Mapping *Phalaris minor* under the Rice-Wheat Cropping System in Different Agro-Ecological Regions of Nepal

Jagat D. Ranjit[1], Robin R. Bellinder[2], Peter Hobbs[3], Nabin K. Rajbhandari[1] and Palit Kataki[4]

[1] Agronomy Division, NARC, Kumaltar
[2] Cornell University, NY, USA
[3] CIMMYT, Nepal
[4] Soil Management-Collaborative Research Support Programme, Cornell Uni./Nepal

ABSTRACT

A survey was conducted in order to map the spread of *Phalaris minor* in wheat in nine districts in the mid-hill, Terai and inner Terai areas of the rice-wheat cropping system in Nepal during 1998/99. Both qualitative and quantitative data were collected from 540 farmers and *P. minor* was recorded in all of the nine surveyed districts. Percent summed dominance ratio (SDR) and average number per unit area (m^2) of *P. minor* was compared to different districts of mid-hills, inner Tarai, and Tarai belts along with other weeds in the wheat crop. *P. minor* ranked as the first and second important weed of wheat that reduced the wheat yield from 10 to 50 percent. Its populations varied from district to district. However, the infestation appeared to be in increasing trend. Future strategies need to consider in increasing growers' abilities to identify *P. minor* at early growth stages when it is particularly difficult to differentiate from wheat seedlings. It is suggested that frequent monitoring of weeds in different tillage and weed management practices should be initiated. Besides farmers' training in the future there needs to be emphasis placed on increasing farmer's awareness on the serious negative impact of *P. minor* on wheat yield and quality.

Key words: Agro-ecology, *Phalaris minor*, survey, weeds, wheat

INTRODUCTION

Wheat is the pre-dominant winter crop in Nepal and more than one-third of the total area planted to rice is followed by wheat. It is an important crop from the point of food security. Wheat occupies 66.9 million hectares with an average productivity of 1.82 t/ha (MOAC 2002/03). The production of rice and wheat crops in the same year is the predominant cropping pattern in the country. Weeds are a major problem in both crops grown under this system. Many weeds have been identified in the wheat crop. Among them *P. minor* is consistently prevalent at all sites in increasing trend. Changes in the *P. minor* populations, biotypes, and the flora of weeds in wheat in the intensively cultivated rice-wheat cropping system of South Asia have been alarming. Reports of high populations (> 500 plants/m^2) of herbicide-resistant (isoproturon) bio-types of *P. minor* in wheat fields of Northern India and Pakistan, have led to partial or complete crop failure has been a matter of concern for the last ten years. There is speculation that with every crop season, resistant biotypes of *P. minor* are spreading eastwards from these countries into Nepal. The spread may occur through *P. minor* contamination in the harvested wheat crop which is then sold and moved to other parts of South Asia. *P. minor* may have developed resistance to isoproturon due to frequent use of it to control grass weeds in wheat. In Nepal, yield loss in wheat ranged from 15% to 70%. Use of 2,4-D and isoproturon to control broadleaf and grass weeds is common in Nepal's Tarai region (Ranjit 1981, 1983, 1997 and Malla and Ranjit 1980).

Due to a lack of quantitative information regarding the spread of *P. minor* in Nepal, a survey was conducted during the 1998/99 wheat season to assess its presence and severity in different agro-ecological regions of Nepal emphasizing the study under the rice-wheat cropping system.

Distribution: *P. minor* is distributed throughout the world. It has been identified in Canada, South-central USA, Mexico, Central America, Colombia, Venezuela, Bolivia, Peru, Brazil, Argentina, Southern Africa, Northern Africa, Iberian Peninsula, Italy, France, South-east-Europe, Middle East, India, Indonesia, Australia, New Zealand, the Pacific Islands and Nepal.

Habitat: It commonly grows during the winter season in wheat, barley legumes, waste places, rotational crops and several other winter crops. The infestations are particularly serious where wheat follows paddy rice.

