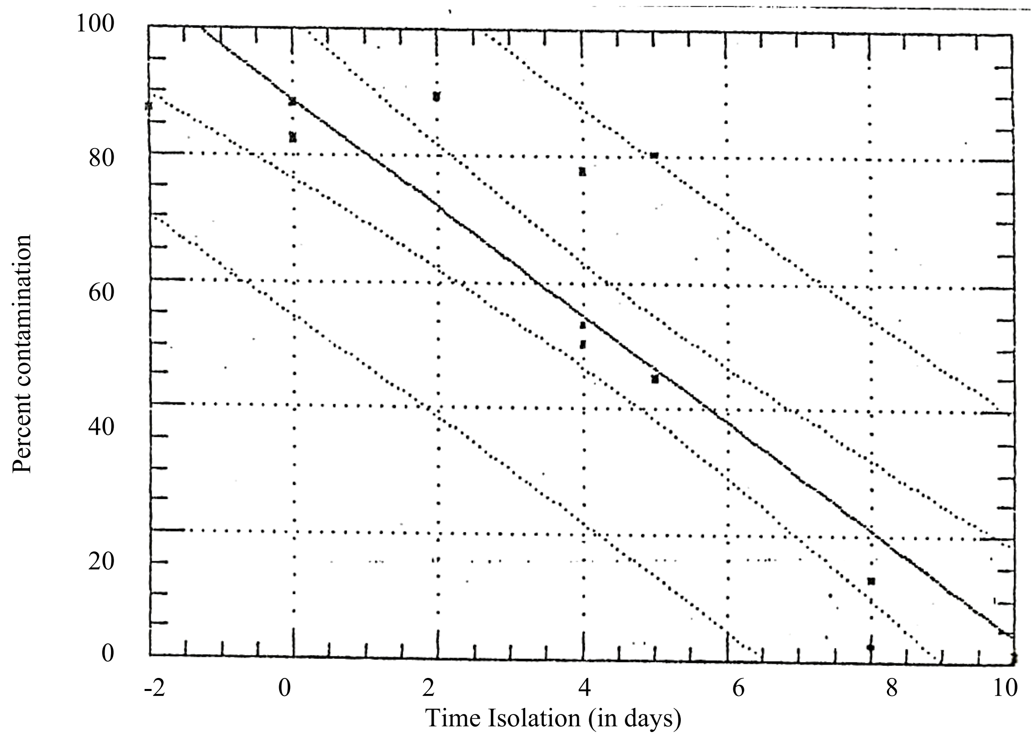

Figure 4.2.1 Linear regression plot of percent contamination on Time Isolation (in days) of initial silking of N3-2-3-3 from terminal pollen shed of ZS206 in 1984/85 season, with 95% confidence belt for estimates of mean value of percent contamination (inner belt), and that for estimates of individual value of percent contamination (outer belt) for specific values of Time Isolation

The linear regression parameter estimates their levels of significance as well as comparison of those regressions are presented in Tables 4.2.3 and 4.2.4, respectively below:

Table 4.2.3 linear regression estimates of percent contamination on achieved Time Isolation (DP_{95}–DS_5) for parents of SR52 planted at varying dates after a yellow contaminant source ZS206

Season	**Estimate**				**Percent**	**Residual**
	a	**S.E. a ±**	**b**	**S.E. b ±**	**R^2**	**D.F.**
1983/84	56,33	3,537	- 15,05	1,769	90,1	8
1984/85	58,95	4,834	- 4,20	0,548	77,6	17
1985/86	88,93	5,870	-8,49	0,984	85,1	13

a = intercept of the regression line, b = slope of the regression line

Table 4.2.4 Statistical comparison of regressions in C1evaluation

Regression source	D.F.	M.S.
Single line	1	34 397 ***
Parallel lines about single line	2	2 121 ***
Separate lines about parallel lines	2	2 491 ***
Residual	38	198 ***

*** = Significant at P = 0,001

Significance of the separate lines and the parallel lines models indicate that per cent contamination in the SR52 seed crop resulting from inadequate Time Isolation was different across years but the rate of increase was almost similar.

