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Performance Evaluation of Herbicide-Resistant Maize Hybrids under Striga Infestation

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Abstract: **Striga hermonthica is the most widespread species affecting maize production and productivity in sub-Saharan Africa. Use of imidazolinone (imazapyr)-resistant (IR) maize genotypes is one of the few control options, which seem to be technically feasible and cost effective. A study was carried out to assess yield and agronomic performance of 21 herbicide-resistant maize hybrids introduced from CIMMYT for Striga control at Pawe, Ethiopia. Analysis of variance revealed significant genotypic difference for grain yield, days to anthesis, root lodging and ear aspect. Hybrids G8 and G7 were identified as promising varieties based on grain yield, ear aspect, and Striga emergence counts. The highest yielding IR maize hybrid (G8) outyielded the Striga-tolerant, commercial IR hybrid and local check by 89.4, 107.3 and 89%, respectively. The best IR hybrid in terms of grain yield (G8) had 81 and 64% less emerged Striga plants at compared with the Striga-tolerant check (G22) and local check (G25), respectively. Genotypic variance (σ^2G) estimates were larger than environment variance (σ^2 E) for grain yield, days to anthesis, root lodging and ear aspect. Very high heritability coupled with high genetic advance was observed for grain yield indicates the dominance of additive gene action in governing the trait which is fixable in subsequent generations. Grain yield showed significant and negative correlations with days to anthesis (rp = −0.69), root lodging (rp = −0.56), ear aspect (rp = −0.83) and plant aspect (rp=-0.79). A negative but not significant correlation coefficient between grain yield and Striga count was observed.**

Keywords: **Grain yield, Herbicide-resistant, Heritability, Imidazolinone-resistant, Maize, Striga hermonthica.**

1. INTRODUCTION

Striga spp., known as witchweeds, are obligate root-parasitic flowering plants indigenous to Africa, and constitute the most important biological constraint limiting maize production and productivity in sub-Saharan Africa (SSA) (Makumbi et al., 2018). The four major parasitic witchweed species that attack maize and other cereal crops are Striga hermonthica (Del.) Benth., Striga asiatica (L.) Kuntze, Striga aspera (Willd.) Benth., and Striga forbesii Benth (Badu-Apraku, & Fakorede 2017). Among them, Striga hermonthica is the most widely distributed in SSA, and cause the most economic damage to maize. Continuous depletion in soil fertility due to mono-cropping practice, and limited and ineffective control options aggravates the Striga infestation in field crops, such as maize, sorghum (Sorghum bicolor [L.] Moench), rice (Oryza sativa L.) and pearl millet (Pennisetum glaucum [L.] R. Br.) (Mrema et al., 2017). Yield losses from Striga parasitism range from 20 to 80% and may suffer complete yield losses under severe Striga infestation (Khan et al., 2006; Ejeta, 2007). Striga management approaches such as crop rotation and intercropping involving legumes (Carsky et al., 2000; Oswald and Ransom, 2001), application of organic and inorganic fertilizers (Gacheru and Rao, 2001), herbicide treatment (Kanampiu et al., 2003) and the use of tolerant and resistant varieties (Badu-Apraku and Lum, 2007; Menkir et al., 2012b) can partially reduce the problem. Control of Striga is difficult due to the ability of the parasite to produce a tremendous number of seeds that may remain viable in the soil for more than 15 year and the intimate physiological interaction of the parasite with host plants (Bebawi et al., 1984).

The use of varieties resistant/tolerant to Striga spp. is the most effective, economically feasible, and sustainable means for Striga damage control by resource-poor farmers of sub-Saharan Africa (Badu-Apraku et al., 2007). Maize breeding at the International Institute of Tropical Agriculture (IITA) has reportedly produced varieties with some level of tolerance /resistance to striga (Kim, 1994) and S. hermonthica-resistant (STR) varieties are being adopted in West Africa (Badu-Apraku and Lum 2007; Menkir et al. 2010, 2012a). However, so far no resistant maize cultivar is commercially available in Ethiopia.

