Ministry for Primary Industries
Manatū Ahu Matua

Risk Management Proposal:

Additional import requirements for maize and sweet corn (Zea mays) *seed for sowing*

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Plant Imports
Plants, Food & Environment
Ministry for Primary Industries
Pastoral House
25 The Terrace
PO Box 2526
Wellington 6140
New Zealand

Tel: +64 4 894 0100
Fax: +64 4 894 0662

Email: plantimports@mpi.govt.nz

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Purpose

1. The purpose of this document is to:
   a) Review the management measures for *Maize dwarf mosaic virus* (MDMV) on *Zea mays* seed for sowing from approved countries;
   b) Propose phytosanitary measures which can effectively manage the risks of entry and establishment of this organism;
   c) Establish the feasibility and practicality of implementation of the proposed measures;
   d) Seek stakeholder feedback on the proposed phytosanitary measures.

Background

2. Maize is the most commonly grown cereal crop in the world. In New Zealand, it is grown for a number of different end markets, including maize grain and maize silage. Sweet corn and popcorn varieties are also grown in New Zealand.

3. The virus *Maize dwarf mosaic virus* (MDMV) is a regulated pathogen of *Zea mays* seed imported for sowing. The current import health standard does not specify a seed sample size for testing for this virus.

COMMODITY DESCRIPTION

4. Seeds eligible for import into New Zealand are listed in the Plants Biosecurity Index**:** http://www1.maf.govt.nz/cgi-bin/bioindex/bioindex.pl.

5. Maize, sweet corn and popcorn (*Zea mays*) have a schedule of special conditions which must be met in addition to the basic requirements of Part A of the import health standard: 155,02.05: Importation of Seed for Sowing.

6. *Zea mays* can be imported from the following countries: Australia, Austria, Canada, Chile, Finland, France, Germany, Greece, Hungary, Japan, the Netherlands, Norway, South Africa, Sweden, Switzerland, the United Kingdom and United States of America.

7. In addition to managing biosecurity risks, the schedule also requires seed to be tested for the presence of unapproved genetically modified seeds, according to the requirements of the Hazardous Substances and New Organisms Act (1996).

TRADE VALUE

8. *Zea mays* is one of the most important crops in New Zealand. The species includes sweet corn, maize and popcorn. Maize is grown for a number of different end markets, including maize grain and maize silage. The largest end user of maize in New Zealand is now the dairy industry. Silage production in 2009 was about 1 million tonnes, valued at $250 million (Booker, 2009).

9. Maize grain production for animal feeds and human foods was approximately 200,000 tonnes in 2009, valued at $80 million (Booker, 2009).

10. The value of sweet corn exports (frozen/dried) in 2012 was $41.8 million. Domestic sales were worth $20 million in 2012 (Fresh Facts, 2012).

11. There is also a significant amount of seed produced for export, using New Zealand as a winter nursery for the Northern Hemisphere breeding programmes (McCarter, 2013. pers. com).

SOURCE INFORMATION

12. In the development of this RMP the following information was used to assess risks and the appropriate measures to manage their entry and establishment in New Zealand:
    a) Relevant literature and database searches;
    b) Plant Health Australia - Risk analysis of *Maize dwarf mosaic virus* http://www.planthealthaustralia.com.au/pests/maize-dwarf-mosaic-virus/
    c) Stakeholder discussions prior to, and during the development of this RMP.

INTERNATIONAL OBLIGATIONS

13. Where possible, phytosanitary measures are aligned with international standards, International Plant Protection Convention guidelines, and recommendations as per New Zealand's obligations under Article 3.1 of the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), WTO 1995. http://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm

14. The SPS Agreement states that phytosanitary measures must not discriminate unfairly between countries or between imported or domestically produced goods, and where there is a choice of phytosanitary measures to reduce risk to an acceptable level, WTO members must select the least trade restrictive measure.

Objective

15. To ensure the biosecurity risks of *Maize dwarf mosaic virus* is managed appropriately and is consistent with New Zealand's domestic legislation and international obligations.

