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SEDGE WEEDS OF EAST AFRICA - II. DISTRIBUTION

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SEDGE WEEDS OF EAST AFRICA - II. DISTRIBUTION

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One of the most important groups of weeds in East Africa are the sedges (family *Cyperaceae*). Over 350 species of sedge have been recorded in East Africa (Napper, 1963, 1964, 1965, 1966, 1971), many of which have been observed as weeds. Some of these weeds are of minor importance but others are believed to be frequent and/or important weeds in a wide range of crops. Some species are cosmopolitan and cause serious problems wherever they occur, whilst others are weeds in small areas of East Africa only. Without knowing the present position it would be impossible to detect future changes in distribution and importance of these weeds. A survey was undertaken, therefore, to determine the present distribution of important sedge weeds and to predict where conditions are suitable in East Africa for successful establishment of these weeds if they were introduced. A key to the identification of these weeds has been given in an earlier publication (Terry, 197).

METHOD OF SURVEY

For the purpose of this survey a sedge was considered to be a weed if it occurred in cropped land, pastures or lawns, but not if it occurred in aquatic or ruderal situations. This excluded common aquatic species such as *Cyperus papyrus* which are serious problems in waterways but are of little or no significance in arable land.

The survey was conducted in three ways:

1) By personal observations.

   By widespread travel it was possible to record and collect sedge weeds from many parts of East Africa.

2) By literature review.

   There are many references to sedges occurring as weeds in East Africa (Table I). References to the occurrence of sedges in non-weed situations are recorded where the information is relevant to studies on distribution.

(Table I)

3) By herbarium material and data.

   Relevant information was collected from the following herbaria:

   East African Herbarium, Nairobi, Kenya
   University of Dar es Salaam, Department of Botany, Tanzania

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University of Dar es Salaam, Faculty of Agriculture, Tanzania
Tanzania National Parks (Serengeti and Arusha)
Research and Training Institute, Ukiriguru, Tanzania
Research and Training Institute, Ilonga, Tanzania
Sisal Research Station, Mlingano, Tanzania
Makerere University, Kampala, Uganda
Kawanda Research Station, Kampala, Uganda
Forest Department, Entebbe, Uganda
Tropical Pesticides Research Institute, Arusha, Tanzania

The use of questionnaires was considered but the difficulties of correctly identifying sedges meant that little reliance could be placed upon the accuracy of replies.

As a result of the survey, 57 sedges were recorded as being weeds. Every specimen collected of these species was examined in the above herbaria and the collectors' information was recorded on indexed punch cards. From this information it was possible to prepare distribution maps.

PREPARATION OF DISTRIBUTION MAPS

Of the 57 sedges recorded as weeds, only 19 were considered to be of sufficient importance to merit individual distribution maps (Fig. 2-20). The remainder were simply recorded on a single distribution map (Fig. 21). The selection of a species for individual maps was made on the arbitrary basis that the sedge must have been recorded as a weed at 3 or more places from at least 14 locations. By this method it was possible to include localised weeds such as *Cyperus grandibulbosus* and exclude common, widespread sedges which are rarely observed as weeds. The minimum sample size required to predict distributions is debatable but 14 specimens is almost certainly too small. However, this is the only information available and it cannot simply be ignored when there is a risk that small infestations of today may develop into severe problems in the future.

Maps were prepared to show the observed and potential distributions of the most important sedge weeds. The former were made by indicating the presence of a sedge in an area bounded by 0.5^o latitude and longitude. In East Africa this corresponds to an area of approximately 3098 km^2. Potential distributions were made from readily available information on elevation and climate using the methods described below.

Precise map references for the collecting location of every specimen were determined from gazetteers (United States Board on Geographic Names, 1964, 1965; Polhill, 1970) and road maps (George Philip & Son, 1968, 1970, 1973). From maps it was possible to estimate the elevation (George Philip & Son, 1968, 1970, 1973; Kenya Government, 1974), average annual rainfall (Tomsett, 1969) and annual actual temperature (Fullard, 1973) at every location. Adaptations of these maps are shown in Figures 22-24. Frequency distributions were then calculated for a range of class intervals within these climatic and geographic parameters. Before using this information it was first necessary to calculate the expected frequency of occurrence of sedges, ie the frequency that could be expected within each class interval if the sedges were evenly distributed throughout East Africa. By using contour, rainfall and temperature maps it was possible to determine the area of East Africa within each class interval using a planimeter or by cutting out the intervals, weighing them and expressing their weights as a percentage of the whole. These data are shown in Table II.

(Table II)

It was then possible to calculate the expected distribution of sedge weeds for comparison with observed distributions. An example of this is given in Table III.

(Table III)

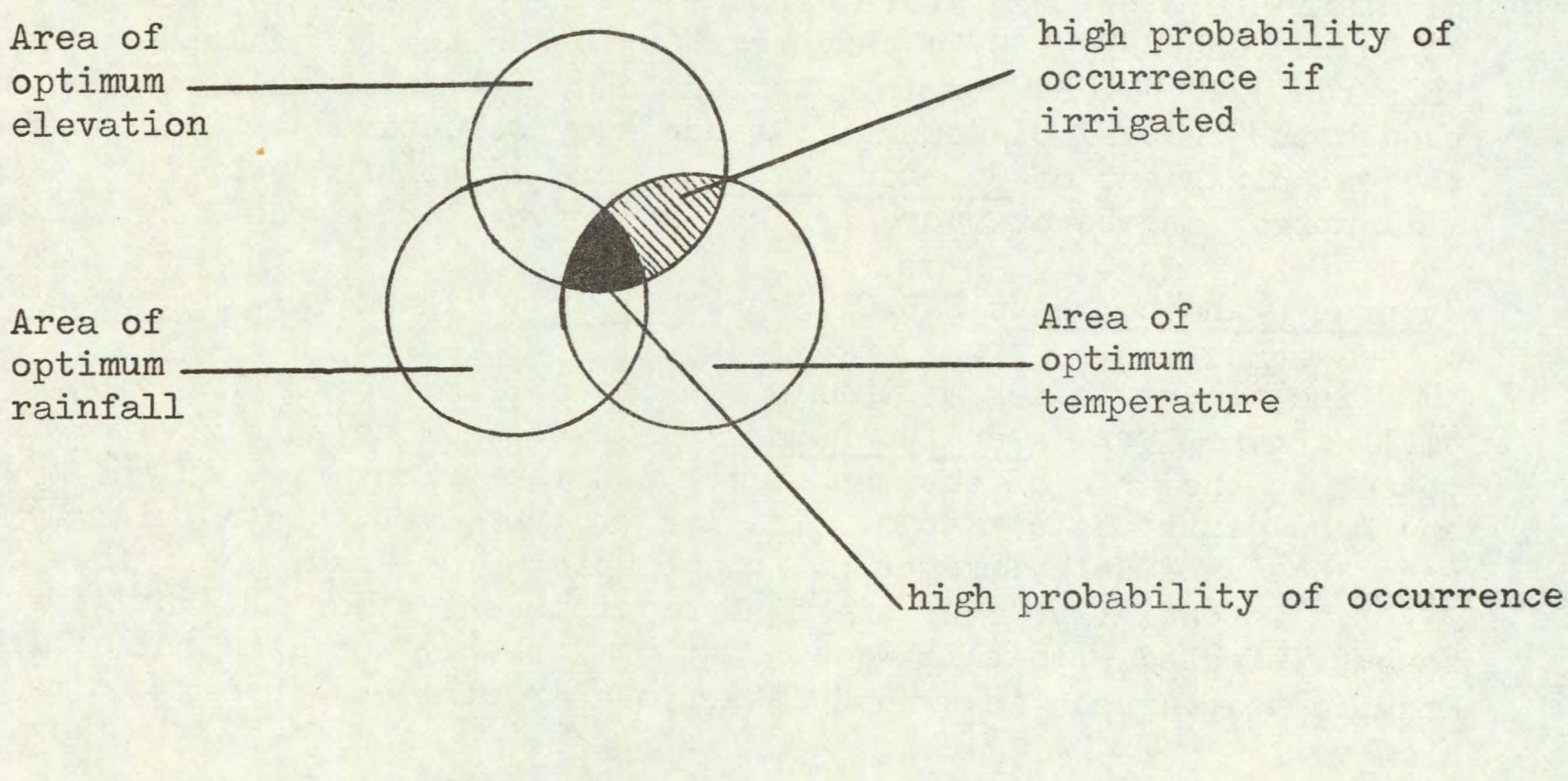
A chi-squared analysis is not applicable to these data because of non-random sampling. However, to make use of the data, the optimum conditions for growth of a sedge were defined as being where the observed frequency distribution was equal to or greater than the expected frequency distribution. Hence, from Table III, the optimum elevation for occurrence of Cyperus rotundus is 1000-1999 m. In the same way optimum elevation, temperature and rainfall were determined for other important sedge weeds (Table IV).

(Table IV)

Elevation, temperature and rainfall are inter-related; in fact it is possible to calculate mean annual maximum and minimum temperatures for any part of East Africa if the elevation is known (East African Meteorological Department, 1970). Rainfall is dependent upon both elevation and temperature but cannot be predicted so readily. It is no coincidence, therefore, that sedges with a preference for high elevations also prefer low temperatures. The importance of rain-fall in determining occurrence is less clear and could be misleading. For example, a sedge may occur where the annual rainfall is 400-600 mm but survives because it is irrigated or grows in a swamp environment.

By determining the places where temperature, rainfall and elevation are all optimum one derives an area where there is a high probability of a sedge weed occurring or where it could thrive if introduced. Where temperature and elevation are optimum and rainfall sub-optimum it is concluded that sedge weed could occur if irrigated. This is illustrated diagramatically in Figure 1.

Fig. 1 Diagrammatic representation of probabilities of a sedge weed's occurrence.



By similar methods it is possible to determine areas where conditions are sub-optimum and where the occurrence of a sedge is possible or unlikely.

Potential distribution could be more accurately predicted if other environmental factors were known. It is quite probable for example that soil type, pH and perhaps salinity are important in sedge establishment but the information is generally not available.

DISCUSSION

Cyperus blysmoides C.B.Cl. (Fig. 2)

This sedge has a limited distribution in highland areas of Northern Tanzania and Kenya. Severe infestations in wheat at West Kilimanjaro have reduced crop yields and it has also been reported as a serious weed in Machakos (Ivens, 1967). It is commonly found in coffee from Ruiru (Chawdhry, 1975) to Nyeri. Potentially, this weed could become a problem in the highlands of western Kenya and southern Tanzania, particularly in small-grain cereal crops.

Cyperus bulbosus Vahl var. melanolepis Kük. (Fig. 3)

The only record of this sedge as a serious weed has been from the Arusha Region of Tanzania where it has been observed to reduce wheat yields. It can survive in relatively dry, unirrigated conditions and could become an important weed of many highland areas of East Africa.

Cyperus difformis L. (Fig. 4)

Despite its widespread occurrence in East Africa this sedge has been recorded infrequently as a weed. This is somewhat surprising for it is reputed to be one of the most serious weeds of rice throughout the world (Holm and Herberger, 1970). It must be assumed that this sedge could become a serious weed of rice in East Africa, particularly in paddies.

Cyperus esculentus L. (Fig. 5)

This common sedge is a serious weed of many crops in almost all the highland areas of East Africa from maize at Kitale (Laycock, 1974) to coffee at Ruiru (Chawdhry, 1975) and wheat in the Southern Highlands of Tanzania (Edwards, 1974). Severe infestations occur at all levels of crop management though the removal of competitive weeds by selective herbicides does favour the establishment of C. esculentus. There is little doubt that this weed will spread and become more serious as agriculture expands in the highlands.

Cyperus grandibulbosus C.B.Cl. var. amplus Kük. and var. grandibulbosus (Fig 6)

The two varieties of this sedge are of limited distribution. The smaller type, var. grandibulbosus, tends to be a serious weed of irrigated cotton in the area of the Tana River and its tributaries in the Mwea Tebere and Embu districts of Kenya. The larger type, var. amplus, is one of the major weeds of Hola Irrigation Scheme which also draws water from the Tana River. Potentially, many areas of moderate elevation in East Africa could become infested with this weed. One very small, isolated infestation at Kingori near Arusha is already a serious problem and appears to be spreading slowly.

Cyperus rigidifolius Steud. (Fig. 7)

This very common sedge occurs in practically all the highland areas of East Africa. Although it is a common weed of most highland crops it is not usually a problem. Ivens (1967) records it as being a troublesome weed of tea in Mufindi but it is usually most serious in pastures where it can displace most of the natural sward. It is unlikely to become more widespread than it is at present but could become more of a problem in minimum or zero-tillage crops in the highlands.

Cyperus rotundus L. (Fig. 8)

This is the commonest sedge weed of East Africa. It occurs in virtually all crops from sea level to about 2000 m with the exception of western and southern Tanzania. It is, however, only locally serious as a weed. It occurs particularly in irrigation schemes and coffee, especially where the latter is maintained by zero-tillage. The peasant farmer is rarely troubled by serious infestations of C. rotundus as it tends to be a weed of more efficient farming systems. This probably happens because good crop management tends to remove annual weeds with which C. rotundus must compete.

There is no obvious reason why C. rotundus should not spread into southern and western areas of Tanzania. It will almost certainly become more important as a weed as new irrigation schemes are started and, paradoxically, as peasant farmers improve their standards of weeding.

Cyperus tuberosus Rottb. (Fig. 9)

This sedge has a marked preference for the high temperatures of low elevations. It has been extensively collected from the wet coastal plains north of latitude 8°S but there is no reason to suppose that it does not also occur down to the Mozambique border. It is potentially a problem in irrigated, hot lowlands of western Kenya and around Lake Turkana (formerly L. Rudolph). It is a very frequent and often serious weed of all crops near the coast from large sugar and sisal estates to small-holdings of cassava, rice, maize and of lawns. Whilst there is little risk of this weed spreading beyond its climatic limitations into the highland areas of East Africa, it will probably become more extensive as coastal agriculture expands.

Cyperus usitatus Burch var. usitatus (Fig. 10)

Locally serious infestations of this sedge are found in the Rift Valley of Kenya, especially in maize and beans grown in the Nakuru-Njoro area, but also extending up to Soy and Kitale. It has also been observed as a common weed of maize in parts of Dodoma Region, Tanzania. It tends to occur at moderate elevations in East Africa although it has not been observed in many parts of Uganda or western and southern Tanzania. The absence of C. usitatus in these areas could be because it has not been introduced or, alternatively, this sedge may prefer areas of relatively low rainfall.

Kyllinga bulbosa P. Beauv. (Fig. 11)

This sedge is widespread in wet, highland areas of East Africa above 800 m. It occurs frequently as a minor weed of gardens and lawns but it has also been recorded as an important weed of young tea in Kericho (Magambo and Kilavuka, 1975). There is little reason to expect it to become more important than it is at present.

Other sedge weeds

Nine other sedges are of rather less significance than those mentioned above and notes on their importance as weeds are summarized in Table V.

Table V. Notes on the distribution of East African sedge weeds of relatively minor importance.