Use of imidazolinone (imazapyr) resistant (IR) maize genotypes is one of the few control options, which seem to be technically feasible and cost effective in small-scale holdings since it allows a very efficient and season-long control of striga emergence (Kanampiu et al., 2003). This novel approach is based upon inherited resistance of maize to a systemic herbicide (imazapyr), a mechanism widely referred to as imazapyr resistance (IR) that was derived from a naturally occurring gene in maize originally identified by researchers at BASF, a multinational producer and supplier of chemicals and made available to International Maize and Wheat Improvement Center (CIMMYT) (Kanampiu et al., 2003). Those maize genotypes, which possess the gene for imidazolinone-resistance successfully, germinate after being coated with the herbicide. The CIMMYT and partners incorporated the IR-gene into African maize varieties following conventional breeding methods and have developed the IR-maize (Clearfield®) seed coating technology for Striga control in maize (Kanampiu et al., 2003). The technology involves coating of non-transgenic, imidazolinone-resistant (IR) maize seed with low doses of an acetolactate synthase-inhibiting herbicide, imazapyr (30 g a.i. ha^{-1}), for early Striga control before or during attachment to the maize roots (Kanampiu et al., 2001). Several IR maize varieties were developed and tested in artificially and naturally Striga-infested fields for Striga control in Kenya with promising varieties identified for wider testing in Striga-infested areas in eastern and central Africa (Makumbi et al., 2018). Therefore, the objective of this study was to assess yield and agronomic performance of herbicide-resistant maize hybrids for Striga control.

2. MATERIALS AND METHODS

2.1 EXPERIMENTAL MATERIALS AND SITE

Twenty-one imidazolinone-resistant (IR) hybrids sourced from The International Maize and Wheat Improvement Center (CIMMYT) was evaluated for this study. Four hybrids checks (a commercial hybrid WH403, a Striga tolerant hybrid WH502, a commercial IR hybrid ‘Ua Kayongo’ and a local check hybrid BH-540) were included in the trial (Table 1). The 21 IR hybrids and checks were evaluated on-station at Pawe under Striga infestation environment during the long rainy season of 2008. Pawe is located at 11°15'N and 36°05'E, with an elevation of 1050 meters above sea level. The mean annual rainfall is 1585 mm, and the mean minimum and maximum temperatures of the area are 16.4 and 32.1°C, respectively. The soil is nitosol with a pH ranging from 5.3-6.0.

2.2 EXPERIMENTAL DESIGN AND FIELD MANAGEMENT

The experimental design was a five by five simple lattice with two replications. Each plot consisted of a single-row plot, 5.1 m long with inter-row spacing of 0.75 m and intra-row spacing of 0.30 m, resulting in a population density of 44,444 plants ha^{-1}. 100 Kg/ha of urea and 100 Kg/ha of Diammonium Phosphate (DAP) was applied of which the entire dose of DAP was applied at planting while half of the urea was applied at planting and the remaining half was top dressed at 35 days after planting. All weeds except Striga were removed before they became critical for nutrient competition. Agronomic and cultural practices were performed as recommended for the location.

2.3 DATA COLLECTION

Data were collected on days to anthesis (AD, days from planting to when 50% of the plants had shed pollen) and days to silking (SD, days from planting to when 50% of the plants had extruded silks). Anthesis–silking interval (ASI) was determined as the difference between days to silking and days to anthesis. Ear height (EH, measured in centimeters as the distance from the base of the plant to the node bearing the top ear), number of ears per plant (EPP, determined by dividing the total number of ears per plot by the number of plants harvested per plot), ear aspect (EA, rated on a scale of 1 to 5, where 1 = nice uniform cobs with the preferred texture and 5 = cobs with the undesirable texture), plant aspect (PA, Plant aspect was rated on a scale of 1–5, where 1 = excellent overall phenotypic appeal and 5 = poor overall phenotypic appeal) and root lodging (RL, the percentage of plants leaning more than 30° from the vertical). The number of emerged Striga plants was recorded on a plot basis at 8 week after planting (WAP). All ears harvested from each plot were weighed and representative samples of ears were shelled to determine percentage moisture using a Dickey Jones moisture meter. Grain yield (kg ha^{-1}) of the experiment was computed from the shelled kernel dry weight and adjusted to 12.5% moisture.

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Table 1: List of 21 herbicide-resistant maize hybrids and 4 checks and their origins.