Summary of Risk

16. Risk organisms are regulated on the commodity if:
    a) they are present in the exporting country and absent from New Zealand (or present but under official control);
    b) they are likely to be present on the pathway if risk was unmitigated;
    c) they are known to be associated with the commodity (as per previous risk analyses);
    d) their hosts include species present in New Zealand;
    e) they are climatically able to establish in New Zealand;
    f) they are likely to cause adverse economic or environmental impacts to New Zealand

MAIZE DWARF MOSAIC VIRUS (MDMV)

17. Maize dwarf mosaic virus (MDMV) is a serious disease of maize and sorghum and was first recorded in the United States in the 1960s. It is now distributed worldwide in most of the main growing areas for these crops, except Australia and New Zealand.

18. The most frequent symptoms are mosaicism, dwarfing, poorly developed tassels and poor seed setting (Revers *et al.*, 1999). Yield losses can be as high as 42% (Szirmai 1968).

19. MDMV has been confirmed in the following countries (www. cabicompendium.org):

Europe	Bosnia and Herzegovinia, Bulgaria, Croatia, Czech Republic, Czechoslovakia (former), Yugoslavia (former), France, Germany, Greece, Hungary, Italy, Romania, Russia, Serbia and Montenegro, Spain, and Ukraine.
Africa	Burkina Faso, Cameroon, Cote d'Ivoire, Egypt, Ethipia, Kenya, Mauritius, Morocco, Niger, Nigeria, South Africa, Zambia and Zimbabwe.
Asia	China, Georgia (Republic), India, Iran, Iraq, Israel, Kazakhstan, Republic of Korea, Pakistan, Philippines, Turkey, Turkey-in-Asia,Uzbekistan and Yemen.
North America	Canada, Mexico and the USA.
Central America	Cuba, Haiti and Honduras.
South America	Argentina, Brazil, Chile, Colombia, Peru and Venezuela.

LIKELIHOOD OF ENTRY INTO NEW ZEALAND

20. New Zealand imports *Zea* seed from countries where MDMV occurs, so there is a high likelihood that MDMV infected seeds could be imported into New Zealand.

LIKELIHOOD OF ESTABLISHMENT IN NEW ZEALAND

21. The rate at which an infected seed can cause an infected plant is known as the seed transmission rate. The seed transmission rate is known to be very low for MDMV in *Zea mays*, however as the virus can be spread from plant-to-plant by aphids, even a low level of infected plants could lead to an establishment of the disease in a field. At least fourteen aphid species are known to be able to acquire and transmit the virus in (Ford *et al.*, 2004).

22. *Zea mays* is a seasonal crop in New Zealand, so it is not clear whether the virus would persist in the environment once the season was finished from year to year, or whether it would depend on a new infection each year.

23. Seed-transmission rates range from 0.007% to 0.4% (Ford *et al.*, 2004; Hill *et al.*, 1974; Mikel *et al.*, 1984; Williams *et al.*, 1968). In the Mikel study, sweet corn seed collected from MDMV infected fields resulted in only one seedling infection out of 22,189 seeds grown and tested by an enzyme-linked immunosorbent assay (ELISA).

24. This low transmission rate is explained by the part of the seed which is infected by the virus. Pericarp and endosperm infections are unlikely to be transmitted, while embryo infections are highly likely to lead to transmission (Mikel *et al*., 1984).

IMPACT OF ESTABLISHMENT

25. Establishment of MDMV in New Zealand could affect a number of primary industries, through the reduction in dry matter production for silage, and poor tassel development affecting grain and seed industries.

26. Seed trade with Australia and other trading partners may also be affected as a consequence of an incursion of this disease in New Zealand.

CURRENT MEASURES TO MANAGE THE RISK OF MDMV

27. MDMV is currently regulated on *Zea mays*, with options for sourcing seed from a Pest Free Area or Pest Free Place of production, maintained by official surveys or in-field inspections during the growing season.

28. Testing for MDMV is also given as an option and the method described by Forster *et al.* (2001) is given. The method describes the use of ELISA testing for *High plains virus* and does not specifically cover testing for MDMV, the seed sample size or testing methodology for the ELISA test. Without this specification, assurance of freedom of seed lots from MDMV may not be consistently applied.