Natural (Naperian) logarithmic transformation of degrees of contamination linearized the curvilinear relationship of per cent contamination with time isolation when parents of SR52 and R201 were planted before ZS206 yellow contaminant during 1986/87 and 1987/88. The 1987/88 regression methods are presented in figures 4.2.2 and 4.2.3 for SR52 and R201 seed production , respectively below:

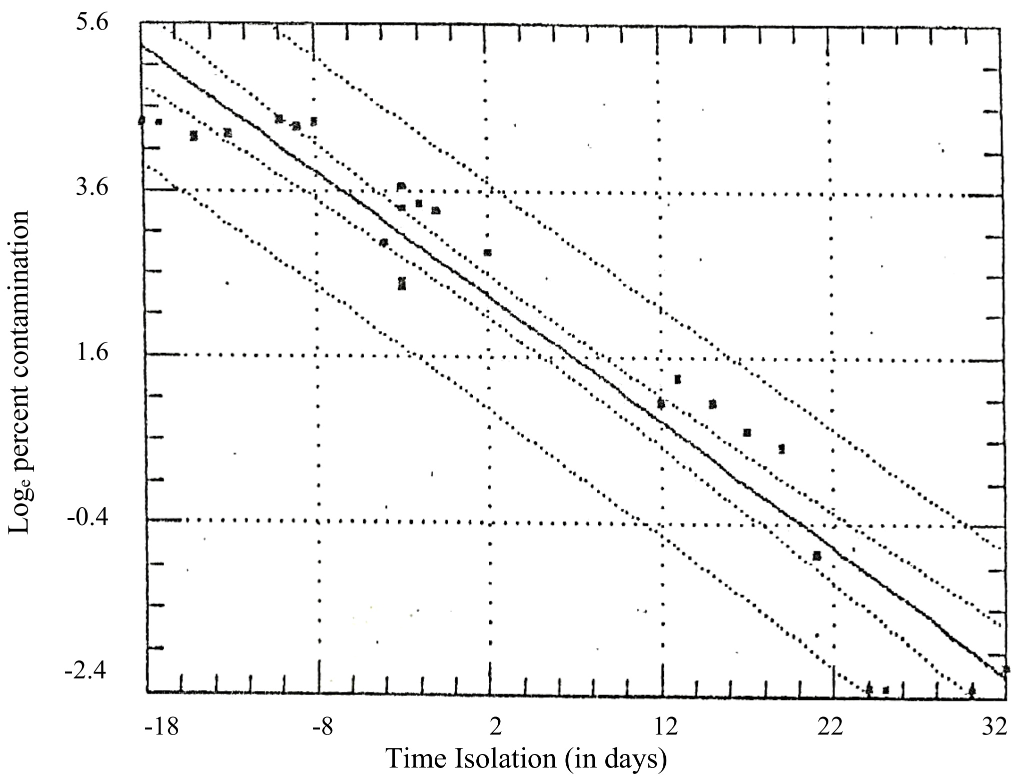

Figure 4.2.2 Linear regression plot of percent contamination on Time Isolation (in days) of terminal silking of N3-2-3-3 from initial pollen shed of ZS206 in 1987/88 season, with 95% confidence belt for estimates of mean value of percent contamination (inner belt), and that for estimates of individual value of percent contamination (outer belt) for specific values of Time Isolation.