Entry	Pedigree	Origin
G1	INTA/INTB-B-41-B-1-1//CML395-IR/ CML202-IR	CIMMYT-Kenya
G2	CML312-IR/CML390-IR/CML373-IR	CIMMYT-Kenya
G3	CML202-IR/CML204-IR/CML444-IR	CIMMYT-Kenya
G4	CML390-IR/CML373-IR/CML445-IR	CIMMYT-Kenya
G5	INTA/INTB-B-52-B-8-1//CML395-IR/ CML202-IR	CIMMYT-Kenya
G6	INTA/INTB-B-215-B-5-1//CML395-IR/ CML202-IR	CIMMYT-Kenya
G7	INTA/INTB-B-132-B-5-1//CML395-IR/ CML202-IR	CIMMYT-Kenya
G8	INTA/INTB-B-121-B-19-1//CML395-IR/ CML202-IR	CIMMYT-Kenya
G9	INTA/INTB-B-110-B-6-1//CML395-IR/ CML202-IR	CIMMYT-Kenya
G10	CML390-IR/CML373-IR/CML395-IR	CIMMYT-Kenya
G11	CML395-IR/CML202-IR/CML444-IR	CIMMYT-Kenya
G12	INTA/INTB-B-161-B-3-1//CML390-IR/ CML373-IR	CIMMYT-Kenya
G13	CML390-IR/CML373-IR/CML444-IR	CIMMYT-Kenya
G14	CML312-IR/CML390-IR/CML395-IR /CML445-IR	CIMMYT-Kenya
G15	CML390-IR/CML373-IR/CML395-IR/CML445-IR	CIMMYT-Kenya
G16	CML390-IR/CML373-IR/CML444-IR/CML445-IR	CIMMYT-Kenya
G17	INTA/INTB-B-116-B-2-1//CML395-IR/ CML202-IR	CIMMYT-Kenya
G18	CML390-IR/CML373-IR/CML445-IR	CIMMYT-Kenya
G19	CML312-IR/CML395-IR/CML202-IR /CML204-IR	CIMMYT-Kenya
G20	CML373-IR/CML445-IR/CML202-IR /CML204-IR	CIMMYT-Kenya
G21	SYNTH2006-IR-#-#/CML202-IR /CML204-IR	CIMMYT-Kenya
G22	WH502 (Striga tolerant)	CIMMYT-Kenya
G23	WH403	CIMMYT-Kenya
G24	UA KAYONGO	CIMMYT-Kenya
G25	BH-540(LOCAL CHECK)	Ethiopia

2.4 STATISTICAL ANALYSIS

Lattice-adjusted genotype means were calculated for the experiment using PROC MIXED procedures of SAS (SAS Institute, 2011) with genotypes considered as fixed effects and replicate and incomplete blocks within replicates considered as random factors. Means were separated using the LSD. Phenotypic, genotypic and environmental variances were computed from the respective mean squares following the procedures suggested by Singh and Chaudhary (1985). The genotypic and phenotypic coefficients of variation were estimated according to the procedure outlined by Johnson et al. (1955). Broad-sense heritability (H) was estimated according to Singh and Chaudhary (1985). Genetic advance (GA) and genetic advance as percent of the mean (GAM), assuming selection of the superior 5% of the genotypes, were determined by the formula illustrated by Johnson et al. (1955). Simple correlation analysis was calculated for all trait combinations based on means of hybrids using PROC CORR in SAS (SAS Institute, 2011).

3. RESULTS AND DISCUSSIONS

3.1. ANALYSIS OF VARIANCE AND MEAN PERFORMANCE

Grain yield was highly significant ($P < 0.001$) among the hybrids evaluated (Table 2). This implies that there were differences in performance among the varieties. The mean grain yield was 3766.6 kg/ha and the variation observed for grain yield ranged from 1300.9 to 7027.5 kg/ha. Hybrids G8 and G7 gave the highest grain yield while hybrid G11 gave the lowest yield (1300.9 kg/ha). Among the 21 IR hybrids tested, 38% had significantly higher grain yield than the Striga-tolerant check, commercial IR hybrid check G24 ('Ua Kayongo ') and local check G25 (BH-540). The highest yielding IR maize hybrid G8 had a yield advantage of 89.4, 107.3 and 89% over the striga-tolerant check G22 (WH502), commercial IR hybrid check G24 ('Ua Kayongo') and local check G25 (BH-540), respectively (Table 3). Similar findings were reported by Makumbi et al. (2015) for IR maize OPVs in Eastern Africa and Menkir et al. (2010) for IR maize hybrids in Nigeria under Striga infestation. Hybrids G8 and G7 also exhibited the best ear aspect. The usefulness of the ear aspect in the assessment of host plant response to Striga infection was reported by other workers (Kim et al., 1997).