Table 1: Summary of *Maize dwarf mosaic virus*

Pathogen	*Maize dwarf mosaic virus* (MDMV)
Hosts	Maize, sorghum.
Seed-transmission	0.007 – 0.4%
Regulated in New Zealand	Regulated.
Distribution	Worldwide (except Australia and New Zealand).
Likelihood of entry and establishment	High likelihood of entry on seed, high likelihood for establishment due to aphid transmission.
Area of greatest uncertainty	Persistance in the environment beyond one season.
Economic impacts	Potential for high economic impact. Yield impacts for silage, seed production, feed and food industries. Seed-multiplication for export may be affected (particularly for Australia).
Reference	Ford *et al.*, 2004.

Risk Management

29. The following measures are proposed for managing the risks associated with the entry of *Zea* seed from all countries. Specific measures are included in Table 2, with options for

official phytosanitary declarations and seed testing, to prevent or minimise known biosecurity risk to an acceptable level.

PHYTOSANITARY CERTIFICATE DECLARATIONS

30. An additional declaration on the phytosanitary certificate for Pest Free Area may be possible for some countries, to declare freedom from *Maize dwarf mosaic virus* in accordance with ISPM 4: *Requirements for the establishment of pest free areas* (2011). Pest free areas are verified by the exporting country's NPPO. This measure offers a good level of assurance that consignments are free from these specified pathogens.

31. An additional declaration on the phytosanitary certificate for Pest Free Place of Production may be possible for some countries, to declare freedom from *Maize dwarf mosaic virus* in accordance with ISPM 10: *Requirements for the establishment of pest free places of production and pest free production sites* (2011). Pest freedom is established by surveys and/or growing season inspections and maintained as necessary by other systems to prevent the entry of the pest into the place of production.

32. Seed testing methods and/or seed treatment methods are another option where other phytosanitary certificate declarations are not possible.

Table 2: Management measures effective at reducing the risk of quarantine organisms.

Pathway Step	Target Organisms/or Risk Group	Description of Possible Measures	Verification
Offshore pre-sowing	*MDMV*	Sourcing certified disease-free seeds. Plants grown in countries/areas designated Pest Free Area. Surveys / systems to verify freedom has been maintained.	Phytosanitary certificate declaration – Pest Free Area
Offshore growing season	*MDMV*	Sourcing certified disease-free seeds. Surveys/ growing season inspections for pest freedom of disease. Systems to prevent the entry of the pest into the area.	Phytosanitary certificate declaration – Pest Free Place of Production
Offshore/onshore testing	*MDMV*	Seed testing using an NPPO approved ELISA testing method.	Phytosanitary certificate declaration – test certification.
On-arrival	*MDMV*	Verification of measures.	Biosecurity inspection. Verification of measures.

SEED TESTING

TESTING METHOD

33. The most commonly available method for testing maize plants for MDMV is an enzyme-linked immunosorbent assay (ELISA) method. This can be used on fresh and dried plant material and is available in a kit form from various suppliers.

34. The National Seed Health System in the US has modified the seed test to enable it to be used as a direct seed test (page 53). This is considered to be more sensitive than a grow out test, which looks for cases of seed transmission, as this is almost always significantly lower than the rate of seed infection (Shepherd, 2013 pers. com.).

SEED SAMPLE SIZE

35. The pericarp/endosperm infection rate for MDMV is much higher than the embryo infection rate (Mikel *et al.*, 1984). Seed transmission of MDMV is thought to be 100% if the virus is found in the embryo, while it may be close to zero if the infection occurs in the pericarp and endosperm of the seed (Vidal, 2013 pers. com.).

36. Studies show that the ratio of infected seed tissues is approximately 1:8 for embryo and endosperm/pericarp respectively (Mikel *et al*., 1984). MDMV seed embryo infection is a rare event which is difficult to reliably detect in a seed health assay unless the sample size is greater than several thousand seeds. It is much more likely for a seed lot to contain pericarp or endosperm infected seeds than embryo infected seed.

37. From the evidence available, it appears that seeds with an infected seed embryo also have a pericarp/endosperm infection. Therefore a positive MDMV test due to pericarp/endosperm infected seeds will result in the rejection of the seed lot even if there are no embryo infected seeds in the lot. A negative result for MDMV gives a good level of assurance that there is an absence of pericarp/endosperm/embryo infected seeds in the lot.