Morphology: *P. minor* Retz. (English name = Littleseed canarygrass, small seed canarygrass, Mediterrnean canarygrass and canarygrass) is an annual, erect (50 to 100 cm) grass of poaceae family (Plates 1, 2 and 3). The leaf blade is linear - acuminate. The ligule is 2-6 mm membranous and often fringed or truncate. In the seedling stage the leaves are bluish green in color. The sheath at the base often exudes a red pigment when broken. The inflorescence is dense, oblong or ovate, 2-10 cm long and 1-2 cm wide. Spikelets are 1-flowered, subsessile, 4-6.5 mm long and 2.5-3 mm wide. Glumes are subequal, 4-6.5 mm long with a broad erose-dentate or entire wing near the tip (Basel and Berlin 1981). Morphologically *P. minor* is similar to wheat plants in its early vegetative stage, which makes identification difficult. Hence, the physical removal of *P. minor* infestations in wheat is very difficult, particularly when the wheat is broadcast seeded rather than planted in rows. *P. minor* seed heads mature earlier than do seed heads in wheat and can be easily identified at that stage. However, competition with the crop for that length of time reduces yields significantly. It is very competitive, as it grows taller and more vigorously than wheat. A single *P. minor* plant, when allowed to reach maturity free from any other competition, has the potential to produce 14,600 seeds in a single season (Sen 1981, Yaduraju 1997).

Plate 1. *P. minor* plant.

Plate 2. *P. minor* infestation in wheat.

Plate 3. Seeds of *P. minor*.

MATERIALS AND METHODS

Nine districts in eastern, central and western regions of Nepal were selected for the survey in year 1998/99. Four Village Development Committees (VDCs) were chosen randomly from each district. A survey questionnaire was developed that divided questions to focus on three groups: village units, households and field. Fifteen farmers from each VDC were selected and interviewed. The districts, VDCs and villages are given in Table 1, Figure 1.

Table 1. Surveyed districts and VDCs

Tarai			Mid hills		
District	VDCs	Village	District	VDCs	Village
Banke	Betahani	Santalia	Dhankuta	Pakhribas	Pakhribas
	Jaispura	Jaispura		Tankhuwa	Tamikhuwa
	Herminiya	Munispura		Belhara	Githitar
	Bankatti	Halbaldoli		Dhankuta	Patlekhola
Rupandehi	West Amuwa	Gothawa	Syangja	Dahathum	-
	Basantpur	Parsauni		Walling	Bhumari
	Kamahriya	Sundi W		Sorek	Paken
	Sakraun-Pakadi	Pakadi W		Khilung-Duerali	Simalchaur
Parsa	Bauhari	Dokaila-Tole	Bhaktpur	Chitapol	Simaltar
	Belwa	Ismailpur		Sipadol	Doleswor
	Lakhanpur	Lakhanpur		Nangkhel	Shantigaum
	Pokhariya	Pokhariya		Bageswori	Thuligaun
Sunsari	Pakali	Naya Tole			
	Madhuban	Madhuban			
	Babiya	Jamuwa			
	Laukahi	Laukahi			
Inner Tarai					
District	VDCs	Village			
Dang	Saudiyar	Guruwa Goan			
	Rampur	Rampur			
	Manpur	Nimbuwa			
	Narayanpur	Belawa			
Chitwan	Khairahani	Badauli			
	Pithuwa	Madhavpur			
	Piple	Kapan Tole			
	Gitanagar	Indrapuri			

Weed samples were collected from four ¼ m^2 quadrats in each farmer's field. Fifteen farmers' fields in each VDC were evaluated. Thus, the data were collected from 540 farmers (9 districts × 4 VDC × 15 farmers = 540) and weed samples were taken from 2160 quadrats (9 districts × 4 VDC × 15 farmers × 4 quadrats = 2160). Latitude, longitude and altitude were recorded in each VDC with the help of GPS instruments. After the quantitative weed measurements eg density, relative density, frequency, and relative frequency, summed dominant ratio (SDR) were calculated (Rao 1985 and Sen 1981). The relative density, relative frequency and summed dominance ratio (SDR) were calculated as follows:

Density = Total number of individuals of a species in all quadrats / Total number of quadrats used

Frequency= (Number of quadrats in which a given species occurs/Total number of quadrats used) × 100

Relative density = (Density of a given species / Total density for all species) × 100

Relative frequency = (Frequency of a given species / Total frequency for all species) × 100

Summed Dominant Ratio (SDR) = (Relative density + Relative frequency) × 100

Summed Dominant Ratio (SDR) is expressed in percentage.

RESULTS AND DISCUSSION

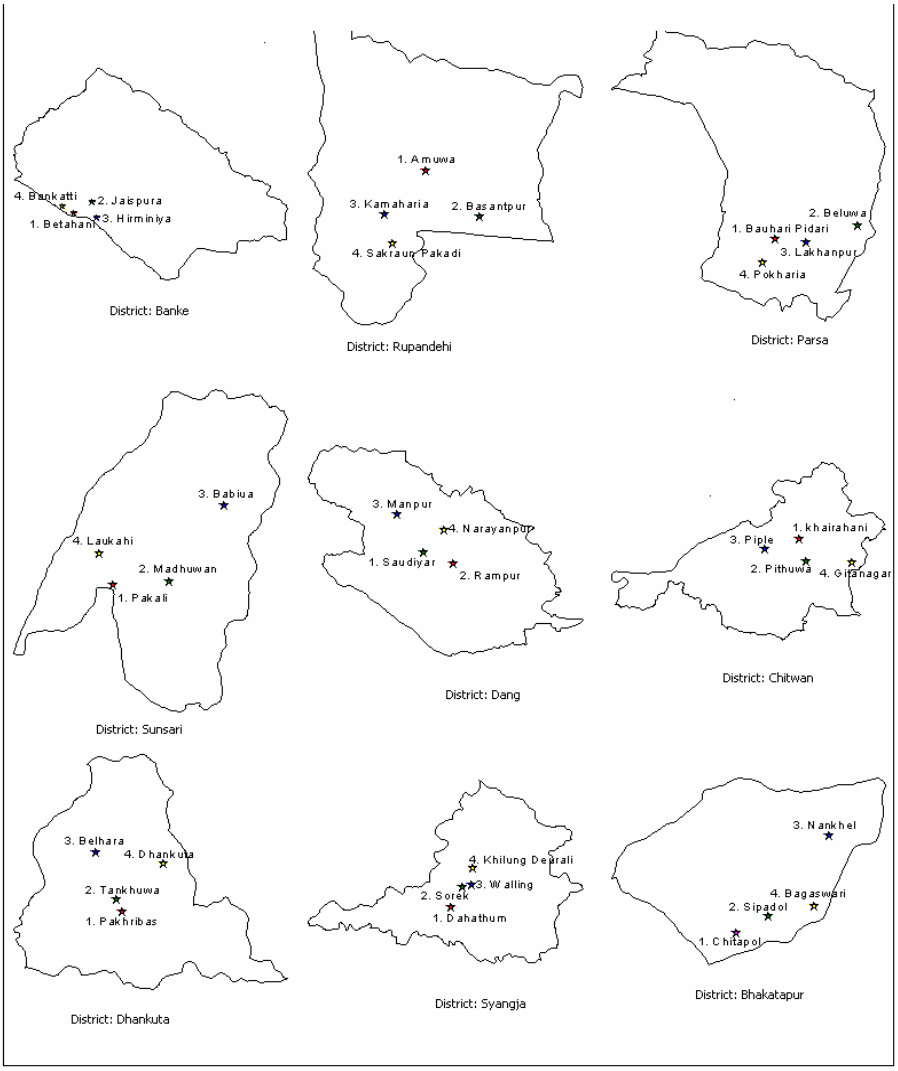

Figure 1. Surveyed districts showing Village Development Committees

Nine rice-based and seven-maize based cropping systems were prevalent in the surveyed districts, but rice-wheat was the major cropping system. Multiple weeds belonging to different botanical families were identified in addition to *P. minor*. In most of the districts *P. minor* was among the 1st five weeds. But this weed was not found in all the VDCs Table 2, 3 and 4.