Sedge	Figure no.	Notes
Cyperus distans L.f.	12	Commonly found in most crops throughout East Africa but rarely, if ever, a problem.
C. longus L. var. tenuiflorus (Rottb.) Boeck	13	Common in N. Tanzania and parts of Kenya. Occurs as a weed of irrigation schemes at Mwea Tebere and Hola. It could become more serious in irrigated crops.
C. maranguensis K. Schum.	14	Quite a common weed of coffee but also recorded in annual crops and sugar cane. It is not expected to become a serious problem.
Kyllinga erecta Schumach.	15	A very common lawn weed, often replacing the natural grass (Ivens, 1967). It is not a problem weed of cultivated crops.
K. erecta var. polyphylla (Kunth) Hooper	16	Observed as weed of rice near the coast and of coffee in Uganda. It is of minor importance in East Africa but it is a very serious weed in some tropical countries, eg India and Fiji (Mune and Parham, 1967), where it is more commonly known under the synonym Cyperus aromaticus (Ridley) Mattf. & Kük. East African clones appear to be less aggressive.
K. odorata Vahl var. major (C.B.Cl.) Chiov.	17	A widespread common sedge occurring as a weed of minor importance in highland crops such as tea, pyrethrum, coffee and in lawns.
K. squamulata Vahl	18	Limited distribution in Uganda and Tanzania where it usually occurs in damp, sandy soils as a weed of cassava, flower beds and annual crops. It is unlikely to be any more than a common, minor weed.
Mariscus macrocarpus Kunth	19	A widespread sedge occurring as a common but minor weed of coffee, maize and other crops. It is unlikely to become a problem.
M. sieberianus Steud.	20	Widespread throughout most of East Africa where it is a common weed, usually of minor importance, in many crops, especially maize and grassland. It is doubtful if it will become more widespread or important.

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Figure 24 is based on a copyright map by George Philip & Son Ltd.

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SUMMARY

1) In a survey, 57 sedges were recorded as weeds in East Africa, 10 of which cause serious local or widespread problems and 9 of which are common weeds of relatively minor importance.

2) Cyperus esculentus, C. rotundus and C. tuberosus are the most serious sedge weeds and are likely to become more important wherever the area under cultivation is increased, irrigation is introduced and crop husbandry techniques favour perennial weeds. The benefits achieved by controlling these weeds are likely to exceed those obtained from controlling all the other sedges.

3) Cyperus blysmoides, C. bulbosus var. melanolepis, C. grandibulbosus and C. usitatus var. usitatus are weeds of localised importance, but are potentially capable of spreading into hitherto uninfested areas and creating more problems. Vigilance in recognizing and destroying new outbreaks of these weeds is very necessary.

4) Cyperus rigidifolius and Kyllinga bulbosa are of somewhat variable importance in the highlands but may become more serious under certain conditions.

5) Cyperus difformis is currently rated as a weed of fairly minor importance in East Africa but is expected to become a major weed of rice, especially when husbandry of this crop improves and growing areas expand.

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Table I. References to the occurrence of sedge weeds in East Africa

Species	Reference
Bulbostylis sp. aff. densa (Wall.) Hand.-Mazz.	P
Cyperus blysmoides C.B.Cl.	5, 6, 18, 19, 28, 31, 33, P
C. bulbosus Vahl var. melanolepis Kük.	P
C. compressus L.	22, P
C. cuspidatus Kunth	22
C. difformis L.	16*, 22, 43*, P
C. distans L.f.	38, P
C. esculentus L.	5, 6, 10, 18, 19[a], 28, 30, 33[a], 43
C. grandibulbosus C.B.Cl.	1*[b], P
C. kilimandscharicus Kük.	P*
C. latifolius Poir.	38, 43*, P
C. longus L. var. tenuiflorus (Rottb.) Boeck.	15*, 44*, P
C. maranguensis K. Schum.	2, 18, P
C. rigidifolius Steud.	3, 9, 10, 18, 23, 31, 37, 38, P
C. rotundus L.	3[c], 4*, 7, 18, 31, 34*, 38, P
C. stuhlmannii C.B.Cl.	P
C. tuberosus Rottb.	22, 31, P
C. usitatus Burch. var. usitatus	28, P
Fimbristylis dichotoma (L.) Vahl	P
F. hispidula (Vahl) Kunth	38, 43*, P
F. littoralis Gaud.	P
F. quinquangularis (Vahl) Kunth	P
Fuirena leptostachya Oliv.	22
Kyllinga aurata Nees var. aurata	29
K. aurata Nees var. lurida (Kük.) Napper	37, P
K. bulbosa P. Beauv.	23, 31, 38[d], P
K. crassipes Boeck.	29
K. erecta Schumach.	5, 6, 18, 38, 43*
K. erecta Schumach. var. polyphylla (Kunth) Hooper	22, 38[e], P
K. nervosa Steud.	10
K. odorata Vahl var. major (C.B.Cl.) Chiov.	5[f], 18, 38[g], P
K. pulchella Kunth	31, 43*
K. pumila Michx.	38
K. squamulata Thonn, ex Vahl	29, P

Table I. continued

Species	Reference
K. tenuifolia Steud.	10
Mariscus alternifolius Vahl	10[h]
M. aristatus (Rottb.) Cherm.	P
M. assimilis (Steud.) Podl.	P
M. dubius (Rottb.) C.E.C. Fischer var. macrocephalus (Boeck.) Chiov.	P
M. ferrugineoviridis (C.B.Cl.) Cherm.	10[i], 29, 38, P
M. hemisphaericus (Boeck.) C.B.Cl.	P
M. longibracteatus Cherm.	10
M. macrocaspus Kunth	29, 38, P
M. macropus C.B.Cl.	10, 35*, P
M. sieberianus Steud.	29, 38, P
Pycreus aethiops (Ridley) C.B.Cl.	29
P. flavescens (L.) Reichenb.	22
P. hildebrandtii C.B.Cl.	22, 29
P. macrostachyos (Lam.) J. Raynal	P
P. rehmannianus C.B.Cl.	29, 43*
Queenslandiella hyalina (Vahl) Ballard	29, P
Rhynchospora holoschoenoides (L.C. Rich.) Herter	26
Scirpus confusus N.E.Br.	P
S. maritimum L.	27
S. rehmanii	P
Scleria foliosa Hochst. ex A. Rich.	P
S. striatinux De Wild.	P

Key P = personal observation by author or collector

* = reference to or observation of sedge in a non-weed situation

a = refers to old synonym of Cyperus auricomus

b = refers to Cyperus giolii. Material recorded in the East African Herbarium, Nairobi as being C. giolii is believed to be C. grandibulbosus but studies are required to eliminate confusion.

c = identification is almost certainly wrong

d = synonyms Kyllinga albiceps (Ridl.) Rendle and K. sphaerocephala Boeck. used

e = synonym Kyllinga pinguis C.B.Cl. used

f = synonym Kyllinga cylindrica Nees var. major C.B.Cl. used

g = synonym Cyperus sesquiflorus (Torr.) Mattf. & Kük. used

h = misnoma Mariscus subumbellatus used

i = synonym Cyperus ferrugineoviridis (C.B.Cl.) Kük. used

Table II. Percentage land area of East Africa within elevation, temperature and rainfall class intervals

Annual average rainfall (mm)		Elevation (m)		Annual actual temperature (^{o}C)*	
Interval	%	Interval	%	Interval	%
0- 199	0.18	0- 499	21.94	<17.5	1.77
200- 399	16.06	500- 999	22.94	17.5-20.0	1.79
400- 599	17.48	1000-1499	41.71	20.0-22.5	18.40
600- 799	11.71	1500-1999	10.28	22.5-25.0	46.58
800- 999	29.86	2000-2499	2.25	25.0-27.5	27.68
1000-1199	13.24	>2500	0.88	>27.5	1.78
1200-1399	6.98	-	-	-	-
>1400	4.49	-	-	-	-
Total	100.0		100.0		100.0

* mean of average annual maximum and minimum temperature

Table III. Frequency distribution of <u>Cyperus rotundus</u> at different elevations in East Africa.

Class interval (m)	% area of East Africa	Observed frequency	Predicted frequency
0- 499	21.94	8	14.0
500- 999	22.94	11	14.7
1000-1499	41.71	33	26.7
1500-1999	10.28	12	6.6
2000-2499	2.25	0	1.4
2500	0.88	0	0.6
Total	100.0	64	64.0

Table IV. Optimum conditions for occurrence of sedge weeds in East Africa.

	Elevation (m)	Annual actual temperature (°C)*	Average annual rainfall (mm)
Cyperus blysmoides	1500-2000	17.5-22.5	600-1000
C. bulbosus var. *melanolepis*	1000-2000	17.5-22.5	400- 800
C. difformis	0-2000	17.5-25.0	1000-1400+
C. distans	1000-2500	<17.5-22.5	1000-1400+
C. esculentus	1500-2000	<17.5-22.5	600-1400+
C. grandibulbosus	500-1500	17.5-22.5	400-1400
C. longus var. *teniflorus*	500-2000	17.5-22.5	400-1400
C. maranguensis	1500-2500	17.5-22.5	600-1400+
C. rigidifolius	1500-2500+	<17.5-22.5	800-1400+
C. rotundus	1000-2000	17.5-22.5	600-1400+
C. tuberosus	0- 500	25.0-27.5+	800-1400+
C. usitatus var. *usitatus*	1000-1500	<17.5-22.5	400-1200
Kyllinga bulbosa	1500-2500+	<17.5-22.5	1200-1400+
K. erecta	1500-2000	<17.5-22.5	600-1400+
K. erecta var. *polyphylla*	0-2000	20.0-22.5	1000-1400+
K. odorata var. *major*	1500-2500+	<17.5-22.5	1000-1400+
K. squamulata	500-1500	17.5-25.0	1000-1400+
Mariscus macrocarpus	1500-2000	<17.5-22.5	1200-1400+
M. sieberianus	1500-2500	<17.5-22.5	1000-1400+

* mean of average annual maximum and minimum temperature

Fig. 2

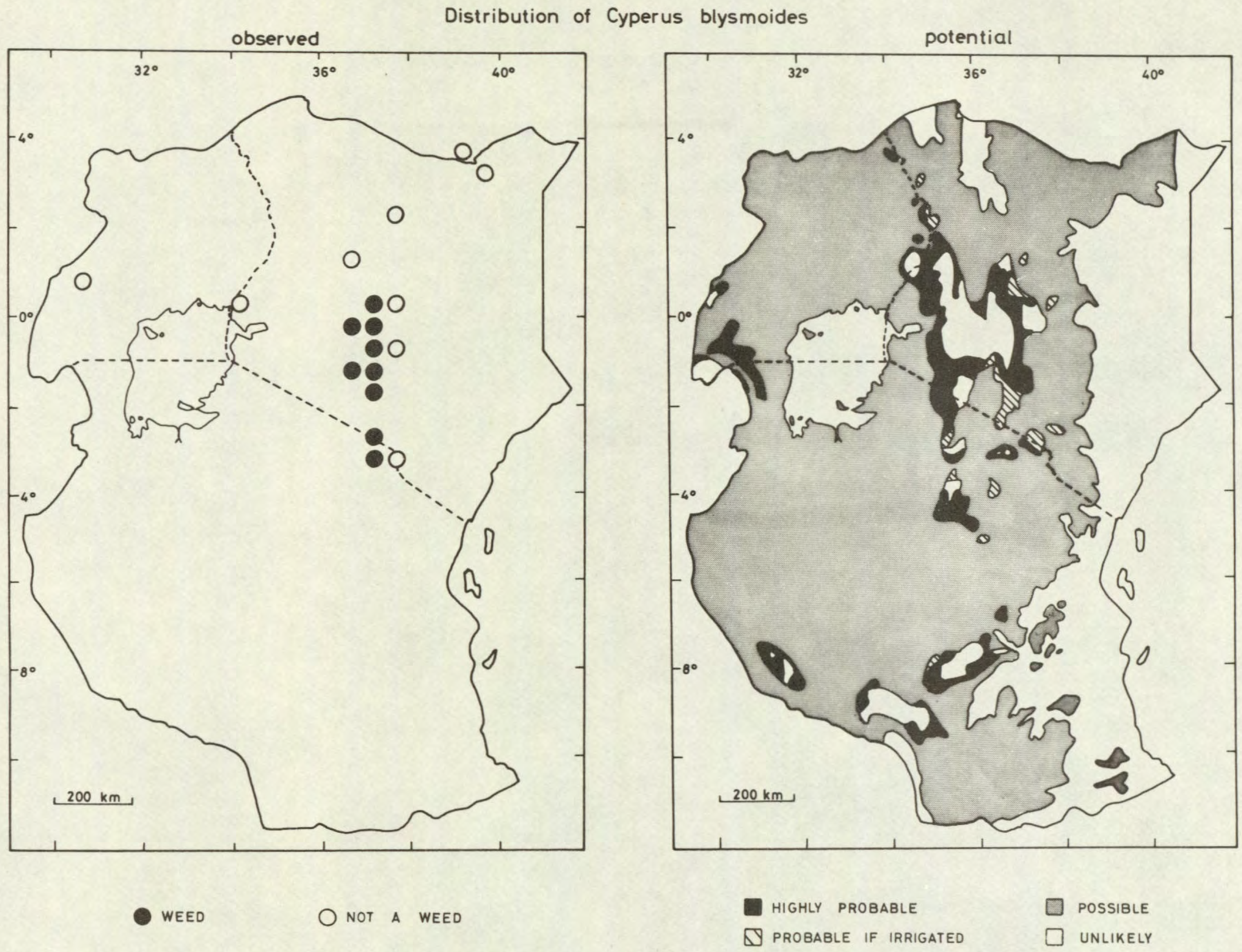

Distribution of Cyperus blysmoides
observed
potential
32°
36°
40°
4°
0°
4°
8°
200 km
WEED
NOT A WEED
HIGHLY PROBABLE
PROBABLE IF IRRIGATED
POSSIBLE
UNLIKELY