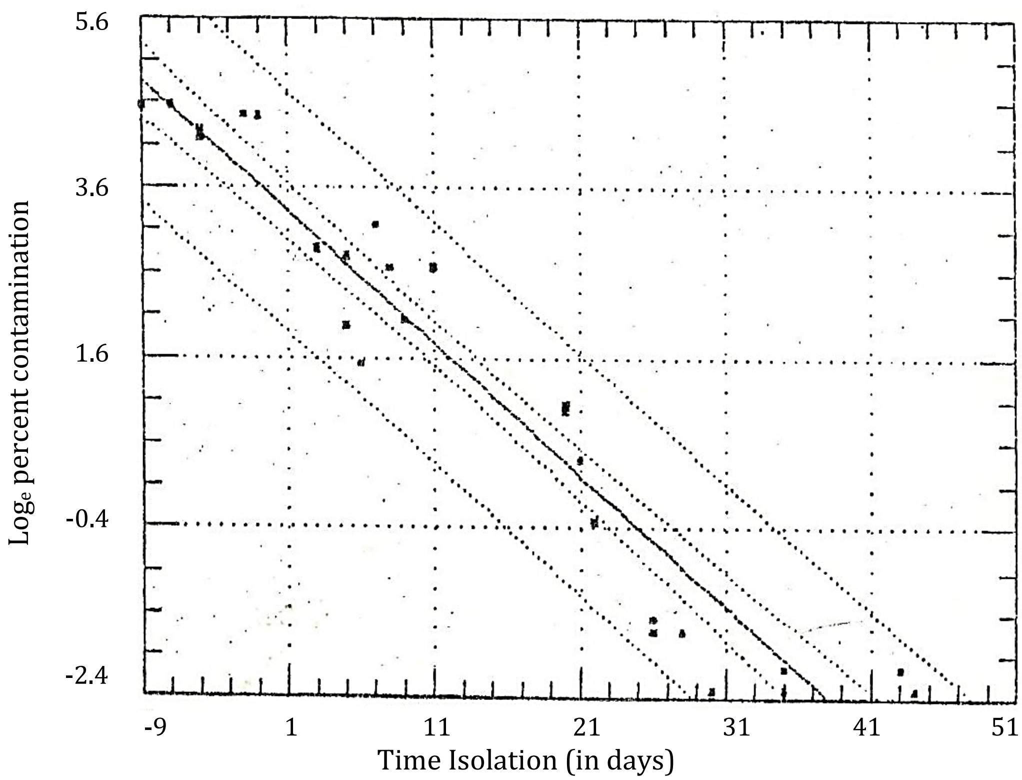

Figure 4.2.3.Linear regression plot of Log_e percent contamination on Time Isolation (in days) of terminal silking of SX6 from initial pollen shed of ZS206 in 1987/88 season, with 95% confidence belt for estimates of mean value of percent contamination (inner belt), and that for estimates of individual value of percent contamination (outer belt) for specific values of Time Isolation.

The linear regressions of degrees of contamination on Time Isolation in the evaluation of Time Isolation Consultant C2 were highly significant as shown in table 4.2.5 below:

Table 4.2.5 linear regression estimates of log_e percent contamination on calculated Time ....Isolation (DS_{95}-DP_5) for parents of SR52 and SX6 planted at varying dates before planting ZS206 at Rattray Arnold Research Station in 1986/87and 1987/88 seasons

Pistillate parent and season	**Estimate**				**Percent R^2**	**Residual D.F.**
	a	**S.E. a ±**	**b**	**S.E. b ±**		
N3-2-3-3 in 1986/87	3,142	0,164	- 0,152	0,014	76,8	34
N3-2-3-3 in 1987/88	2,630	0,131	- 0, 150	0,009	92,8	24
SX6 in 1987/88	3,474	0,164	- 0,154	0,008	93,5	26

Means of Genotypic terms (DS_{95}-DP_5) (DS_{95}-DS_5) and their standard errors when flowering progression records in different maize genotypes at different altitudes over different seasons , are presented in tables 4.2.6 and 4.2.7 below :

Table 4.2.6 Mean differences in days between termination of pollen shed in pollen parents and initial silking in pistillate parents (DP_{95}-DS_5) for different maize cultivar combinations grown in a range of soil types at two altitudes during two summer seasons (1983/84 and 1985/86)

CULTIVAR COMBINATION		**ALTITUDE**		**MEAN**
Female	Male	1 100m	1 500m	
N3-2-3-3	SC5-5-2-2	16,23	14,23	15,23
N3-2-3-3	K64r	12,20	14,13	13,17
N3-2-3-3	SR52	11,80	9,17	10,48
SX6	SC5-5-2-2	17,27	15,93	16,60
SX6	K64r	13,23	14,83	14,03
SX6	SR52	12,90	9,83	11,37
S.E. of means ±		0,663		0,469
SEASON				
1983/84		12,54	9,72	11,13
1985/86		15,33	16,54	15,94
S.E. of means ±		0,383		0,270
		SEASON		
SOIL TYPE ‘EFFECT’		1983/84	1985/86	
Poor		13,72	17,80	15,76
Average		11,72	15,60	13,66
Good		7,97	14,42	11,19
S.E. of means ±		0,469		0,332