Table 2. *P. minor* and other weed species in the Tarai districts of Nepal 1998/99

District: Banke							
VDC							
1) Betahani		2) Jaispura		3) Hirminiya		4) Bankatti	
Chenopodium album	(28.9)	Polygonum plebejum	(29.8)	Soliva anthemifolia	(31.8)	Chenopdium album	(23.3)
Phalaris minor	(13.1)	Anagalis arvensis	(15.6)	Anagalis arvensis	(20.41)	Gnaphalium sp.	(16.7)
Medicago denticulatus	(9.55)	Cyodon dactylon	(9.91)	Gnaphalium sp.	(9.72)	Anagalis arvensis	(15.37)
Anagalis arvensis	(8.74)	Chenopodium album	(9.36)	Chenopodium album	(7.96)	Vicia sativa	(11.41)
Lathyrus aphaca	(8.5)	Gnaphalium sp.	(7.5)	Fumaria parviflora	(7.18)	Cynodon dactylon	(6.97)
Polygonum plebejum	(6.22)	Vicia hirsute	(6.99)	Vicia hirsuta	(5.26)	Soliva anthemifolia	(6.49)
Cynodon dactylon	(6.6)	Soliva anthemifolia	(5.16)	Vicia sativa	(4.73)	Cyprus sp.	(5.68)
Fumaria parviflora	(5.48)	Medicago denticulatus	(3.92)	Phalaris minor	(4.0)	Lathyrus aphaca	(3.92)
Cyperus sp.	(2.95)	Cyperus sp.	(3.06)	Medicago denticulatus	(2.14)	Circium arvense	(3.69)
Vicia sativa	(2.46)	Phalaris minor	(2.55)	Cynodon dactylon	(2.63)	Medicago denticulatus	(3.26)
Rumex sp.	(2.5)	Rumex sp.	(2.0)	Cyprus sp.	(1.67)	Fumaria parviflora	(2.45)
Gnaphalium sp.	(1.72)	Lathyrus aphaca	(1.38)	Spergula arvensis	(1.52)	Phalaris minor	(0.76)
Circium arvense	(1.15)	Galinsoga parviflora	(0.81)	Cysella bursa pastories	(0.51)		
Soliva anthemifolia	(0.96)	Unidentified (B)	(0.66)	Unidentified	(0.50)		
Equisitum sp.	(0.67)	Fimbristylis littoralis	(0.63)				
Unidentified (D)	(0.49)	Unidentified (a)	(0.63)				