Fig. 3

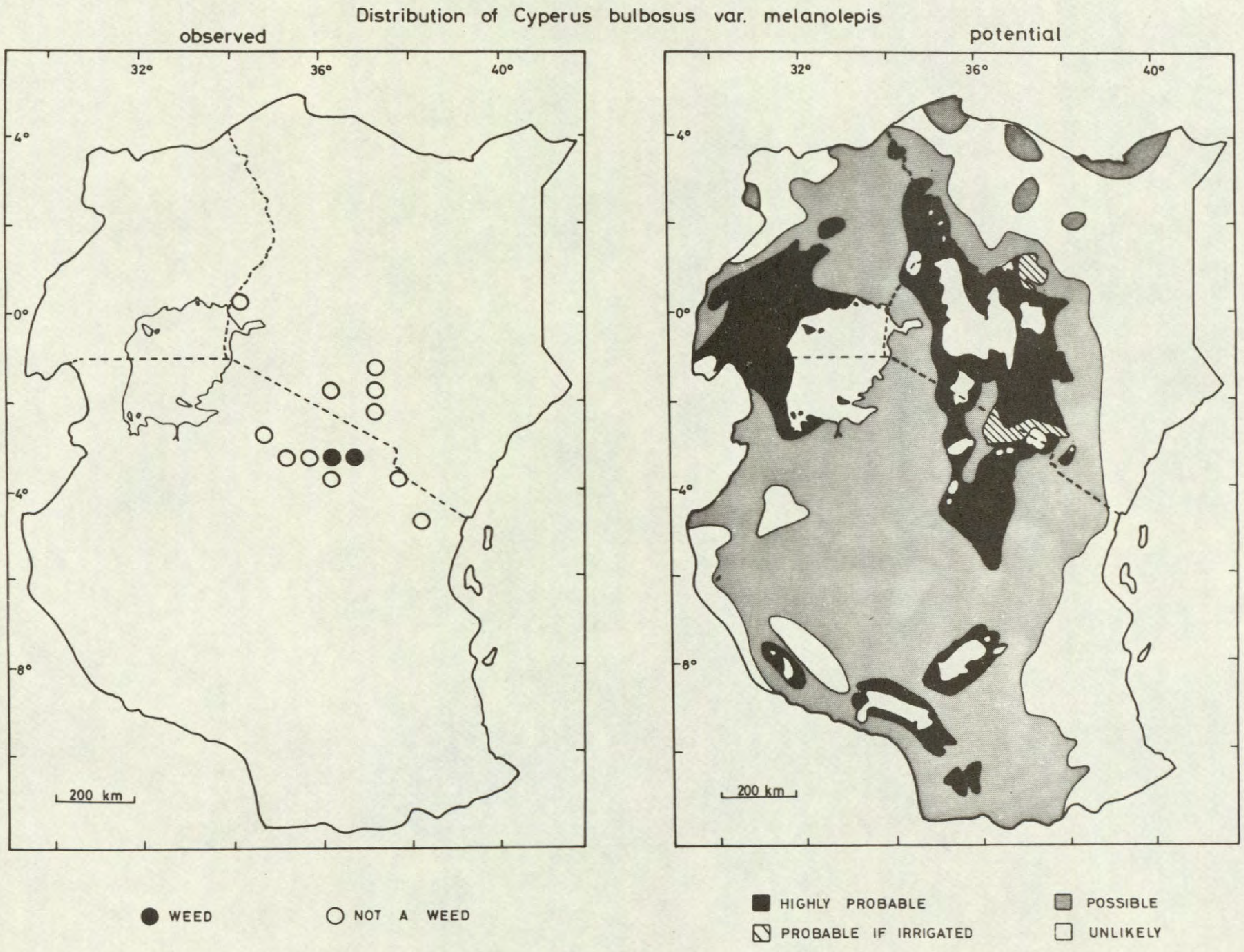

Distribution of Cyperus bulbosus var. melanolepis
observed
potential
32°
36°
40°
4°
0°
4°
8°
200 km
WEED
NOT A WEED
HIGHLY PROBABLE
PROBABLE IF IRRIGATED
POSSIBLE
UNLIKELY