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Table 2: Analysis of variances for grain yield and other agronomic traits

Traits	Range of variation	Genotypic Mean Square	Mean	CV (%)	Error Mean Square
GY (kg ha^{-1})	1300.9-7027.5	3854097***	3766.6	19.9	561004
AD (days)	61.5-71	12.8***	66.8	2	1.72
ASI (days)	2-6.8	2.89ns	4.3	30.8	1.75
EH (cm)	93.9-122.7	96ns	108.5	8.7	88.89
RL (%)	2.8-69.8	503.1*	28.3	52.4	219.69
EPP (#)	0.7-1.2	0.03ns	0.916	15.7	0.02
EA (1-5)	0.9-4	1.08*	2.1	29	0.37
PA (1-5)	1.3-4.4	1.2ns	2.6	31.7	0.68
STRC (#per 3.825 m^2)	3-20.5	38ns	9.8	62	36.9339

*P < 0.05. ***P < 0.001. ns, not significant, GY=grain yield, AD=days to anthesis, ASI=anthesis-silking interval, EH=ear height, RL=Root lodging, EPP=number of ears per plant, EA=ear aspect, PA=plant aspect, STRC=striga count per plot

There were no significant differences in Striga counts among the hybrids. The number of emerged Striga plants varied from 3 to 20 at 8 WAP for the IR maize hybrids, while the Striga-tolerant hybrid check G22, Striga-susceptible hybrid check G23, commercial IR hybrid check G24 and local check G25 had 11, 12, 5 and 21 emerged Striga plants, respectively. Among the 21 IR hybrids tested, 5 hybrids (G17, G8, G6, G7 and G12) supported lower number (3-6) of emerged Striga plants. The best IR hybrid in terms of grain yield (G8) had 81 and 64% less emerged Striga plants at 8 WAP compared with the Striga-tolerant check (G22) and local check (G25), respectively. Herbicide-resistant maize varieties have been reported to support a lower number of Striga plants in other studies (Kanampiu et al., 2003; Menkir et al., 2010; Makumbi et al., 2015). In spite of support high striga emergence, G5 produced higher grain yield (Table 1). This is an indication that this variety exhibited some levels of tolerance to Striga hermonthica. Tolerance refers to the ability of a maize genotype to produce relatively better grain yield and biomass under Striga infestation compared to susceptible genotypes (Badu-Apraku, B., & Fakorede, 2017). Earlier results on maize showed that the extent to which striga affects maize is dependent on host ability to tolerate the parasite (Kim and Adetimirin, 1997). Similarly, recent studies have also indicated that tolerant genotypes of maize permit and support as many striga plants as susceptible genotypes, but produce more grain (Menkir et al., 2010; Karaya et al., 2012).

Table 3: Performance of 21 herbicide-resistant maize hybrids and four checks under Striga-infested conditions at Pawe

Entry	GY	AD	ASI	EH	RL	EPP	EA	PA	STRC
G1	5741.5	66.0	5.0	115.7	8.8	1.0	1.5	1.6	7.0
G2	2298.9	66.0	6.4	97.8	17.4	0.8	2.0	2.9	10.5
G3	1932.6	71.0	5.0	114.9	32.4	0.7	2.9	3.1	11.5
G4	4346.4	64.5	3.7	109.0	21.7	1.2	1.9	2.0	10.5
G5	6141.9	67.0	3.1	107.1	16.7	1.0	1.3	1.3	13.0
G6	3302.4	67.0	3.4	118.5	54.8	0.9	2.4	3.3	4.0
G7	6536.6	66.0	5.2	118.9	11.0	1.0	1.0	1.3	6.0
G8	7027.5	61.5	3.3	105.5	16.0	0.9	1.0	1.8	4.0
G9	5344.1	66.0	5.2	106.5	2.8	1.0	1.1	2.0	7.5
G10	3037.1	66.0	6.8	118.8	18.2	1.0	2.6	2.1	8.5
G11	1300.9	71.0	5.1	102.9	69.8	0.7	3.5	4.4	9.0
G12	5161.7	62.0	4.7	110.1	34.2	0.9	1.9	2.5	6.0
G13	2420.5	68.5	4.8	97.9	28.2	0.8	4.0	4.0	8.5
G14	3703.2	66.0	3.6	104.8	15.7	1.0	1.5	2.2	13.0
G15	2931.0	66.0	5.6	112.0	23.0	1.1	2.6	2.7	11.5
G16	3593.1	66.0	3.4	104.4	41.5	1.1	2.4	2.7	10.5
G17	4783.8	66.0	5.7	109.8	14.6	0.8	1.6	1.7	3.0
G18	3154.8	66.0	5.2	107.2	48.4	1.1	2.1	3.2	11.0
G19	2830.8	69.5	3.4	122.7	24.5	1.1	3.0	3.8	19.5
G20	2320.5	69.5	2.7	108.4	20.9	1.0	2.7	2.4	7.0