District: Rupandehi							
VDC							
1) Amuwa		2) Basantpur		3) Kamahariya		4) Sakraun Pakadi	
Cynodon dactylon	(19.0)	Phalaris minor	(24.59)	Polygonum plebejum	(30.19)	Anagalis arvensis	(26.05)
Polygonum plebejum	(18.32)	Soliva anthemifolia	(19.9)	Anagalis arvensis	(22.21)	Phalaris minor	(14.06)
Medicago denticulatus	(17.89)	Anagalis arvensis	(15.62)	Lathyrus aphaca	(9.63)	Polygonum plebejum	(13.03)
Anagalis arvensis	(12.4)	Polygonum plebejum	(13.04)	Chenopodium album	(5.61)	Lathyrus aphaca	(7.85)
Chenopodium album	(8.30)	Medicago denticulatus	(8.44)	Rumex sp.	(5.17)	Soliva anthemifolia	(6.65)
Rumex sp.	(4.19)	Lathyrus aphaca	(5.22)	Gnaphalium sp.	(4.8)	Cynodon dactylon	(6.39)
Alopecuros sp.	(3.65)	Vicia sativa	(5.81)	Fumaria parviflora	(3.7)	Chenopodium album	(6.29)
Lathyrus aphaca	(3.52)	Circium arvense	(2.26)	Cynodon dactylon	(3.63)	Medicago denticulatus	(6.01)
Cyperus sp.	(3.74)	Cynodon dactylon	(1.69)	Medicago denticulatus	(3.48)	Cyperus sp.	(3.15)
Vicia sativa	(3.64)	Chenopodium album	(1.64)	Circium arvense	(3.65)	Rumex sp.	(2.80)
Lactuca sp.	(0.99)	Seinebeira pinnatifida	(0.63)	Cyperus sp.	(2.23)	Circium arvense	(2.33)
Fumaria parviflora	(0.89)	Cardamine pratense	(0.62)	Vicia sativa	(1.98)	Vicia sativa	(1.91)
Gnaphalium sp.	(0.89)	Gnaphalium sp.	(0.55)	Oxalis corniculata	(1.37)	Alternanthera sp.	(1.61)
Phalaris minor	(0.85)			Ageratum conyzoides	(1.31)	Fumaria parviflora	(1.24)
Soliva anthemifolia	(0.82)			Alopecuros sp.	(0.67)	Gnaphalium sp.	(0.62)
Ageratum conyzoides	(0.82)			Alternanthera sp.	(0.65)		

District: Parsa							
VDC							
1) Bauhari Pidari		2) Beluwa		3) Lakhanpur		4) Pokhariya	
Polygonum plebejum	(29.77)	Polygonum plebejum	(21.3)	Unidentified (A)	(28.21)	Anagalis arvensis	(19.18)
Soliva anthemifolia	(19.0)	Anagalis arvensis	(19.6)	Polygonum plebejum	(20.0)	Phalaris minor	(14.35)
Anagalis arvensis	(12.0)	Soliva anthemifolia	(10.54)	Cynodon dactylon	(19.88)	Polygonum plebejum	(12.94)
Phalaris minor	(9.66)	Chenopodium album	(10.34)	Chenopodium album	(7.129)	Soliva anthemifolia	(10.12)
Chenopodium album	(9.12)	Phalaris minor	(9.10)	Phalaris minor	(5.85)	Rumex sp.	(10.0)
Vicia sativa	(6.17)	Vicia sativa	(8.21)	Xanthium strumarium	(4.89)	Gnaphalium sp.	(7.80)
Fumaria parviflora	(3.0)	Cynodon dactylon	(5.62)	Medicago denticulatus	(3.64)	Chenopodium album	(6.75)
Alternanthera sp.	(2.71)	Gnaphalium sp.	(3.38)	Soliva anthemifolia	(2.76)	Vicia sativa	(6.39)
Gnaphalium sp.	(2.51)	Medicago	(2.81)	Leucas aspera	(2.58)	Senecio vulgaris	(3.15)

		denticulatus					
Cynodon dactylon	(2.47)	Alternanthera sp.	(2.71)	Anagalis arvensis	(1.35)	Cynodon dactylon	(3.04)
Lathyrus aphaca	(1.85)	Cyperus sp.	(2.89)	Rumex sp.	(1.93)	Alopecuros sp.	(1.69)
Oxalis corniculata	(0.59)	Digitaria ascendens	(2.47)	Senecio vulgaris	(0.59)	Medicago denticulatus	(1.80)
Centella asiatica	(0.59)	Stellaria media	(0.70)	Vicia sativa	(0.58)	Cyperus sp.	(0.67)
Rumex sp.	(0.60)			Lathyrus aphaca	(0.55)	Fumaria parviflora	(0.53)
						Circium arvense	(0.51)
						Equisitum sp.	(0.51)
						Lathyrus aphaca	(0.51)

Table 2. Contd….