Fig. 4

Distribution of Cyperus difformis

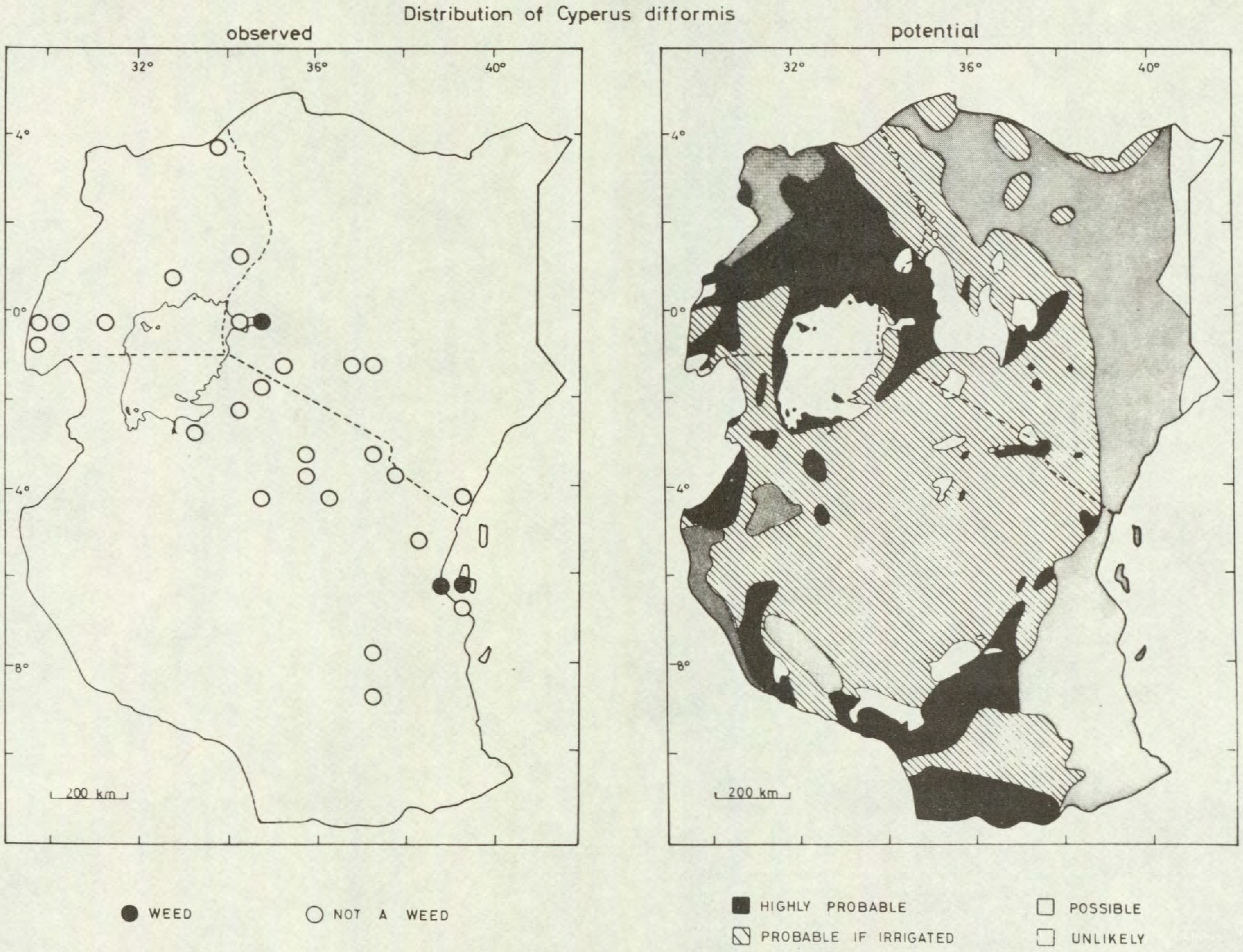


Fig. 5

Distribution of Cyperus esculentus

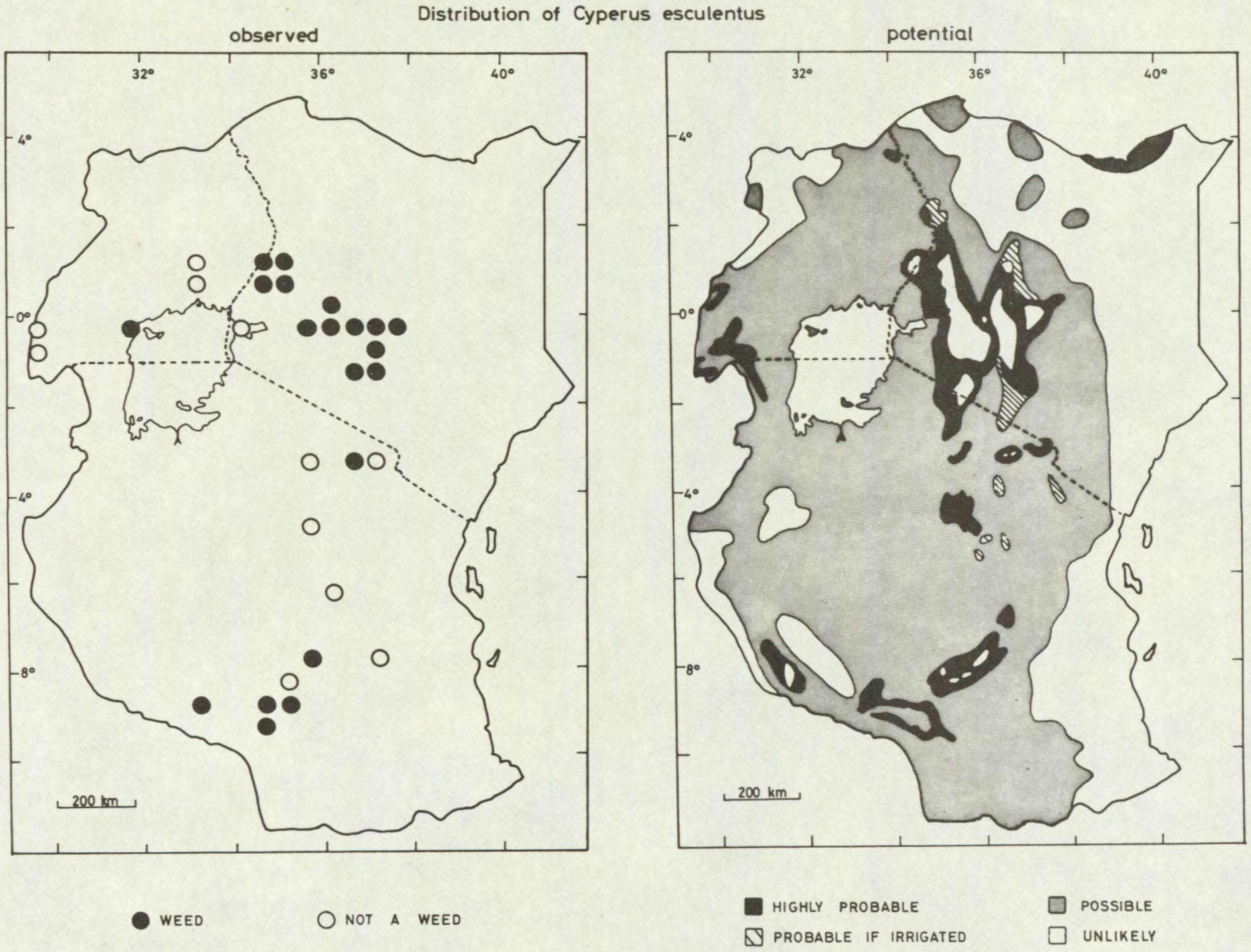


Fig. 6

Distribution of Cyperus grandibulbosus

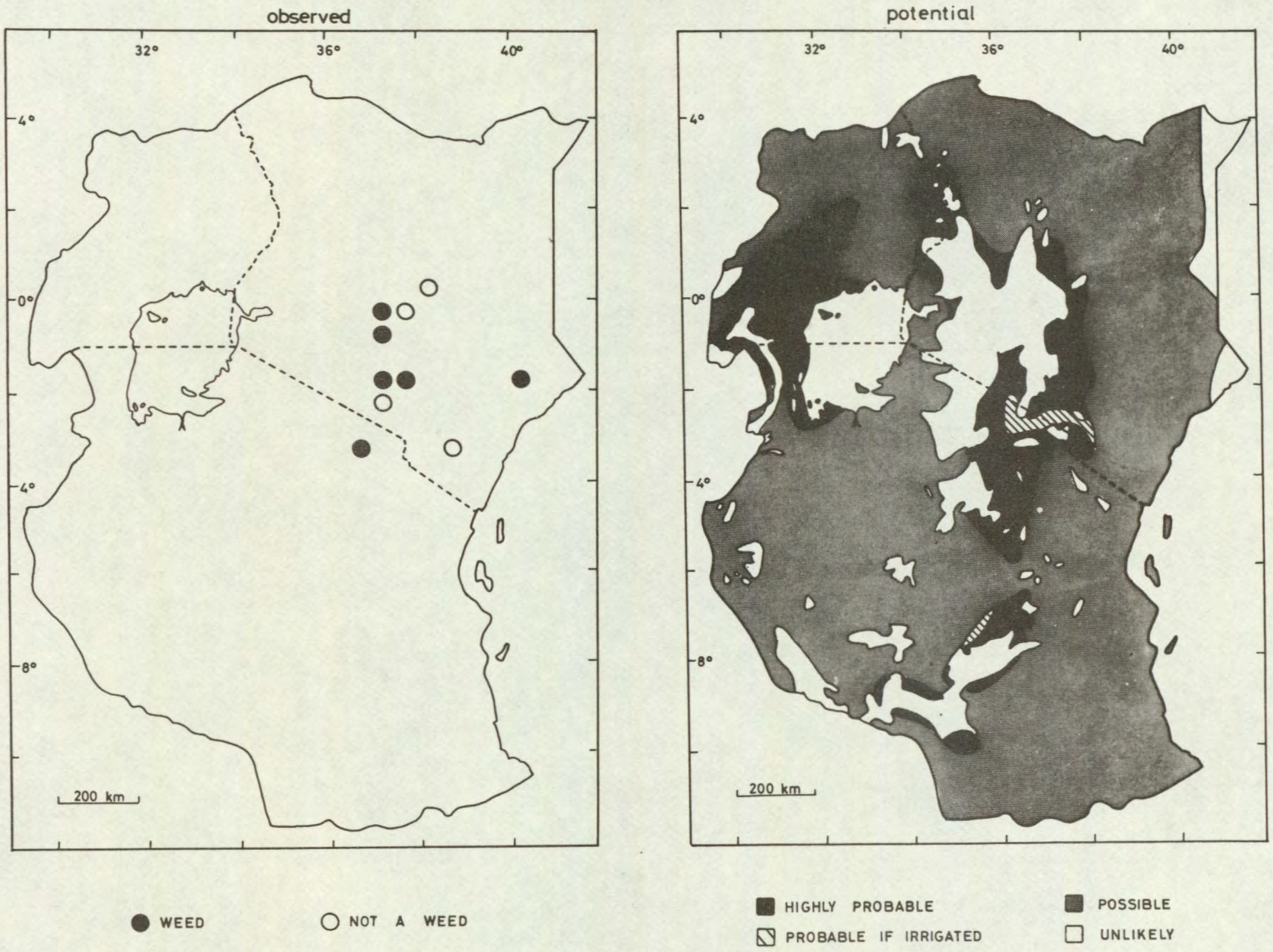


Fig. 7

Distribution of Cyperus rigidifolius

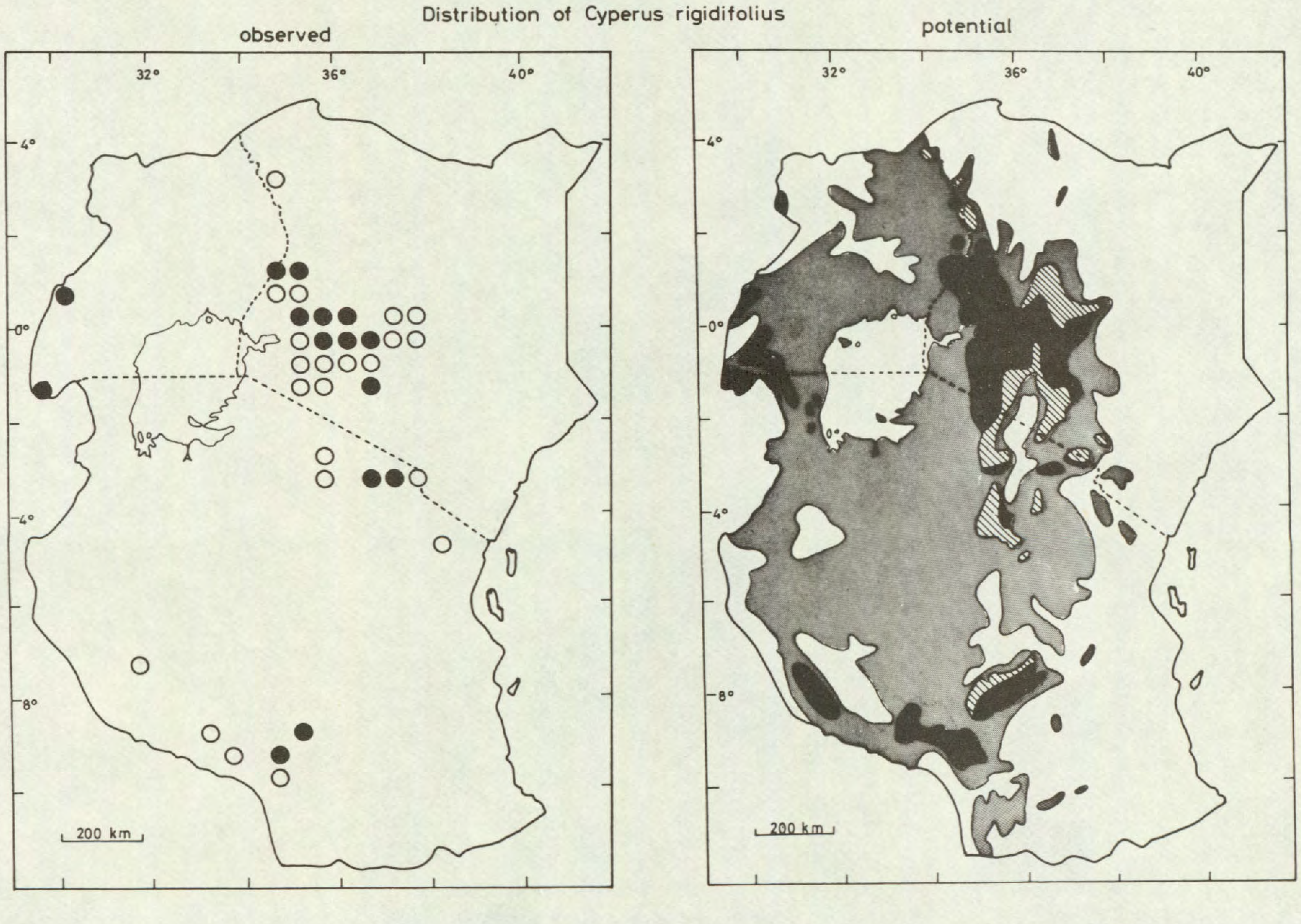


Fig. 8

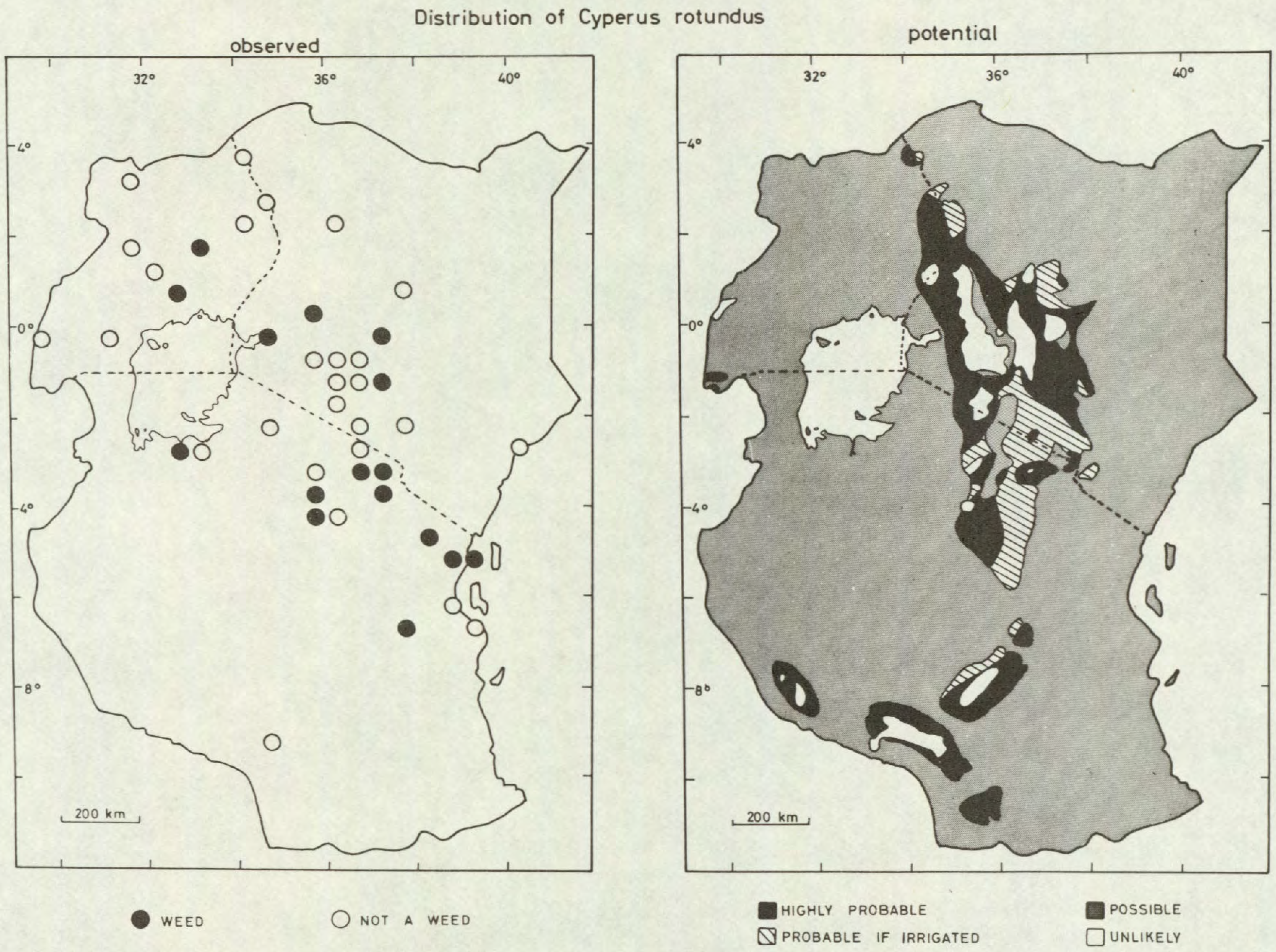

Distribution of Cyperus rotundus
observed
potential
32°
36°
40°
4°
0°
4°
8°
200 km
WEED
NOT A WEED
HIGHLY PROBABLE
PROBABLE IF IRRIGATED
POSSIBLE
UNLIKELY

Fig. 9

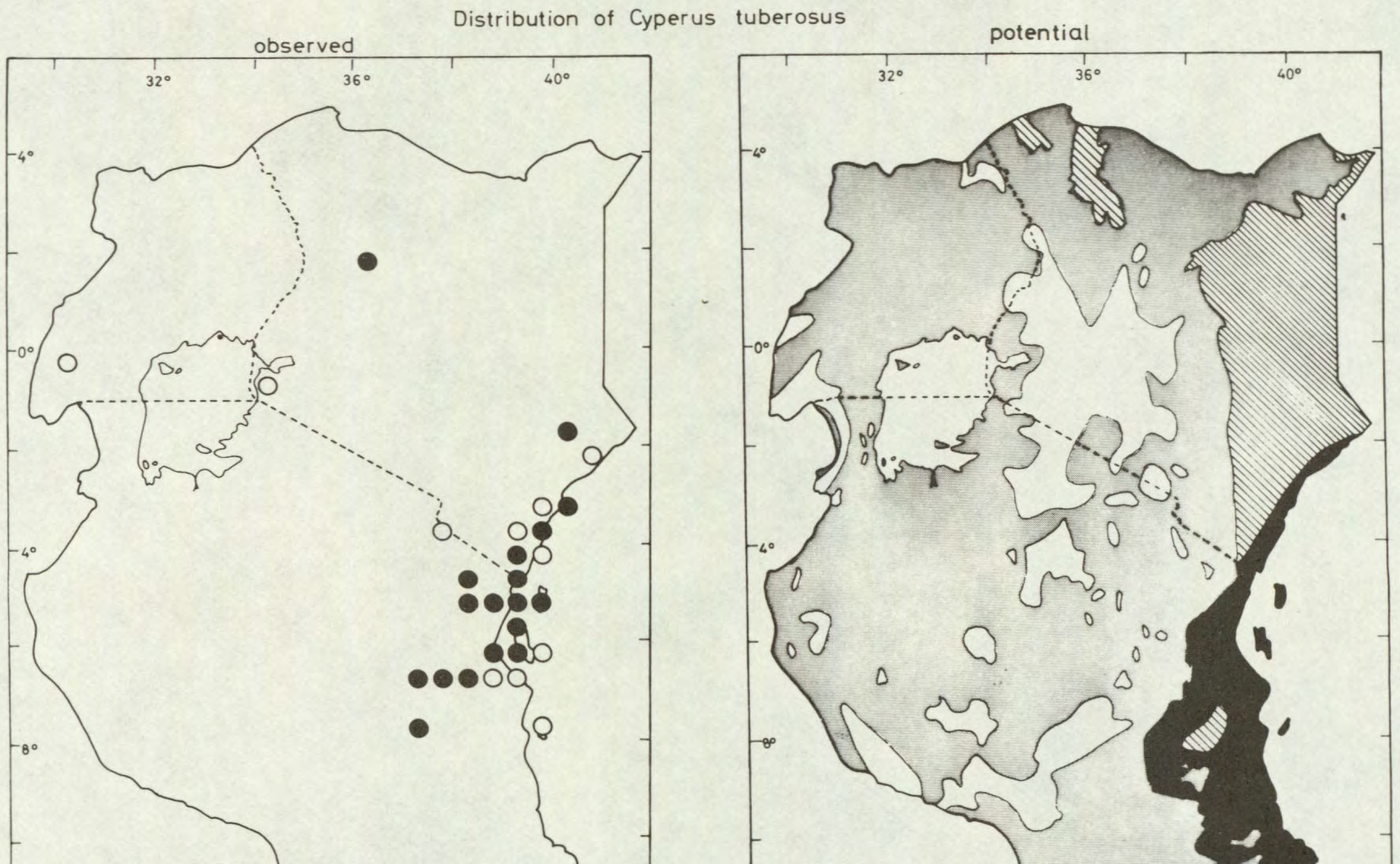

Distribution of Cyperus tuberosus
observed
potential
32°
36°
40°
4°
0°
4°
8°
200 km
WEED
NOT A WEED
HIGHLY PROBABLE
PROBABLE IF IRRIGATED
POSSIBLE
UNLIKELY