G21	2076.1	71.0	3.6	107.1	40.6	0.9	2.5	3.5	14.5
G22	3710.3	69.5	2.9	93.9	22.3	0.9	1.7	1.8	11.0
G23	3158.9	67.7	3.4	104.1	48.7	0.8	1.7	3.8	12.4
G24	3390.2	68.0	4.7	101.8	32.0	0.9	2.4	2.7	5.0
G25	3919.7	63.5	2.0	111.4	44.5	1.0	2.0	2.4	20.5
mean	3766.6	66.8	4.3	108.5	28.3	0.916	2.1	2.6	9.8
LSD	1606.60	2.79	2.82	20.10	31.60	0.30	1.30	1.80	12.90

Analysis of variance showed significant differences among cultivars for days to anthesis (Table 1). The study indicated that among the IR hybrids, the genotype G3, G11 and G21 recorded higher number of days to tasseling (71 days), this was followed by G19 and G20 (70 days) and G13 (69 days). Whilst the hybrid G8 recorded lower number of days to anthesis (62 days) (Table 9). Anthesis-silking interval (ASI) did not significantly differ among cultivars.

3.2 ESTIMATES OF COEFFICIENTS OF VARIATION, HERITABILITY, AND GENETIC ADVANCE

The genotypic and phenotypic variance, genotypic and phenotypic coefficient of variation, broad sense heritability (H), and genetic advance as percent of mean (GAM) for all the traits studied are presented in Table 4. Agronomic trait such as grain yield, days to anthesis, ear aspect and root lodging showed the highest genotypic variance. Genotypic variance (σ^2G) estimates were was smaller than environment variance (σ^2 E) for anthesis silking interval, ear height, number of ears per plant, plant aspect and emerged striga plants. High values of PCV and GCV (> 20%) observed in grain yield, ear aspect and root lodging not only show that the selection can be effective for these traits but also indicated the existence of substantial variability, ensuring ample scope for their improvement through selection. On the other hand, very low values of GCV recorded for days to anthesis, ear height, number of ears per plant and emerged stiga plants revealed that low variability among the genotypes for these characters. The genetic variance components also play a crucial role in study of heritability. Heritability which is the heritable portion of phenotypic variance is a good index of transmission of characters from parents to offspring (Falconer, 1960).

Table 4: Phenotypic (σ^2p), genotypic (σ^2g), and error ($\sigma^2\varepsilon$) variances, and genetic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV), broad sense heritability (H), genetic advance (GA) genetic advance as percent of mean (GAM) for grain yield and other agronomic traits

Traits	Genotypic variance	Environmental variance	Phenotypic variance	GCV(%)	PCV(%)	H(%)	GA	GAM (%)
GY	1646546.5	280502	1927049	37	34	85.44	2438.66	64.74
AD	5.54	0.86	6.4	4	4	86.56	4.50	6.74
ASI	0.57	0.875	1.445	28	18	39.45	0.97	22.67
EH	3.56	44.45	48	6	2	7.41	1.05	0.97
RL	141.71	109.85	251.55	56	42	56.33	18.37	64.91
EPP	0.005	0.01	0.02	13	8	33.33	0.08	9.16
EA	0.36	0.19	0.54	35	28	65.74	0.99	47.30
PA	0.26	0.34	0.6	30	20	43.33	0.69	26.54
STRC	0.53	18.47	19	44	7	2.81	0.25	2.57

The broad-sense heritability (H) was usually used to determine whether the expression of plant traits was mainly influenced by heredity or environment. Heritability percentage was categorized as low when less than 40%, medium, 40-59%, moderately high, 60-79% and very high, 80% and above (Johnson et al., 1955). In present study grain yield and days to anthesis were very highly heritable (>0.80). The high heritability estimates for grain yield and days to anthesis under Striga infestation suggested that actual heritability estimates for these two traits would be high (Falconer and Mackay, 1996) to permit substantial genetic gain from selection for these traits. The broad-sense heritability for these two traits is similar to that reported in imidazolinone resistant (IR) maize by Makumbi et al. (2015). Moderately high heritability value was recorded for ear aspect. On the other hand, medium broad sense heritability estimate (40-59%) was observed for root lodging and plant aspect. Evaluation of Striga-resistant maize varieties will have to be performed over locations and years for traits with low broad-sense heritability to obtain consistent varietal reactions compared with those traits with higher broad-sense heritability (Makumbi et al., 2015). Genetic advance as percent of mean in the present study was relatively high for grain yield (64.7 %), root lodging (64.9%) and anthesis silking interval (22.7%). Whereas, low level of genetic advance was observed for days to anthesis, ear height, number of ears per plant and emerged striga plants. High heritability estimates coupled with high estimates of genetic advance expected in the next generation in grain yield, indicate the preponderance of additive gene action for the expression of these traits which is fixable in subsequent generations (Panse, 1957). Emerged Striga plants, anthesis silking interval, ear height and number of ears per plant exhibited low heritability with low genetic advance indicating non-additive genetic effects governing this trait.