District: Sunsari							
VDC							
1) Pakali		2) Madhuwan		3) Babiya		4) Laukahi	
Chenopodium album	(21.5)	Digitaria ascendens	(16.4)	Soliva anthemifolia	(21.0)	Soliva anthemifolia	(21.2)
Cynodon dactylon	(19.4)	Alopecuros sp.	(13.8)	Polygonum plebejum	(13.0)	Chenopodium album	(16.6)
Lactuca sp.	(11.3)	Cynodon dactylon	(10.8)	Anagalis arvensis	(11.7)	Polygonum plebejum	(15.8)
Polygonum plebejum	(8.1)	Polygonum plebejum	(10.2)	Lathyrus aphaca	(11.5)	Gnaphalium sp.	(7.4)
Lamium amplexicaule	(7.5)	Phalaris minor	(11.0)	Phalaris minor	(11.1)	Cynodon dactylon	(5.8)
Vicia sativa	(7.2)	Chenopodium album	(8.35)	Cynodon dactylon	(5.4)	Phalaris minor	(5.5)
Alternanthera sp.	(0.7)	Gnaphalium sp.	(6.64)	Fumaria parviflora	(5.1)	Cyperus sp.	(5.0)
Medicago denticulatus	(5.5)	Centella asiatica	(5.35)	Chenopodium album	(4.6)	Fumaria parviflora	(5.0)
Lathyrus aphaca	(4.6)	Rumex sp.	(3.81)	Rumex sp.	(4.5)	Rumex sp.	(4.8)
Gnaphalium sp.	(3.6)	Lactuca sp.	(3.13)	Medicago denticulatus	(4.3)	Leucas aspera	(2.7)
Anagalis arvensis	(3.2)	Alternanthera sp.	(2.88)	Cyperus sp.	(4.0)	Vicia sativa	(2.1)
Digitaria ascendens	(2.7)	Anagalis arvensis	(2.22)	Digtaria ascendens	(0.6)	Lactuca sp.	(1.6)
Phalaris minor	(2.7)	Vicia sativa	(1.0)	Alopecuros sp.	(0.6)	Digtaria ascendens	(1.2)
Unidentified (Z)	(0.8)	Mazus	(0.82)	Alternanthera sp.	(0.6)	Medicago denticulatus	(1.1)
Fumaria parviflora	(0.7)	Lindernia sp.	(063)	Cardamine pratense	(0.4)	Lathyrus aphaca	(0.7)
Cyperus sp.	(0.7)	Stellaria media	(0.6)	Circium arvense	(0.4)	Anagalis arvensis	(0.5)
		Soliva anthemifolia	(0.58)	Melilotus parviflora	(0.4)	Alternanthera sp.	(0.5)
		Equisitum sp.	(0.55)	Vicia sativa	(0.4)	Circium arvense	(0.5)
		Lathyrus aphaca	(0.55)	Lactuca sp.	(0.4)	Equisitum sp.	(0.5)
		Medicago denticulatus	(0.55)			Oxalis corniculata	(0.5)
						Eleusine indica	(0.5)
						Unidentified	(0.5)

Values in the bracket indicates percent Summed Dominant Ratio (SDR) of weeds.