Fig. 10

Distribution of Cyperus usitatus var. usitatus

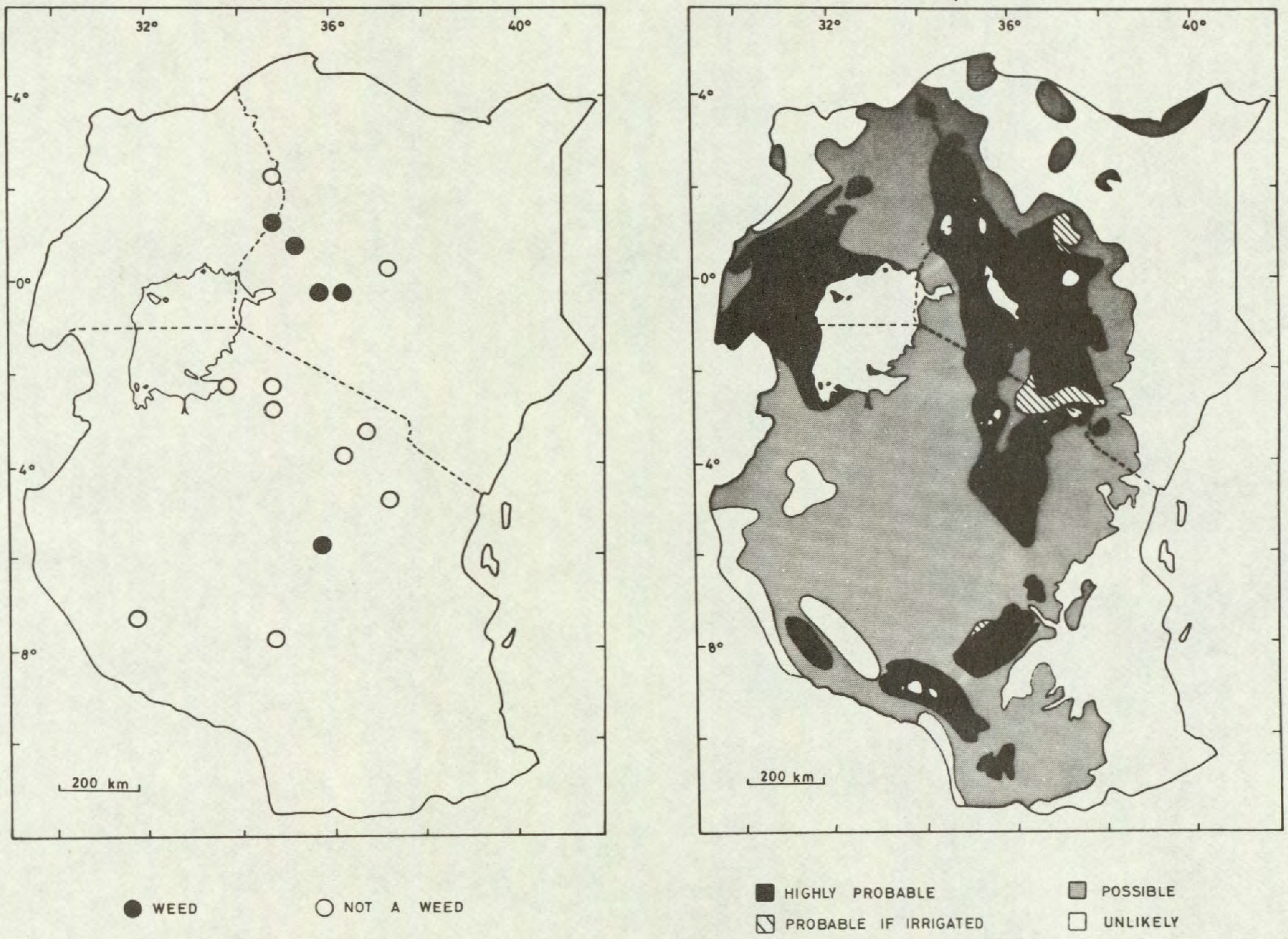


Fig. 11

Distribution of Kyllinga bulbosa

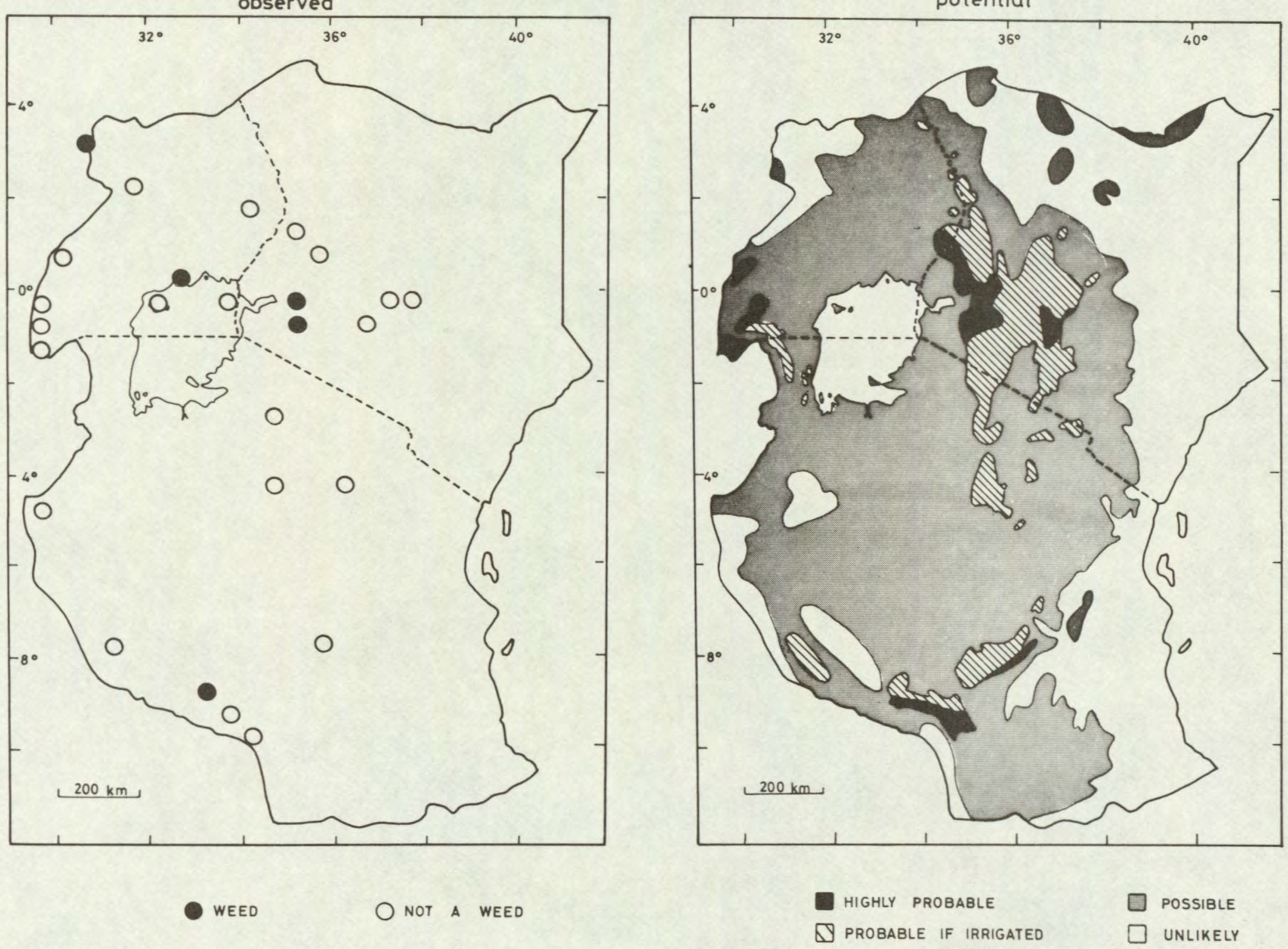


Fig. 12

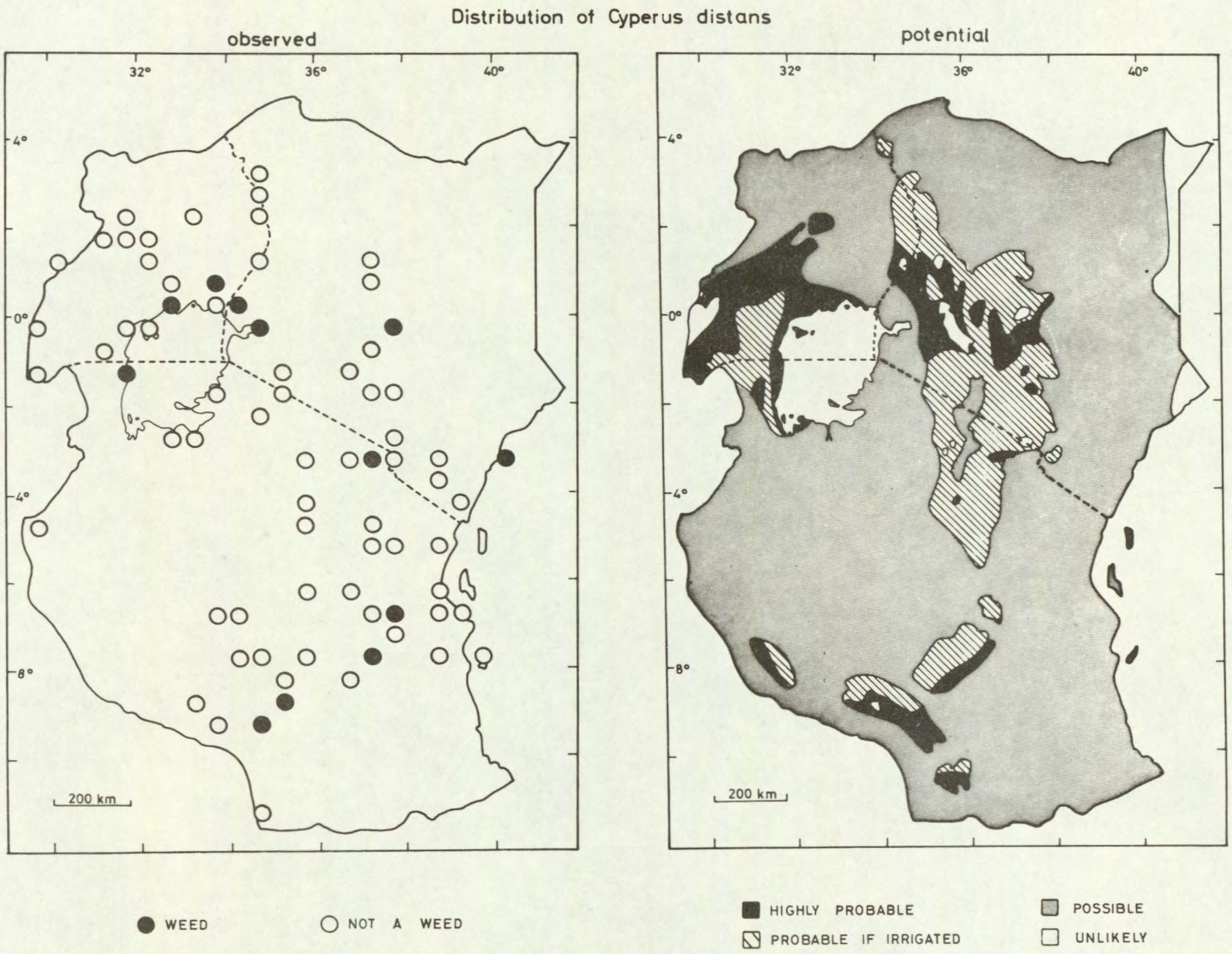

Distribution of Cyperus distans
observed
potential
32°
36°
40°
4°
0°
4°
8°
200 km
WEED
NOT A WEED
HIGHLY PROBABLE
PROBABLE IF IRRIGATED
POSSIBLE
UNLIKELY

Fig. 13

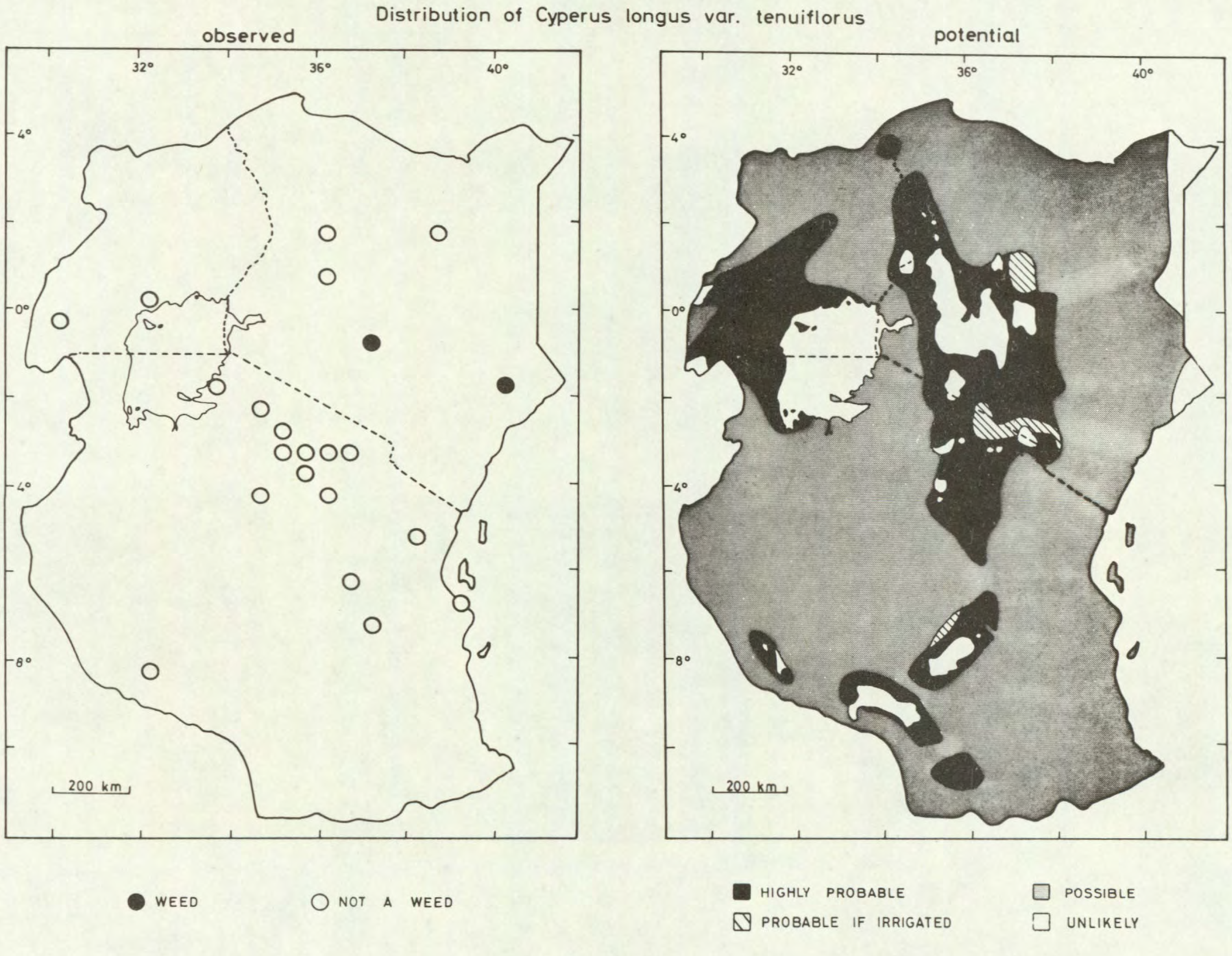
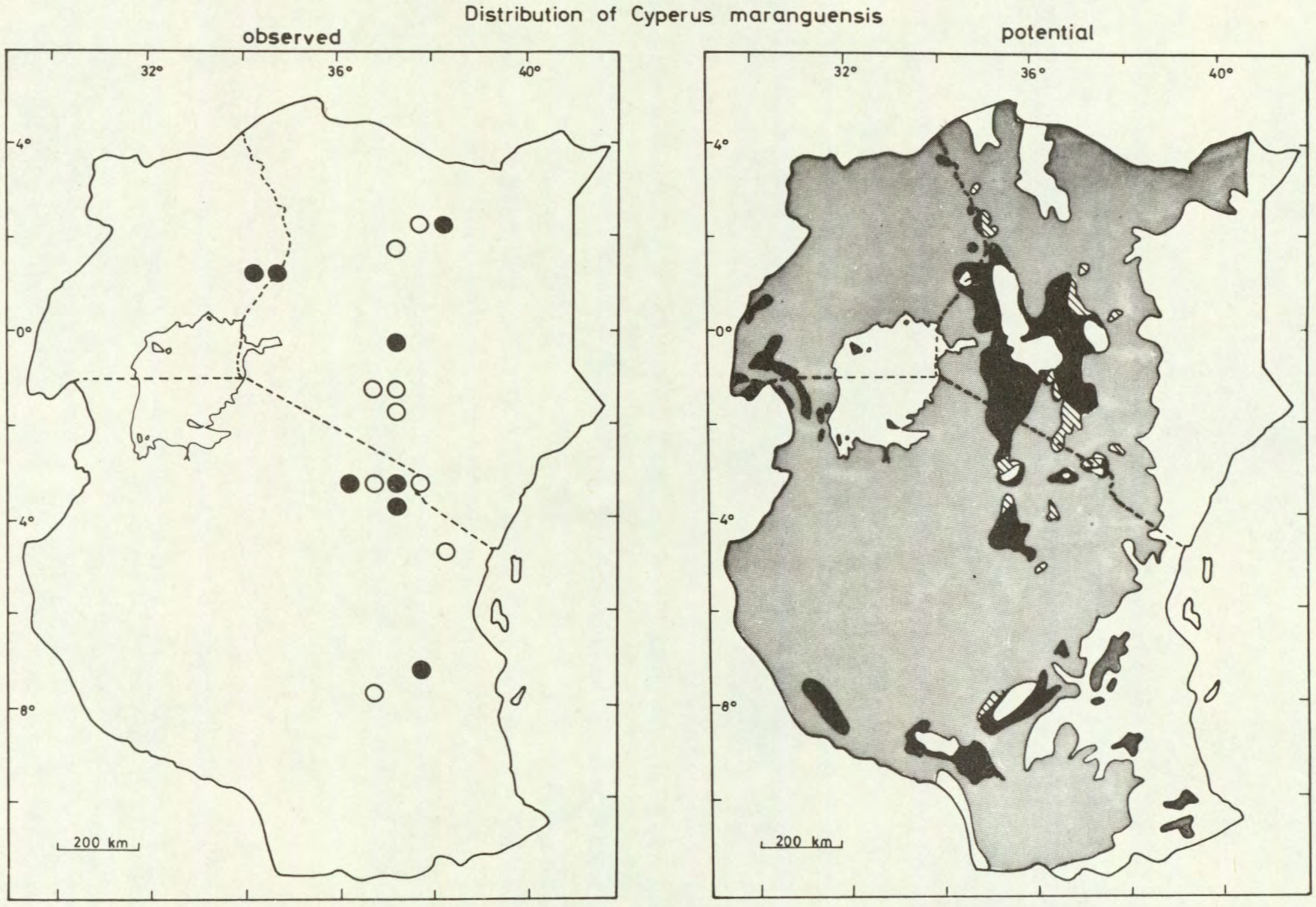

Distribution of Cyperus longus var. tenuiflorus
observed
potential
32°
36°
40°
4°
0°
4°
8°
200 km
WEED
NOT A WEED
HIGHLY PROBABLE
PROBABLE IF IRRIGATED
POSSIBLE
UNLIKELY