Table 4.2.7 Mean differences in days between termination of silking in pistillate parents and initial pollen shed of pollen parents (DS_{95}-DP_5) for different maize cultivar combinations grown in a range of soil types at two altitudes during two summer seasons (1983/84 and 1985/86)

CULTIVAR COMBINATION		**ALTITUDE**		**MEAN**
Female	Male	1 100m	1 500m	
N3-2-3-3	SC5-5-2-2	12,90	14,40	13,65
N3-2-3-3	K64r	10,07	11,67	10,87
N3-2-3-3	SR52	13,00	17,17	15,08
SX6	SC5-5-2-2	11,33	15,57	13,45
SX6	K64r	8,43	13,93	11,18
SX6	SR52	11,43	19,07	15,25
S.E. of means ±		0,635		0,444
SEASON				
1983/84		10,91	11,86	11,38
1985/86		11,48	18,74	15,11
S.E. of means ±		0,367		0,259
		SEASON		
SOIL TYPE ‘EFFECT’		1983/84	1985/86	
Poor		14,32	17,03	15,68
Average		11,47	14,85	13,16
Good		8,37	13,45	10,91
S.E. of means ±		0,449		0,318

Altitude, season and Soil Type effect were estimated from the altitude x genotype, altitude x season, altitude x soil type interaction matrices in preceding Table 4.2.6 and Table 4.2.7.

4.3Derivation of Blending Formula to conform seed lots to meet Certification Standards of genetic or physical purity

4.3.1 Havazvidi (2014) Algorithm 1**:** Finding M when (M:1) is the mixing ratio of quantities and percentage purities in Seed Lots are specified.

Let M = quantity of Superior Lot (M)

and 1 = quantity of lot (A)

Where

a = Percent (genetic or physical purity) of inferior Lot (A)

b = Percent (genetic or physical purity) of superior Lot (M)

c = Percent (genetic or physical purity) of resultant Blend (M+A)

Hence M = (100a-100c)/(100c-100b)

= (a-c)/(c-b) (usable in Excel format)

To validate, if;

a = 20%

b = 95%

c = 90%

Then M = ((20-90)/(90-95))

= -70/-5

= 14

Therefore, the mixing or blending ratio is **14M:1A**

4.3.2 Determination of Percent genetic or physical purity (c) of a given Blend (M+A) when Percent Purity of M and A are known:

Percent purity of Blend (M+A), c = (bM+a)/(M+1) (usable in Excel format)

where

b = % genetic or physical purity of Superior Lot (M)

a = % genetic or physical purity of Inferior Lot (A)

and M = Proportion of Superior Lot (M) in ratio M:A = M:1

5. Discussion

5.1 Scope for minimising Distance Isolation.

SR52 white seed crop was worst contaminated by bordering ZS206 yellow contaminant in 1983/84 dry season, with mean 10% yellow contamination penetration distance of 121.6m. This penetration distance takes account of dilution of contamination by pure seed across all four quadrants. Distance Isolations specified in various Seed Certification Schemes can be safely reviewed backwards provided winds are not excercebating and that synchronisation of parents of maize hybrids under production is satisfactory.

5.2 Evaluation of Time Isolation Safety Parameters

Time Isolation Constant C1(DP_{95}-DS_5) read off from 1984/85 Regression Line represented the worst situation in terms of late maturity female inbred parent SC52 and good rainy conditions for seed crop catch up with earlier planted contaminant maize . C1 was then 15 days with an adjustment of one (1) day for unaccounted variation, UV taken as the upper limit of the confidence interval in estimating (DP_{95}-DS_5). Time Isolation Constant C2 (DS_{95}-DP_5) was read off from regression models of SR52 seed production and R201 seed production, as 30 days and 35 days respectively. R201 female parent lost Time Isolation because its silks stays viable and receptive to pollination longer than inbred female parents of SR52 single hybrid. An adjustment of one (I) day, for the unaccounted variation in estimating (DS_{95}-DP_5) was incorporated in both cases. Time Isolations involving planting contaminant sources first followed by seed crops are narrower and vice versa. The following Environmental Safety Factors were extracted from the Genotype x Altitude x Season x Soil Type interaction matrices of (DP_{95}-DS_5) for C1 and (DS_{95}-DP_5) for C2 as follows :