Table 3. *P. minor* and other weed species in the inner terai districts of Nepal 1998/99

District: Dang							
VDC							
1) Soudiyar		2) Rampur		3) Manpur		4) Narayanpur	
Phalaris minor	(23.3)	Anagalis arvensis	(18.99)	Anagalis arvensis	(21.20)	Cynodon dactylon	(18.09)
Lathyrus aphaca	(21.14)	Lathyrus aphaca	(13.68)	Medicago denticulatus	(13.26)	Lathyrus aphaca	(15.84)
Alopecuros sp.	(10.95)	Phalaris minor	(13.13)	Phalaris minor	(11.83)	Alopecuros sp.	(13.42)
Cynodon dactylon	(8.18)	Polygonum plebejum	(10.36)	Cynodon dactylon	(10.42)	Anagalis arvensis	(13.37)
Anagalis arvensis	(7.96)	Alopecuros sp.	(11.62)	Polygonum plebejum	(8.64)	Vicia sativa	(9.39)
Polygonum plebejum	(8.07)	Chenopodium album	(8.54)	Gnaphalium sp.	(8.64)	Polygonum plebejum	(8.92)
Chenopodium album	(6.13)	Cynodon dactylon	(7.05)	Cyperus sp.	(4.58)	Phalaris minor	(8.43)
Vicia sativa	(4.01)	Gnaphalium sp.	(4.65)	Vicia sativa	(4.58)	Oxalis corniculata	(3.86)
Eqisitum sp.	(3.35)	Vicia sativa	(4.00)	Lathyrus aphaca	(3.24)	Chenopodium album	(2.35)

Fumaria parviflora	(2.72)	Medicago denticulatus	(2.20)	Alopecuros sp.	(2.65)	Medicago denticulatus	(1.79)
Dactyloctenium aegyptiacum	(1.65)	Fumaria parviflora	(1.47)	Oxalis corniculata	(2.23)	Gnaphalium sp.	(1.75)
Lindernia sp.	(0.82)	Cyperus sp.	(1.43)	Fimbristylis littoralis	(2.22)	Rumex sp.	(1.66)
Vicia hirsute	(0.65)	Circium arvense	(1.34)	Cannabis sativa	(0.67)	Equisitum sp.	(0.58)
Gnaphalium sp.	(0.56)	Lactuca sp.	(0.65)	Polygonum sp.	(0.64)	Centella asiatica	(0.56)
Unidentified	(0.52)	Equisitum sp.	(0.90)	Rumex sp.	(0.59)		
Unidentified	(0.52)						

District: Chitwan							
VDC							
1) Khairahani		2) Pithuwa		3) Piple		4) Gitanagar	
Cynodon dactylon	(31.72)	Gnaphalium sp.	(23.16)	Cynodon dactylon	(23.41)	Polygonum plebejum	(32.11)
Cyperus sp	(11.92)	Polygonum plebejum	(22.6)	Ageratum conyzoides	(14.47)	Chenopodium album	(27.75)
Vicia sativa	(10.64)	Chenopodium album	(17.62)	Vicia sativa	(10.95)	Cynodon dactylon	(9.65)
Digtaria ascendens	(8.93)	Vicia sativa	(9.20)	Gnaphalium sp.	(9.08)	Anagalis arvensis	(6.77)
Polygonum plebejum	(7.89)	Anagalis arvensis	(7.73)	Chenopodium album	(8.57)	Vicia sativa	(6.23)
Ageratum conyzoides	(4.58)	Fumaria parviflora	(4.91)	Oxalis corniculata	(5.69)	Fumaria parviflora	(5.94)
Digitaria ascendens	(4.58)	Unidentified	(4.91)	Polygonum plebejum	(5.38)	Solanum nigrum	(2.65)
Chenopodium album	(4.26)	Oxalis corniculata	(3.59)	Digitaria ascendens	(4.89)	Digtaria ascendens	(2.13)
Alopecuros sp.	(3.16)	Cynodon dactylon	(1.83)	Solanum nigrum	(3.26)	Phalaris minor	(1.78)
Unidentified	(2.74)	Medicago denticulatus	(1.48)	Unidentified	(3.78)	Gnaphalium sp.	(1.63)
Phalaris minor	(2.65)	Phalaris minor	(0.82)	Phalaris minor	(2.27)	Lathyrus aphaca	(0.84)
Gnaphalium sp.	(2.27)	Lathyrus aphaca	(0.71)	Xanthium strumarium	(2.27)	Oxalis corniculata	(0.84)
Equisitum sp.	(1.73)	Ageratum conyzoides	(0.74)	Fumaria parviflora	(1.78)	Rumex sp.	(0.82)
Solanum nigrum	(0.82)	Amaranthus veridis	(0.70)	Polygonum capitatum	(1.24)	Lactuca sp.	(0.90)
Oxalis corniculata	(0.72)			Cyperus sp.	(1.17)		
Unidentified	(0.66)			Amaranthus veridis	(0.90)		
Medicago denticulatus	(0.66)			Alternanthera sp.	(0.90)		