Fig. 14

Distribution of Cyperus maranguensis



WEED

NOT A WEED

HIGHLY PROBABLE

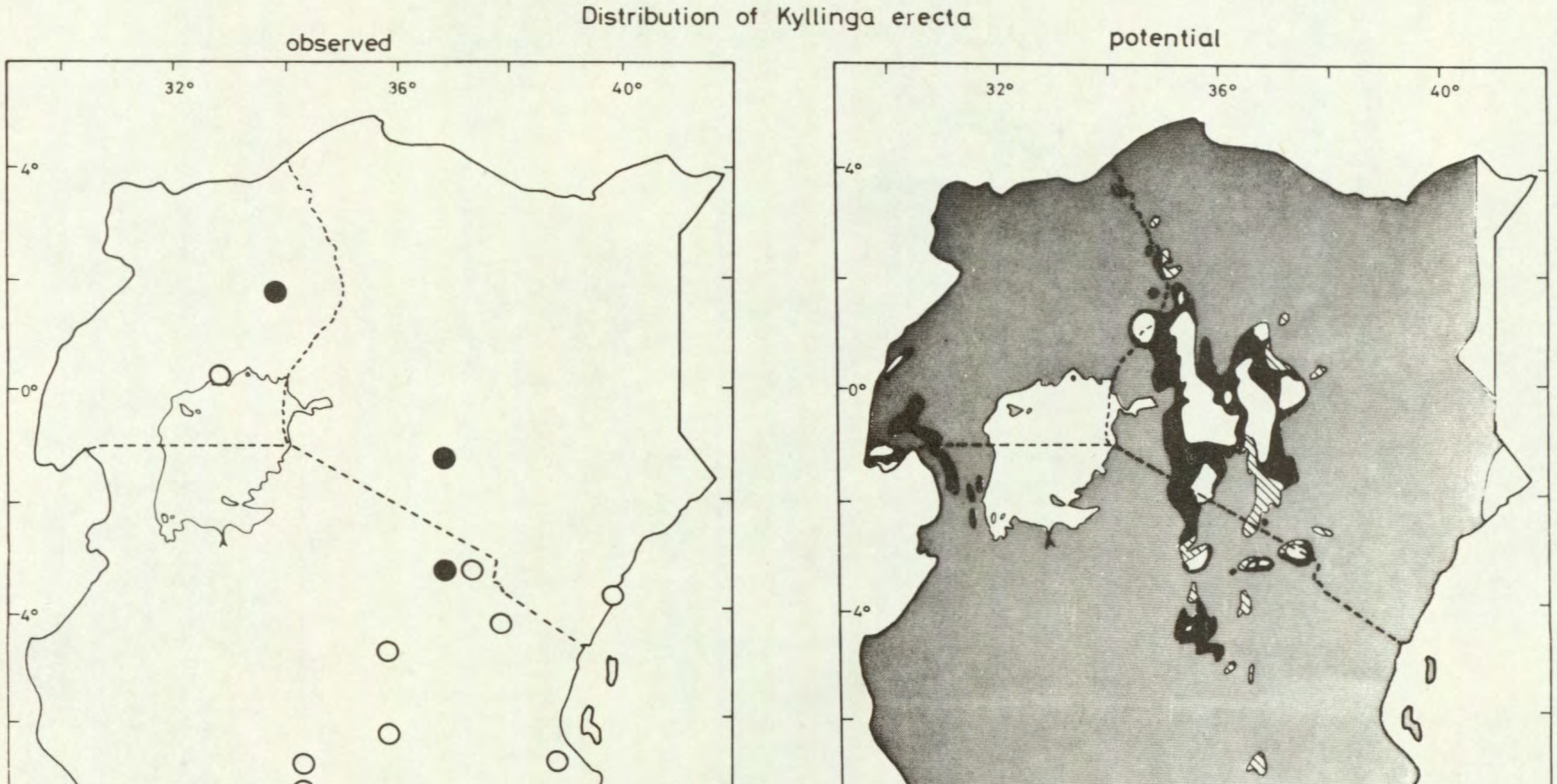
PROBABLE IF IRRIGATED

POSSIBLE

UNLIKELY

Fig. 15

Distribution of Kyllinga erecta



WEED

NOT A WEED

HIGHLY PROBABLE

PROBABLE IF IRRIGATED

POSSIBLE

UNLIKELY

Fig. 16

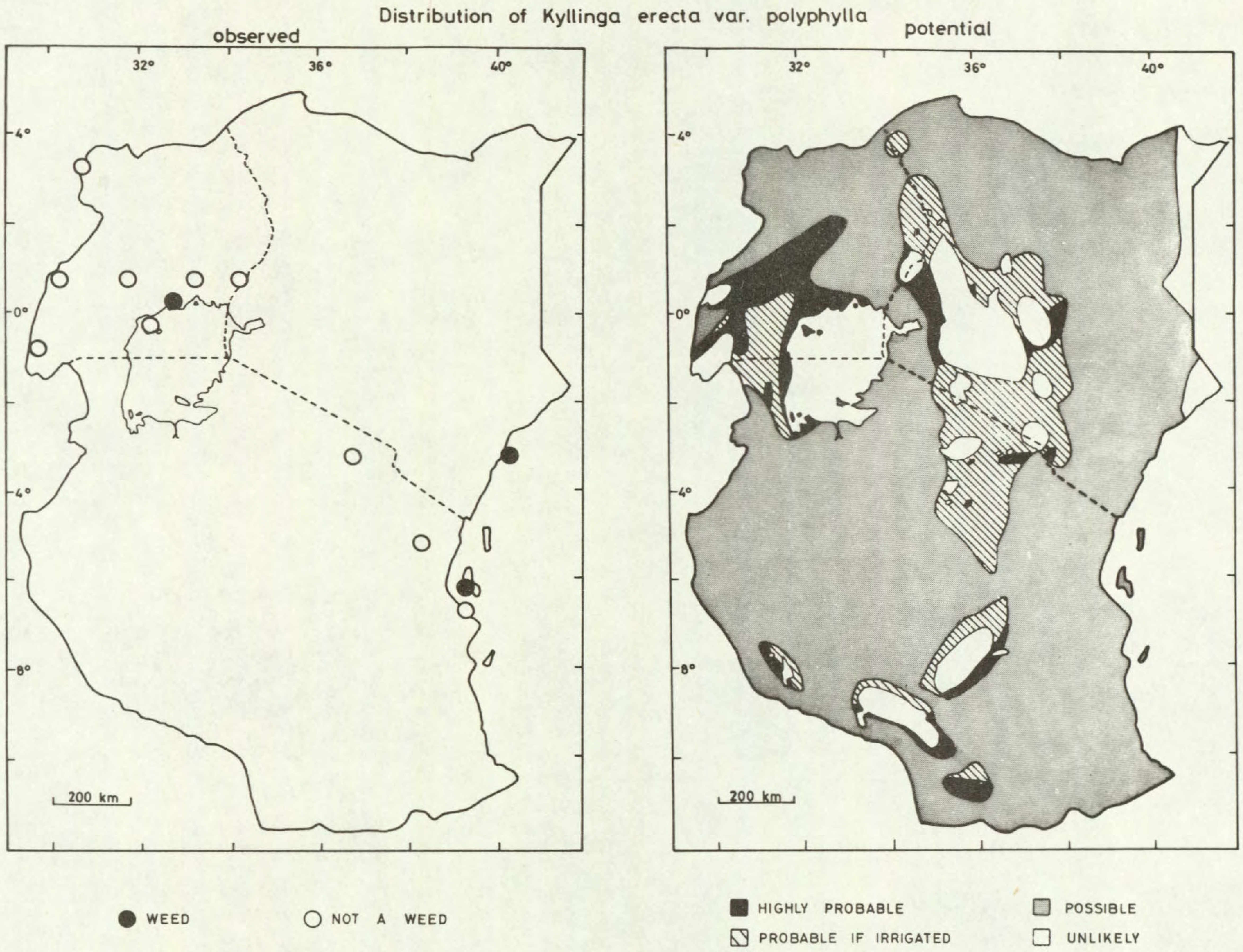

Distribution of Kyllinga erecta var. polyphylla
observed
potential
32°
36°
40°
4°
0°
4°
8°
200 km
WEED
NOT A WEED
HIGHLY PROBABLE
PROBABLE IF IRRIGATED
POSSIBLE
UNLIKELY

Fig. 17

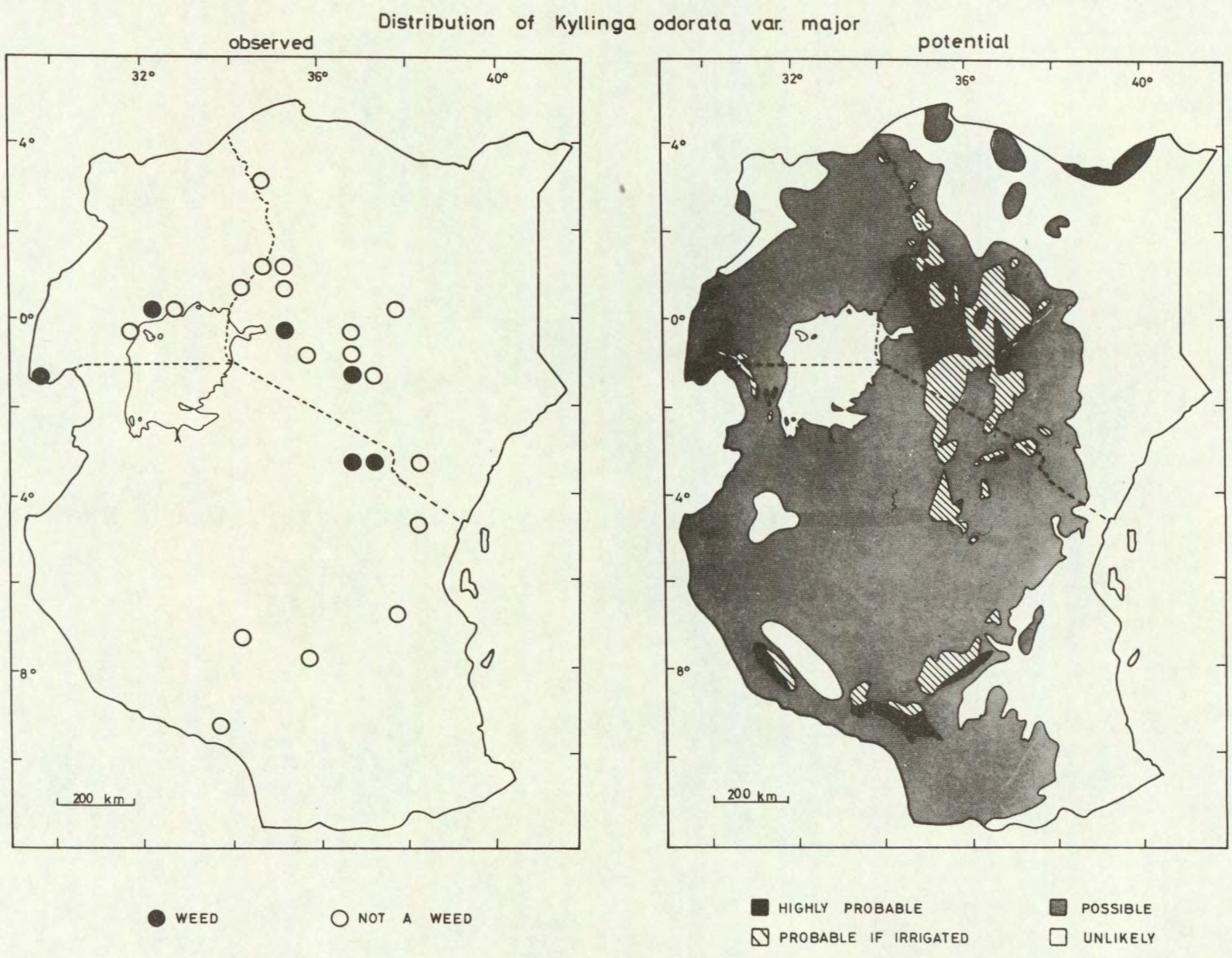

Distribution of Kyllinga odorata var. major
observed
potential
32°
36°
40°
4°
0°
4°
8°
200 km
WEED
NOT A WEED
HIGHLY PROBABLE
PROBABLE IF IRRIGATED
POSSIBLE
UNLIKELY