3.3 CORRELATIONS BETWEEN AGRONOMIC TRAITS

Estimates of correlations between pairs of traits are indicated in Table 5. Grain yield showed significant and negative correlations with days to anthesis (rp = −0.69), root lodging (rp = −0.56), ear aspect (rp = −0.83) and plant aspect (rp=-0.79) (Table 4). This implies that grain yield is likely to increase with decrease in days to anthesis, ear and plant aspect and root lodging. While, weak positive correlations were found between grain yield and ear height (rp = 0.17) and EPP (rp = 0.30). Earlier studies in maize under striga infestation also reported that grain yield was positively correlated with ear height and number of ears per plant but negatively correlated with ear aspect, anthesis silking interval, plant aspect, days to anthesis, and root lodging (Badu-Apraku and Lum, 2007). The correlations of days to anthesis with ear and plant aspect were positive and significant. EPP exhibited negative association with days to anthesis (rp=-0.37), anthesis silking interval (ASI) (rp = -0.21), root lodging (rp=-0.29), but the magnitude of associations were low. A negative but not significant correlation coefficient between grain yield and Striga counts was observed (Table 4). Menkir and Kling (2007) and Yallou et al. (2009) reported weak phenotypic correlations between grain yield and Striga emergence count in maize germplasm. Striga counts at 8 WAP showed non-significant positive association (rp = 0.07) with ear height. Other study also reported weak positive correlation between Striga counts and ear height under striga infestation (Karaya et al., 2012).

Table 5: Correlation between grain yield and agronomic traits under Striga-infested conditions

Traits	GY	AD	ASI	EH	RL	EPP	EA	PA
AD	-0.68606							
	(0.0002)							
ASI	-0.10287	-0.02724						
	(0.6246)	(0.8972)						
EH	0.17337	-0.10013	0.10306					
	(0.4072)	(0.6339)	(0.624)					
RL	-0.56	0.29183	-0.22357	-0.09339				
	(0.0036)	(0.1569)	(0.2827)	(0.657)				
EPP	0.30226	-0.36952	-0.21313	0.33032	-0.29249			
	(0.142)	(0.0691)	(0.3064)	(0.1068)	(0.1559)			
EA	-0.8291	0.58655	0.11628	-0.02693	0.51431	-0.24942		
	(<.0001)	(0.0021)	(0.5799)	(0.8983)	(0.0085)	(0.2292)		
PA	-0.79103	0.51763	0.01018	-0.12501	0.74051	-0.37359	0.77714	
	(<.0001)	(0.008)	(0.9615)	(0.5516)	(<.0001)	(0.0658)	(<.0001)	
STRC	-0.33446	0.22193	-0.40052	0.06539	0.1961	0.26416	0.19908	0.28473
	(0.1022)	(0.2863)	(0.0473)	(0.7561)	(0.3475)	(0.202)	(0.3401)	(0.1677)

4. CONCLUSIONS

Imidazolinone (imazapyr) is a systemic, very low cost and environmentally friendly herbicide which has the capacity to destroy germinating striga seeds attempting to parasitise maize plants and giving almost season long Striga control when used as a seed coating. The results of this study showed that a number of promising seed coated hybrids with imazapyr, based on high grain yield and other agronomic traits compared with Striga tolerant and commercial maize check hybrids under Striga infested conditions. In addition to increased maize yield for farmers, IR maize technology for Striga control would also reduce the parasite seed bank from the soil and prevent production of new seeds. Imidazolinone-resistant maize will be used as a stopgap measure to reduce Striga infestation in maize and obtain good maize yields until maize varieties with sufficient genetic resistance become available. Since there is no any single control option, which can solve the problem of Striga, the IR technology should combine other effective Striga control technologies that can decrease Striga seed banks in the soil.

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