38. The following table shows the level of infected seeds in a seed lot which can be reliably detected with differing seed sample sizes. For the stated level of pericarp/endosperm infection, the equivalent level of seed embryo expected to be infected with MDMV is presented. It is assumed that the efficacy of the ELISA testing method is 95% and that the sample is taken from a lot which is sufficiently mixed.

Table 3. The seed sample size required to detect at least one seed infected with MDMV at 95% confidence.

Seed sample size	Level of pericarp/endosperm infection detected	Level of embryo infection likely to be present
400	0.79% (1 in 127 seeds)	0.10% (1 in 1,019 seeds)
1000	0.31% (1 in 318 seeds)	0.04% (1 in 2,541 seeds)
2000	0.16% (1 in 635 seeds)	0.02% (1 in 5,078 seeds)
4000	0.08% (1 in 1,269 seeds)	0.01% (1 in 10,151 seeds)

39. MPI has proposed an appropriate minimum sample size as 2000 seeds, which gives a high level of confidence of detecting infected seed lots, while still being a practical test to implement in the laboratory.

Feasibility & Practicality of Measures

40. An additional declaration for testing for MDMV allows trade to occur while managing the industry from biological risks.

41. The National Seed Health Testing unit in the USA has modified the MDMV ELISA kit for use as a direct seed test, and uses a standard 400 seed sample. The test sample is broken down into pools each of about 100 seeds, which are tested individually (Shepherd, 2013. pers. com.).

42. The larger the sample size, the greater the number of pools of samples need to be ground and homogenized, assayed and analysed. A 2000 seed sample is a practical sample size, and increasing the current level of assurance which is provided by testing.

Proposed IHS requirements

43. The following change is proposed to the Import Health Standard schedule of special conditions for *Zea mays*:

Maize dwarf mosaic virus
A negative result from testing a minimum of 2000 seeds, representatively drawn from the seed lot, using an NPPO approved method must be used to show that the consignment is free of *Maize dwarf mosaic virus*.

44. See Appendix 1 for the full proposed IHS schedule for *Zea mays*.

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Appendix 1: Proposed Import Health Standard Amendment

Zea

The following entry conditions only apply to species in the Plants Biosecurity Index listed under Import Specifications for Seed as "see 155.02.05 under *Zea*".

Approved Countries: Australia, Austria, Canada, Chile, Finland, France, Germany, Greece, Hungary, Japan, the Netherlands, Norway, South Africa, Sweden, Switzerland, the United Kingdom and United States of America

Quarantine Pests: *Acidovorax avenae* subsp. a*venae*, *Clavibacter michiganensis* subsp. *nebraskensis, Pantoea stewartii, High plains virus*, *Maize dwarf mosaic virus*, *Maize chlorotic mottle virus, Botryosphaeria zeae*, *Cochliobolus pallescens*, *Cochliobolus tuberculatus*, *Claviceps gigantea*, *Gloeocercospora sorghi, Ustilago maydis*, *Peronosclerospora heteropogoni*, *P. maydis*, *P. philippinensis*, *P. sacchari*, *P.sorghi*, *Phaeocytostroma ambiguum*, *Sclerophthora rayssiae* var. *zeae*, *Rhizopus maydis*, *Stenocarpella macrospora* and *Cephalosporium maydis.*

Regulated Pests: For the full regulated pest list refer to "Pest List for *Zea*"

A Permit to Import is not required, unless seeds are to be grown in PEQ.

Phytosanitary Certificate - Additional declarations

1) If satisfied that the pre-shipment activities have been undertaken, the exporting country NPPO must confirm this by recording the treatments applied in the "Disinfestation and/or Disinfection Treatment" section (if applicable), and by providing the following additional declarations to the phytosanitary certificate:

   a) The *Zea mays* seeds for sowing have been:

      i) inspected in accordance with appropriate official procedures and found to be free of any visually detectable regulated pests, including the regulated insects, mites and weed seeds on MPI's "Pest List for *Zea mays*".

   AND

   b) The *Zea mays* seeds for sowing have been:

      i) sourced from a "Pest free area", free from the named regulated bacteria (*Acidovorax avenae* subsp. a*venae*, *Clavibacter michiganensis* subsp. *nebraskensis, Pantoea stewartii*) and viruses (*High plains virus*, *Maize dwarf mosaic virus*, *Maize chlorotic mottle virus*).