Fig. 18

Distribution of Kyllinga squamulata

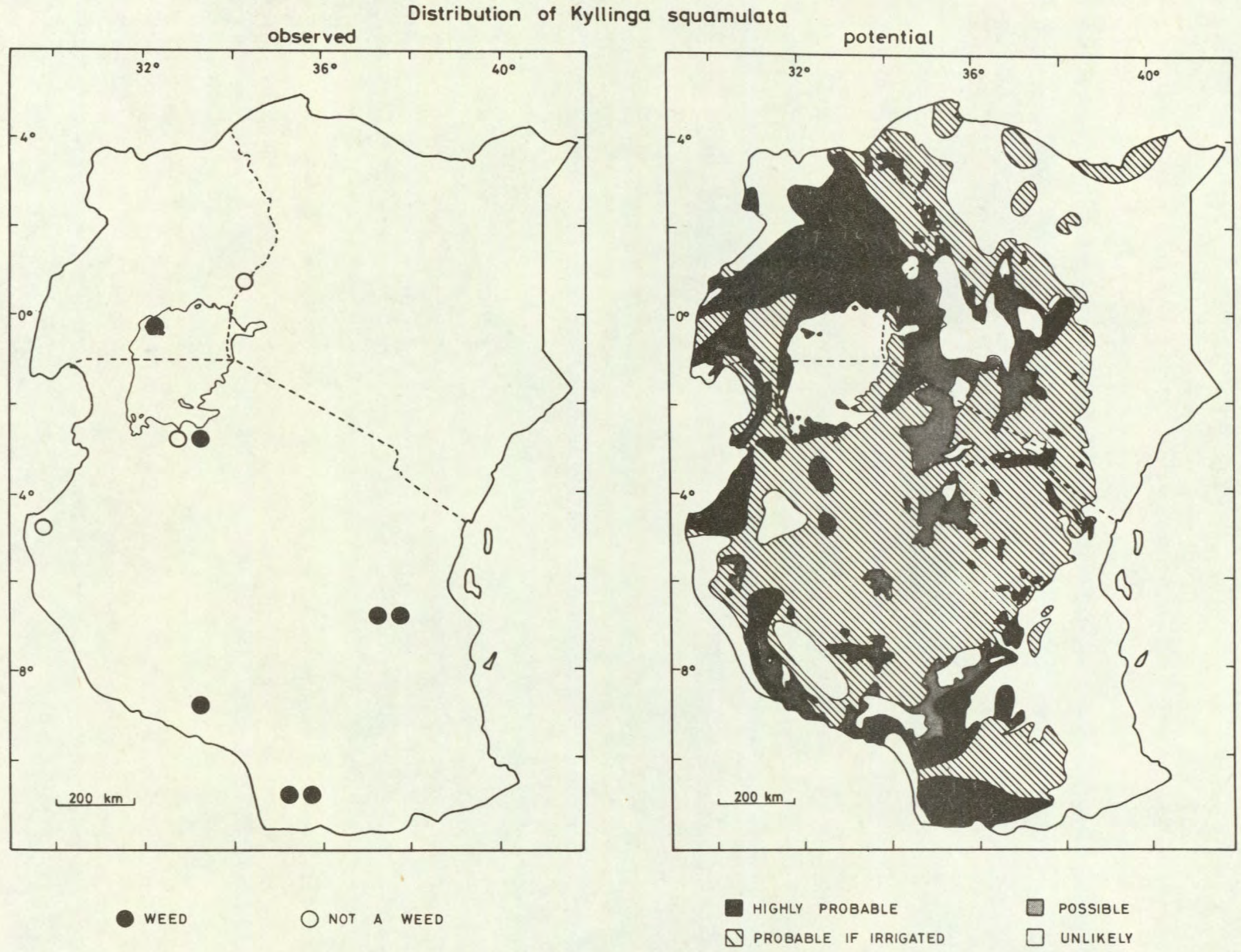


Fig. 19

Distribution of Mariscus macrocarpus

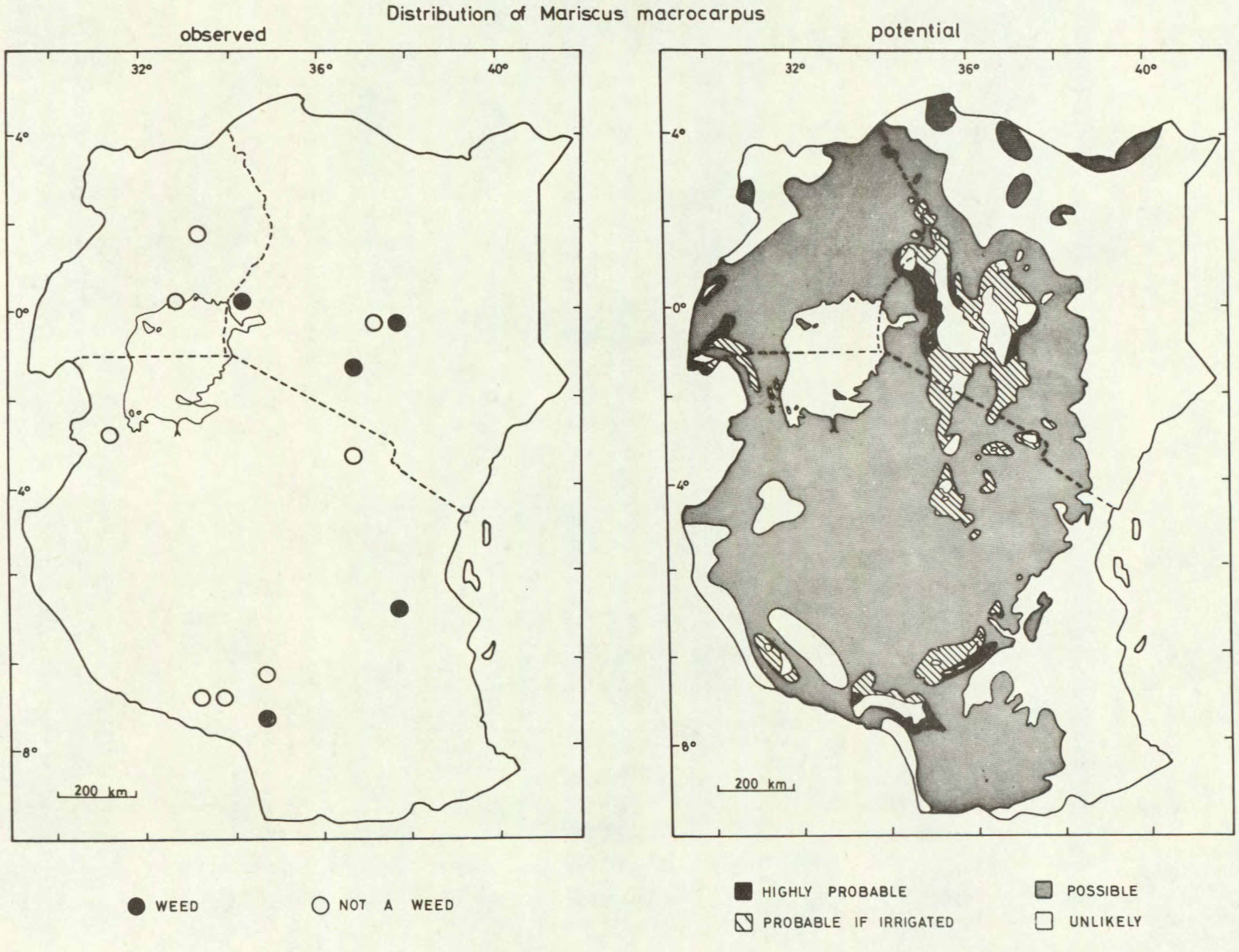


Fig. 20

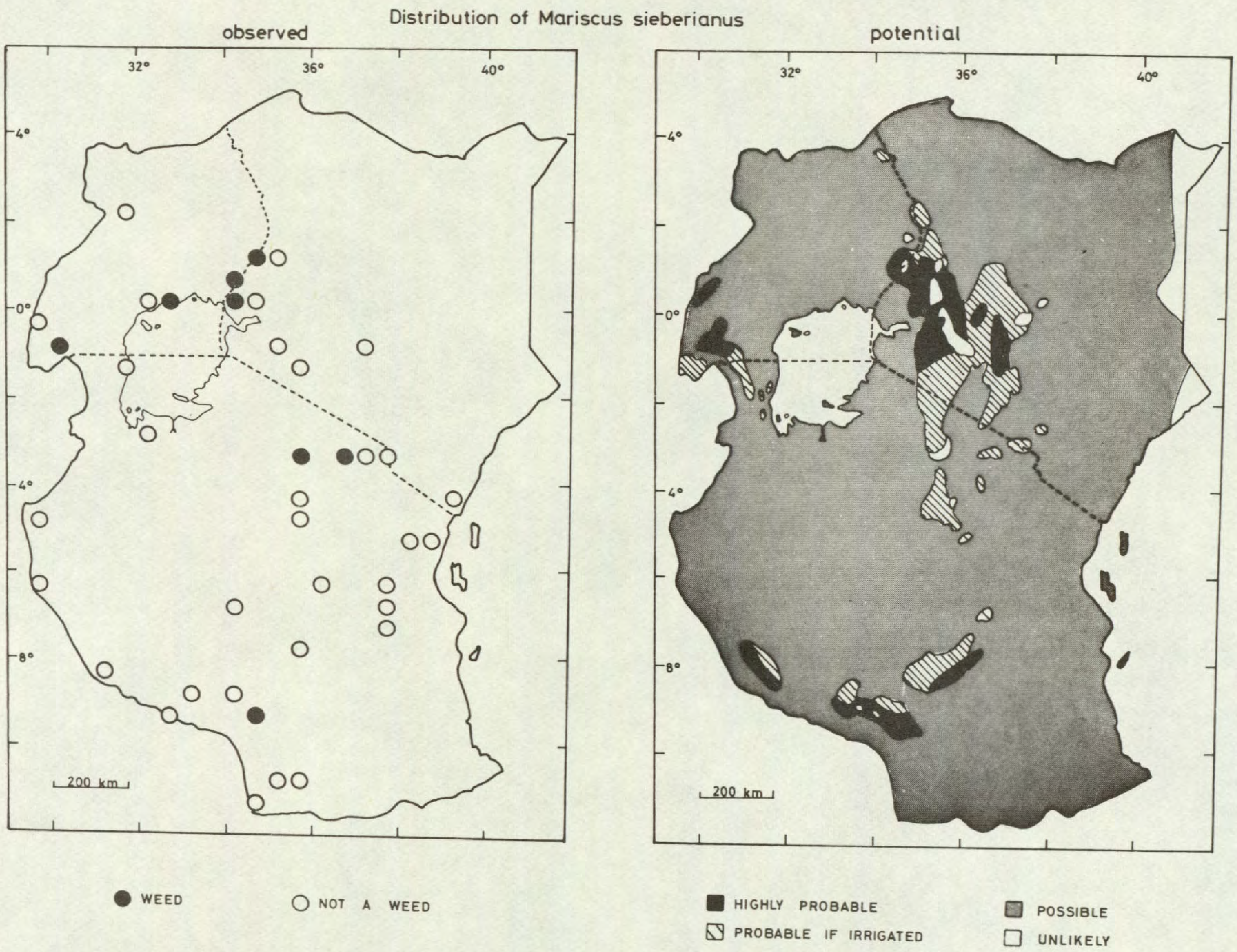
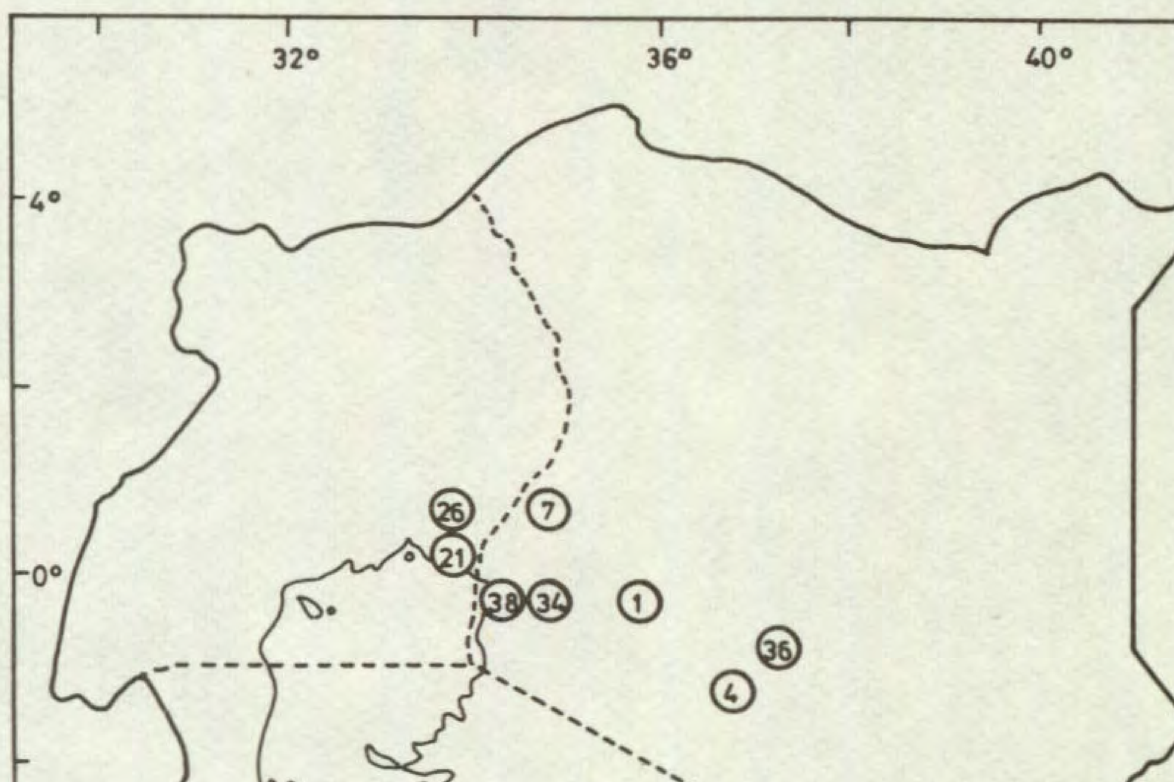


Fig. 21

Occurrence as weeds - 38 sedges not commonly observed as weeds

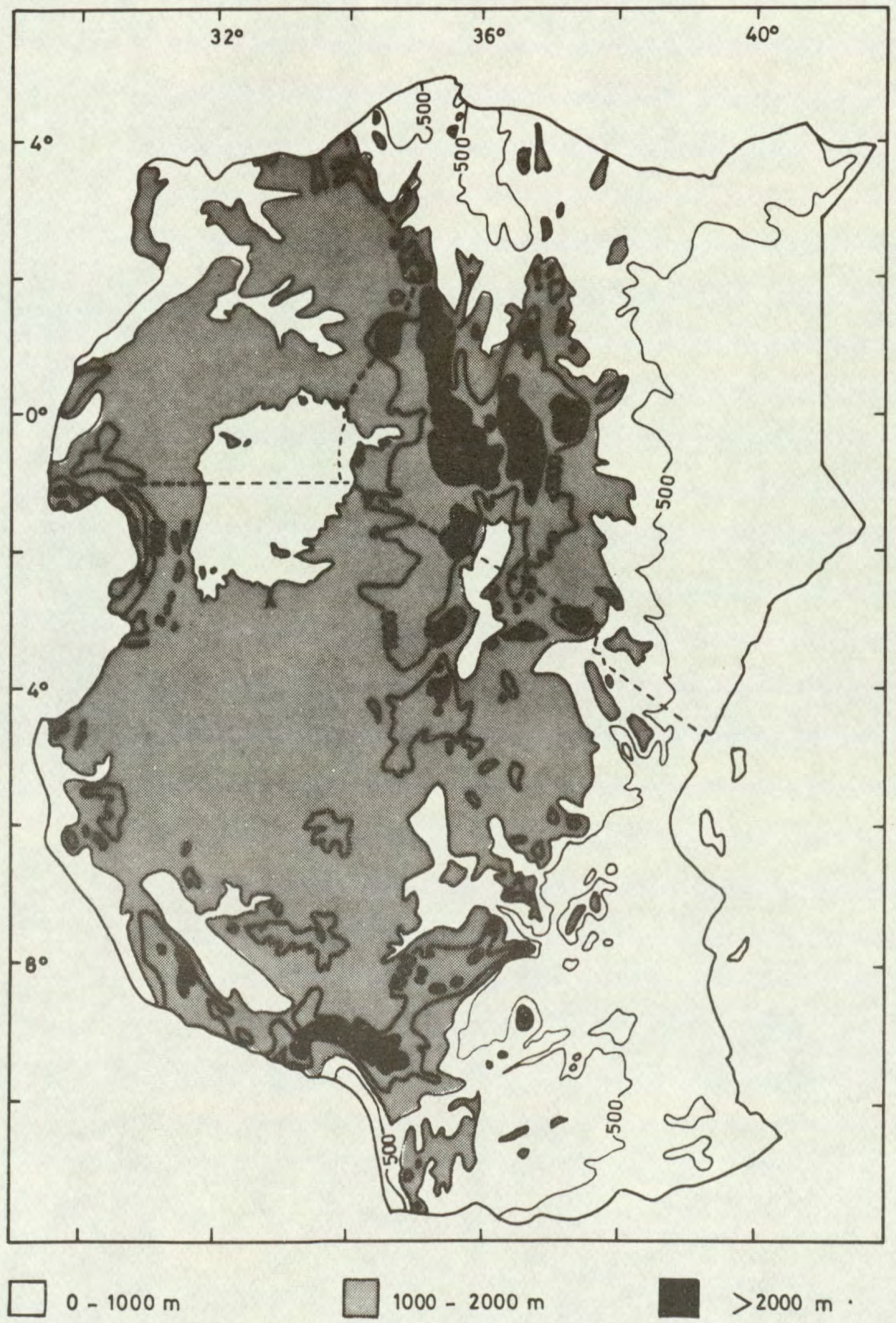


Key:

1. Bulbostylis sp. aff. densa
2. Cyperus compressus
3. Cyperus cuspidatus
4. Cyperus kilimandscharicus
5. Cyperus latifolius
6. Cyperus stuhlmannii
7. Fimbristylis dichotoma
8. Fimbristylis hispidula
9. Fimbristylis littoralis
10. Fimbristylis quinquangularis
11. Fuirena leptostachya
12. Kyllinga aurata var. aurata
13. Kyllinga aurata var. lurida
14. Kyllinga crassipes
15. Kyllinga nervosa
16. Kyllinga pulchella
17. Kyllinga pumila
18. Kyllinga tenuifolia
19. Mariscus aristatus
20. Mariscus assimilis
21. Mariscus dubius var. macrocephalus
22. Mariscus ferrugineoviridis
23. Mariscus hemisphaericus
24. Mariscus longibracteatus
25. Mariscus macropus
26. Mariscus alternifolius
27. Pycreus aethiops
28. Pycreus flavescens
29. Pycreus hildebrandtii
30. Pycreus macrostachyos
31. Pycreus rehmannianus
32. Queenslandiella hyalina
33. Rhynchospora holoschoenoides
34. Scirpus confusus
35. Scirpus maritimus
36. Scirpus rehmanii
37. Scleria foliosa
38. Scleria striatinux