	C1: (DP_{95}-DS_5)	C2 : (DS_{95}-DP_5)
Altitude effect >1300m (days)	1	3
Season effect>1300m (days)	1	2
Soil Effect across altitudes (days)	3	3

The number of days in the columns must be added in computing Time Isolations at altitudes above 1300m in receptive Time Isolation Formulae.

5.3 Havazvidi (2014) Blending Algorithms

The blending algorithms can be applied in conforming Seed Lots to Seed Certification Standards provided the seed defects do not corrupt the resultant blend. The formulae can also be applied in Industrial Blending.

6. Conclusions

Distance Isolations in the prevention of genetic contamination in seed maize production, can be revised backwards particularly when good pollinator male parents and good synchronisation of flowering of male and female parents are ensured. Effective Time Isolation of seed maize crops from maize contamination can be calculated from Havazvidi (1989) C1 and C2 Formulae inserting safety parameters estimated in this project. Seed Lots not meeting Seed Certification can be reclaimed by blending with above Standard Seed Lots using Havazvidi (2014). Blending Algorithms provided the seed contaminant does not corrupt the resultant seed blend.

Acknowledgements

I am grateful to Professor Charles Mbowa and IEOM Society for inviting me to present this Paper. I greatly appreciate Seed Co Zimbabwe for providing time and resources for this research project. Michael Caulfield , Sr Jane Canao, Professor Pangirayi Tongoona and Davidson Mugwenhe helped immensely in the conduction of the projects and presentation of results. My deep and sincere gratitude is here extended to my grandchildren Ivy (Junior) Ruvarashe Florence Havazvidi and Tapiwanashe Isheanesu Michael Shumba for their dire effort in typing and organising this paper. My spouse Elizabeth Ivy (Senior) and children gave me moral support and encouragement for which I am deeply thankful.

Biography

Dr Ephrame Kudzaishe Havazvidi is the Senior Group Research Consultant for Seed Co Group Ltd, in retirement. He has served this top Pan African Seed Organisation for forty years since 1980. Dr Havazvidi headed Seed Co Group Research and Development Function for ten years (2005-2015) during which he recruited, mentored, trained and directed a Team of Plant Breeders to top performance in the region. Dr Havazvidi and his Team significantly raised genetic grains in maize, wheat, and soyabean varieties in pertinent traits such as grain yield, disease tolerance, climate resilience and heat and drought tolerance, conferring wide adaptation across Sub Saharan Africa. Dr Ephrame Havazvidi released thirty high Industrial Quality wheat varieties whose top yield performance enabled Zimbabwean irrigated spring wheat farmers to rank top in the world in 1996 up to 2014. There after this crown slipped to Egypt upon land ownership reforms. Dr Havazvidi has been nominated by SAPBA among the top twenty influential Plant Breeders in Africa after receiving the C.F.U 'Alan Pilditch ' and the Zimbabwe Wheat Board 'Wheat Legend ' awards for significant contribution to the Wheat Value Chain Industries in Southern Africa. Dr Ephrame Havazvidi holds a BSc Agric Crop Science Degree (1976), a Master of Philosophy Degree in Seed Technology (1989), a Doctor of Philosophy Degree in Plant Breeding (2003) and an Executive Development Program (EDP) Certificate (2005), all of the University of Zimbabwe. He also holds a Diploma in Cereal Technology of El Bataan CIMMYT H/Q in Mexico. Dr Havazvidi is a member of the Wheat Independent Steering Committee of CGIAR CIMMYT, representing SSA. He is also a member of Zimbabwe Wheat Board (ZWB), University of Zimbabwe Council, ZPBA, CSSZ and SAPBA.

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