      OR

      ii) sourced from a "Pest free place of production", free from the named regulated bacteria (*Acidovorax avenae* subsp. a*venae*, *Clavibacter michiganensis* subsp. *nebraskensis, Pantoea stewartii*) and viruses (*High plains virus*, *Maize dwarf mosaic virus*, *Maize chlorotic mottle virus*).

      OR

      iii) a representative sample, officially drawn from this consignment according to ISTA or AOSA methodology, has been tested for the presence of the named regulated bacteria (*Acidovorax avenae* subsp. *avenae*, *Clavibacter michiganensis* subsp. *nebraskensis*,

Pantoea stewartii) and viruses (*High plains virus*, *Maize dwarf mosaic virus*, *Maize chlorotic mottle virus*).

AND

c) The *Zea mays* seeds for sowing have been:

i) sourced from a "Pest free area" free from the named regulated fungi (*Botryosphaeria zeae*, *Cochliobolus pallescens*, *Cochliobolus tuberculatus*, *Claviceps gigantea*, *Gloeocercospora sorghi, Ustilago maydis*, *Peronosclerospora heteropogoni*, *Peronosclerospora maydis*, *Peronosclerospora philippinensis*, *Peronosclerospora sacchari*, *Peronosclerospora sorghi*, *Phaeocytostroma ambiguum*, *Sclerophthora rayssiae* var. *zeae*, *Rhizopus maydis*, *Stenocarpella macrospora* and *Cephalosporium maydis*).

OR

ii) treated with one of the fungicide combinations described in MPI's "Approved Treatments for *Zea mays*".

Testing Requirements

(1) *Pantoea stewartii*
A negative result from testing a representative sample of 400 seeds using the immunosorbent assay test described by Lamka *et al.* (1991) may be used to show that the consignment is free of *Pantoea stewartii*.

(2) *Clavibacter michiganensis* subsp. *nebraskensis*
A negative result from testing a minimum of 400 seeds, representatively drawn from the seed lot, and tested using the sCNS Culture Plate Method (Shepherd, 1999; www.seedhealth.org) may be used to show that the consignment is free of *Clavibacter michiganensis* subsp. *nebraskensis*.

(3) *Acidovorax avenae* subsp. *avenae*
A negative result from testing a representative sample of 400 seeds using the methodology of Dange *et al.* (1978) may be used to show that the consignment is free of *Acidovorax avenae* subsp. *avenae*.

(4) *High plains virus*
A negative result from testing a representative sample of seeds using greenhouse grow-out tests and ELISA testing as described by Forster *et al.* (2001) and Crop Plant Compendium 2003 may be used to show that the consignment is free of *High plains virus*.

(5) *Maize dwarf mosaic virus*
A negative result from testing a minimum of 2000 seeds, representatively drawn from the seed lot, using an NPPO approved method must be used to show that the consignment is free of *Maize dwarf mosaic virus*.

(6) *Maize chlorotic mottle virus*
Due to the low levels of seed transmission MPI will consider testing based upon request and will calculate the sample size required based upon the size of the consignment and at 95% confidence levels.

Guidance:
MPI will consider alternative virus and bacterial testing methods from those described in this schedule upon request.

Genetically Modified Seed Testing

(1) All maize (*Zea mays* var. *indentata*) and sweet corn (*Zea mays* var. *saccharata*) consignments imported into New Zealand must be tested for unapproved GM seeds. If unapproved GM seeds are detected, the consignment will not be permitted to enter New Zealand.

(2) Testing must be conducted by laboratories approved to the Standard "*Approval of Facilities for Genetically Modified Organism Testing*". Testing certificates must accompany the consignment imported into New Zealand, and the test sample name must reconcile with the seed lines in the consignment. Importers must ensure that MPI has access to all pertinent testing records held by the testing laboratory for audit purposes.