Fig. 22

East Africa - elevation contours



(After Kenya Government, 1974)

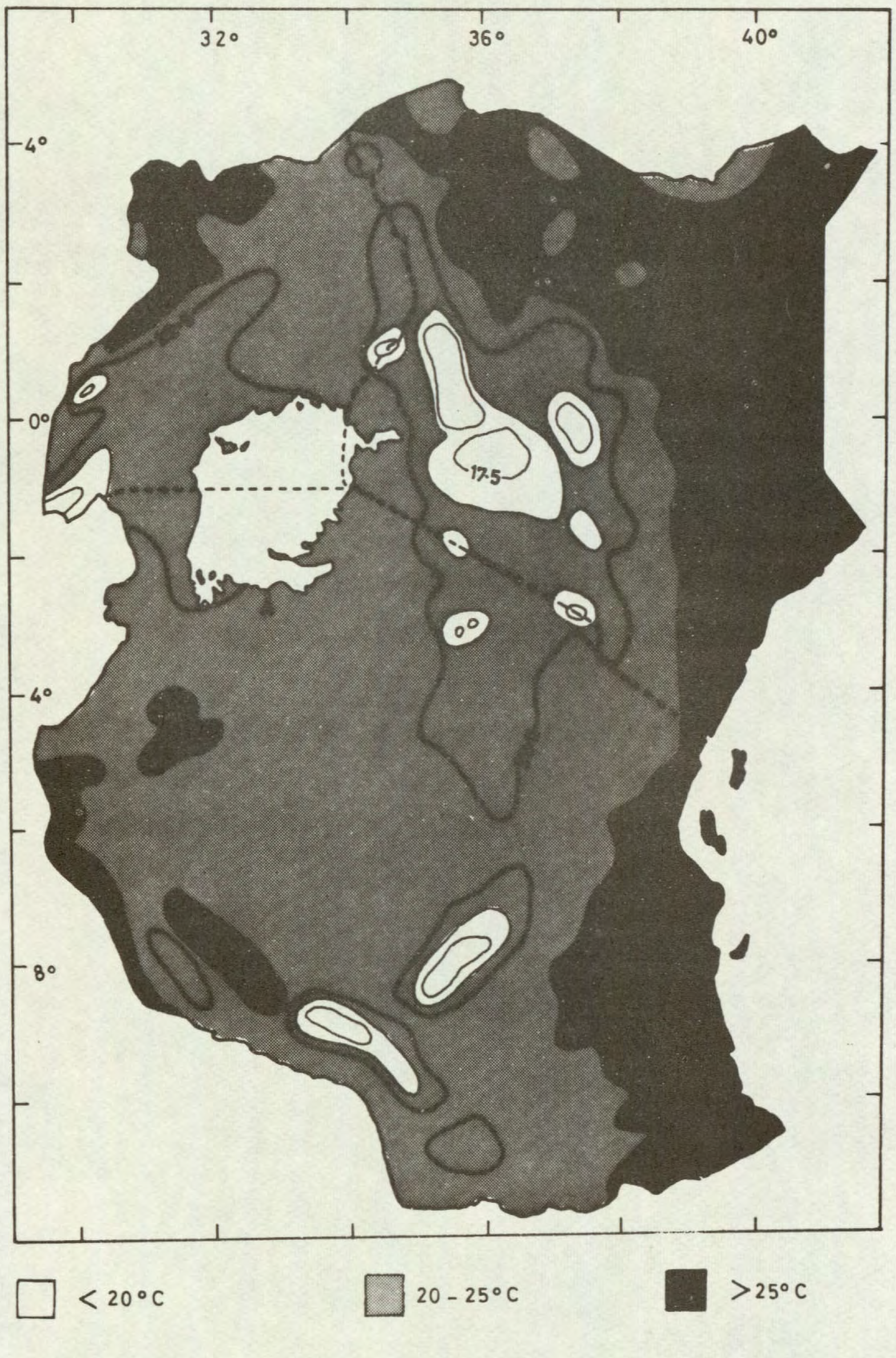
Fig. 23

East Africa - average annual rainfall

(After Tomsett, J.E., 1969)

Fig. 24

East Africa - annual actual temperature



(After Fullard, H., 1973)

ABBREVIATIONS

ångström	Å
Abstract	Abs.
acid equivalent*	a.e.
acre	ac
active ingredient*	a.i.
approximately equal to*	$\simeq$
aqueous concentrate	a.c.
bibliography	bibl.
boiling point	b.p.
bushel	bu
centigrade	C
centimetre*	cm
concentrated	concd
concentration	concn
concentration x time product	ct
concentration required to kill 50% test animals	LC50
cubic centimetre*	cm^3
cubic foot*	ft^3
cubic inch*	in^3
cubic metre*	m^3
cubic yard*	yd^3
cultivar(s)	cv.
curie*	Ci
degree Celsius*	^oC
degree centigrade	^oC
degree Fahrenheit*	^oF
diameter	diam.
diameter at breast height	d.b.h.
divided by*	÷ or /
dry matter	d.m.
emulsifiable concentrate	e.c.
equal to*	=
fluid	fl.
foot	ft
freezing point	f.p.
from summary	F.s.
gallon	gal
gallons per hour	gal/h
gallons per acre	gal/ac
gas liquid chromatography	GLC
gramme	g
hectare	ha
hectokilogram	hkg
high volume	HV
horse power	hp
hour	h
hundredweight*	cwt
hydrogen ion concentration*	pH
inch	in.
infra red	i.r.
kilogramme	kg
kilo ($x10^3$)	k
less than	$<$
litre	l.
low volume	LV
maximum	max.
median lethal dose	LD50
medium volume	MV
melting point	m.p.
metre	m
micro ($x10^{-6}$)	µ
microgramme*	µg
micromicro (pico: $x10^{-12}$)*	µµ
micrometre (micron)*	µm (or µ)
micron (micrometre)*†	µm (or µ)
miles per hour*	mile/h
milli ($x10^{-3}$)	m
milliequivalent*	m.equiv.
milligramme	mg
millilitre	ml

† The name micrometre is preferred to micron and µm is preferred to µ.

millimetre*	mm
millimicro* (nano: x10^{-9})	n or mμ
minimum	min.
minus	-
minute	min
molar concentration*	M (small cap)
molecule, molecular	mol.
more than	>
multiplied by*	x
normal concentration*	N (small cap)
not dated	n.d.
oil miscible concentrate	o.m.c. (tables only)
organic matter	o.m.
ounce	oz
ounces per gallon	oz/gal
page	p.
pages	pp.
parts per million	ppm
parts per million by volume	ppmv
parts per million by weight	ppmw
percent(age)	%
pico (micromicro: x10^{-12})	p or μμ
pint	pint
pints per acre	pints/ac
plus or minus*	±
post-emergence	post-em
pound	lb
pound per acre*	lb/ac
pounds per minute	lb/min
pound per square inch*	lb/in^2
powder for dry application	p. (tables only)
power take off	p.t.o.
precipitate (noun)	ppt.

pre-emergence	pre-em.
quart	quart
relative humidity	r.h.
revolution per minute*	rev/min
second	s
soluble concentrate	s.c.
soluble powder	s.p.
solution	soln
species (singular)	sp.
species (plural)	spp.
specific gravity	sp. gr.
square foot*	ft^2
square inch	in^2
square metre*	m^2
square root of*	$\sqrt{\ }$
sub-species*	ssp.
summary	s.
temperature	temp.
ton	ton
tonne	t
ultra-low volume	ULV
ultra violet	u.v.
vapour density	v.d.
vapour pressure	v.p.
varietas	var.
volt	V
volume	vol.
volume per volume	v/v
water soluble powder	w.s.p. (tables only)
watt	W
weight	wt
weight per volume*	w/v
weight per weight*	w/w
wettable powder	w.p.
yard	yd
yards per minute	yd/min

* Those marked * should normally be used in the text as well as in tables etc.

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WEED RESEARCH ORGANIZATION

TECHNICAL REPORTS

(Price includes surface mail; airmail £0.50 extra)

6. The botany, ecology, agronomy and control of Poa trivialis L. rough-stalked meadow-grass. November 1966. G P Allen. Price - £0.25

7. Flame cultivation experiments 1965. October, 1966. G W Ivens. Price - £0.25

8. The development of selective herbicides for kale in the United Kingdom. 2. The methylthiotriazines. Price - £0.25

10. The liverwort, Marchantia polymorpha L. as a weed problem in horticulture; its extent and control. July 1968. I E Henson. Price - £0.25

11. Raising plants for herbicide evaluation; a comparison of compost types. July 1968. I E Henson. Price - £0.25

12. Studies on the regeneration of perennial weeds in the glasshouse; I. Temperate species. May 1969. I E Henson. Price - £0.25

13. Changes in the germination capacity of three Polygonum species following low temperature moist storage. June 1969. I E Henson. Price. - £0.25

14. Studies on the regeneration of perennial weeds in the glasshouse. II. Tropical species. May 1970. I E Henson. Price - £0.25

16. Report on a joint survey of the presence of wild oat seeds in cereal seed drills in the United Kingdom during Spring 1970. November 1970. J G Elliott and P J Attwood. Price - £0.25

17. The pre-emergence selectivity of some newly developed herbicides, Orga 3045 (in comparison with dalapon), haloxydine (PP 493), HZ 52.112, pronamide (RH 315) and R 12001. January 1971. W G Richardson, C Parker and K Holly. Price - £0.25

18. A survey from the roadside of the state of post-harvest operations in Oxfordshire in 1971. November 1971. A Phillipson. Price - £0.12

19. The pre-emergence selectivity of some recently developed herbicides in jute, kenaf and sesamum, and their activity against Oxalis latifolia. December 1971. M L Dean and C Parker. Price - £0.25

20. A survey of cereal husbandry and weed control in three regions of England. July 1972. A Phillipson, T W Cox and J G Elliott. Price - £0.35

21. An automatic punching counter. November 1972. R C Simmons. Price - £0.30

22. The pre-emergence selectivity of some newly developed herbicides: bentazon, BAS 3730H, metflurazone, SAN 9789, HER 52.123, U 27,267. December 1972. W G Richardson and M L Dean. Price - £0.25

23. A survey of the presence of wild oats and blackgrass in parts of the United Kingdom during summer 1972. A Phillipson. Price - £0.25

24. The conduct of field experiments at the Weed Research Organization. February 1973. J G Elliott, J Holroyd and T O Robson. Price - £1.25

25. The pre-emergence selectivity of some recently developed herbicides: lenacil , RU 12068, metribuzin, cyprazine, EMD-IT 5914 and benthiocarb. August 1973. W G Richardson and M L Dean. Price - £1.75.

26. The post-emergence selectivity of some recently developed herbicides: bentazon, EMD-IT 6412, cyprazine, metribuzin, chlornitrofen, glyphosate, MC 4379, chlorfenprop-methyl. October 1973. W G Richardson and M L Dean. Price - £3.31

27. Selectivity of benzene sulphonyl carbamate herbicides between various pasture grasses and clover. October 1973. A M Blair. Price - £1.05

28. The post-emergence selectivity of eight herbicides between pasture grasses: RP 17623, HOE 701, BAS 3790, metoxuron, RU 12068, cyprazine, MC 4379, metribuzin. October 1973. A M Blair. Price - £1.00

29. The pre-emergence selectivity between pasture grasses of twelve herbicides: haloxydine, pronamide, NC 8438, Orga 3045, chlortoluron, metoxuron, dicamba, isopropalin, carbetamide, MC 4379, MBR 8251 and EMD-IT 5914. November 1973. A M Blair. Price - £1.30

30. Herbicides for the control of the broad-leaved dock (<u>Rumex obtusifolius</u> L.). November 1973. A M Blair and J Holroyd. Price - £1.06

31. Factors affecting the selectivity of six soil acting herbicides against <u>Cyperus rotundus</u>. February 1974. M L Dean and C Parker. Price - £1.10

32. The activity and post-emergence selectivity of some recently developed herbicides: oxadiazon, U-29,722, U-27,658, metflurazone, norflurazone, AC 50-191, AC 84,777 and iprymidam. June 1974. W G Richardson and M L Dean. Price - £3.62

33. A permanent automatic weather station using digital integrators. September 1974. R C Simmons. Price £0.63.

34. The activity and pre-emergence selectivity of some recently developed herbicides: trifluralin, isopropalin, oryzalin, dinitramine, bifenox and perfluidone. November 1974. W G Richardson and M L Dean. Price - £2.50

35. A survey of aquatic weed control methods used by Internal Drainage Boards, 1973. January 1975. T O Robson. Price - £1.39

36. The activity and pre-emergence selectivity of some recently developed herbicides: Bayer 94871, tebuthiuron, AC 92553. March 1975. W G Richardson and M L Dean. Price - £1.54

37. Studies on Imperata cylindrica (L.) Beauv. and Eupatorium odoratum L. October 1975. G W Ivens. Price - £1.75

38. The activity and pre-emergence selectivity of some recently developed herbicides: metamitron, HOE 22870, HOE 23408, RH 2915, RP 20630. March 1976. W G Richardson, M L Dean and C Parker. Price - £3.25

39. The activity and post-emergence selectivity of some recently developed herbicides: HOE 22870, HOE 23408, flamprop-methyl, metamitron and cyperquat. May 1976. W G Richardson and C Parker. Price - £3.20

40. The activity and pre-emergence selectivity of some recently developed herbicides: RP 20810, oxadiazon, chlornitrofen, nitrofen, flamprop--isopropyl. August 1976. W G Richardson, M L Dean and C Parker. Price - £2.75.

41. The activity and pre-emergence selectivity of some recently developed herbicides: K 1441, mefluidide, WL 29226, epronaz, Dowco 290 and triclopyr. November 1976. W G Richardson and C Parker. Price - £3.40.

42. The activity and post-emergence selectivity of some recently developed herbicides: KUE 2079A, HOE 29152, RH 2915, Triclopyr and Dowco 290. March 1977. W G Richardson and C Parker. Price - £3.50

43. The activity and pre-emergence selectivity of some recently developed herbicides: dimefuron, hexazinone, trifop-methyl, fluothiuron, buthidazole and butam. November 1977. W G Richardson and C Parker. Price - £3.75.

44. The activity and selectivity of the herbicides: ethofumesate, RU 12709 and isoproturon. December 1977. W G Richardson, C Parker, & M L Dean. Price - £4.00

45. Methods of analysis for determining the effects of herbicides on soil soil micro-organisms and their activities. January 1978. M P Greaves, S L Cooper, H A Davies, J A P Marsh & G I Wingfield. Price - £4.00

46. Pot experiments at the Weed Research Organization with forest crop and weed species. February 1978. D J Turner and W G Richardson. Price - £2.70

47. Field experiments to investigate the long-term effects of MCPA, tri-allate, simazine and linuron - the effect on the quality of the produce. (NOT YET PUBLISHED)

48. Factors affecting the toxicity of paraquat and dalapon to grass swards. March 1978. A K Oswald. Price - £2.90

49. The activity and post-emergence selectivity of some recently developed herbicides: NP 48, RH 5205 and Pyridate. May 1978. W G Richardson and C Parker. Price - £2.50

50. Sedge weeds of East Africa - II. Distribution. July 1978. P J Terry.
Price - £1.50

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WEED RESEARCH ORGANIZATION

BEGBROKE HILL, YARNTON, OXFORD