Guidance:

1. Popcorn does not require GM testing. The full scientific name must be specified on the phytosanitary certificate (e.g. *Zea mays* var. *everta*) to enable popcorn to be given clearance without a GM testing certificate.
2. Complete guidelines for sampling and testing for the presence of GM seeds are specified in the *Protocol for Testing Seed Imports for the Presence of Genetically Modified Seed*. http://www.biosecurity.govt.nz/regs/imports/plants/gmo

Approved Treatments

(1) The active ingredients in one of the following fungicide treatments are required:
(a) Carboxin at 0.8 g a.i. per kg seed & thiram at 0.8 g a.i. per kg seed.
(b) Carboxin at 0.8 g a.i. per kg seed & captan at 0.7 g a.i. per kg seed.
(c) Fludioxonil at 0.025 g a.i.per kg seed & metalaxyl at 0.03 g a.i. per kg seed.
(d) Imazalil at 80 mg a.i. per kg seed & triadimenol at 220 mg a.i. per kg seed.
(e) Imazalil at 80 mg a.i. per kg seed & flutriafol at 80 mg a.i. per kg seed.
(f) Difenoconazole at 0.12 g a.i per kg seed & mefenoxam at 0.01g a.i per kg seed.
(g) Fludioxonil at 0.025 g a.i.per kg seed & mefenoxam at 0.01 g a.i. per kg seed.

(2) As required, MPI may evaluate other treatments and if effective, will approve these treatments and add them to this schedule.

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Pest List for Zea

REGULATED PESTS (actionable)

Fungi

Botryosphaeria zeae	grey ear rot
Cephalosporium maydis	-
Claviceps gigantea	ergot
Cochliobolus pallescens	maize leaf spot
Cochliobolus tuberculatus	leaf spot
Gloeocercospora sorghi	zonate leaf spot
Peronosclerospora heteropogoni	-
Peronosclerospora maydis	Java downy mildew
Peronosclerospora philippinensis	Philippine downy mildew
Peronosclerospora sacchari	-
Peronosclerospora sorghi	sorghum downy mildew
Phaeocytostroma ambiguum	-
Rhizopus maydis	Rhizopus seed rot
Sclerophthora rayssiae var. *zeae*	-
Stenocarpella macrospora	dry rot
Ustilago maydis	boil smut

Bacteria

Acidovorax avenae subsp. *avenae*	bacterial blight
Clavibacter michiganensis subsp. *nebraskensis*	Goss' bacterial wilt
Pantoea ananatis	maize white spot/leaf spot disease
Pantoea stewartii	Stewart's bacterial wilt

Viruses

High plains virus	-
Maize chlorotic mottle virus	-
Maize dwarf mosaic virus	MDMV

Insects

Alphitobius laevigatus	black fungus beetle
Attagenus unicolor	black carpet beetle
Carpophilus freemani	dried fruit beetle
Cathartus quadricollis	squarenecked grain beetle
Caulophilus oryzae	broadnosed grain weevil
Corcyra cephalonica	rice moth
Cryptophlebia leucotreta	false codling moth
Cynaeus angustus	larger black flour beetle
Dinoderus distinctus	bostrichid beetle
Doloessa viridis	-
Euxesta stigmatias	-
Gibbium psylloides	shiny spider beetle
Glischrochilus quadrisignatus	four-spotted sap beetle
Gnatocerus maxillosus	slenderhorned flour beetle
Latheticus oryzae	longheaded flour beetle
Lepinotus reticulatus	booklouse
Leptoglossus zonatus	coreid bug

Liposcelis bostrychophilus	booklouse
Liposcelis entomophilus	grain psocid
Liposcelis paetus	booklouse
Mussidia nigrivenella	pyralid moth
Pagiocerus frontalis	bark borer
Palorus ratzeburgi	smalleyed flour beetle
Palorus subdepressus	depressed flour beetle
Paralipsa gularis	stored nut moth
Pharaxonotha kirschii	Mexican grain beetle
Prostephanus truncatus	larger grain borer
Pyroderces rileyi	pink scavenger caterpillar
Sesamia calamistis	pink stalk borer
Teretriosoma nigrescens	-
Tribolium freemani	flour beetle
Trogoderma glabrum	khapra beetle
Trogoderma granarium	khapra beetle
Trogoderma inclusum	trogoderma beetle
Trogoderma variabile	warehouse beetle

Mite

Acaropsellina sollers	-

Weeds

Striga asiatica	witch-weed
Striga hermonthica	witch-weed