Values in the bracket indicate percent Summed Dominant Ratio (SDR) of weeds.

Table 4. *P. minor* and other weed species in the mid-hill districts of Nepal 1998/99

District: Dhankuta							
VDC							
1) Pakhribas		2) Tankhuwa		3) Belhara		4) Dhankuta	
Stellaria media	(29.24)	Polygonum plebejum	(31.94)	Gnaphalium sp.	(18.81)	Cynodon dactylon	(18.84)
Lamium amplexicaule	(12.77)	Stellaria media	(31.48)	Oxalis corniculata	(18.66)	Chenopodium album	(18.67)
Polygonum capitatum	(10.34)	Galinsoga parviflora	(6.53)	Polygonum plebejum	(13.15)	Phalaris minor	(17.9)
Galinsoga Parviflora	(9.69)	Unidentified	(6.53)	Cynodon dactylon	(9.53)	Polygonum plebejum	(14.59)
Vicia sativa	(9.25)	Alopecuros sp.	(6.04)	Chenopodium album	(6.18)	Alopecuros sp.	(11.48)
Fumaria parviflora	(4.03)	Polygonum capitatum	(4.29)	Anagalis arvensis	(3.87)	Stellaria media	(4.12)
Centella asiatica	(2.85)	Alternanthera sp.	(2.16)	Unidentified	(3.58)	Centella asiatica	(3.69)
Drymaria cordata	(2.85)	Chenopodium album	(1.47)	Xanthium strumarium	(3.53)	Oxalis corniculata	(2.49)
Ageratum conyzoides	(2.84)	Centella asiatica	(1.35)	Argemone maxicana	(3.16)	Vicia sativa	(2.13)
Lathyrus aphaca	(2.40)	Medicago denticulatus	(1.08)	Galinsoga parviflora	(2.86)	Alternanthera sp.	(1.51)
Artimesia vulgaris	(2.06)	Oxalis corniculata	(1.08)	Medicago denticulatus	(1.99)	Ageratum conyzoides	(1.29)
Digitaria sp.	(1.95)	Phalaris minor	(1.02)	Cyperus sp.	(1.81)	Digitaria ascendens	(0.98)
Bidens pilosa	(1.79)	Cardamine pratense	(1.02)	Polygonum capitatum	(1.81)	Gnaphalium sp.	(0.84)
Xanthium strumarium	(1.77)	Lactuca sp	(1.02)	Circium arvense	(1.63)	Cannabis sativa	(0.75)
Chenopodium album	(1.53)	Cynodon dactylon	(0.99)	Stellaria media	(1.53)	Lactuca sp.	(0.75)
Oxalis corniculata	(1.51)	Gnaphalium sp.	(0.99)	Vicia sativa	(1.44)		
Unidentified	(1.05)	Digitaria sp.	(0.99)	Ageratum conyzoides	(1.34)		
Gnaphalium sp.	(0.92)			Alopecuros sp.	(1.34)		
Medicago denticulatus	(0.89)			Lactuca sp.	(1.34)		
Cynodon dactylon	(0.79)			Phalaris minor	(1.25)		
Cyperus sp.	(0.77)			Fumaria parviflora	(1.25)		
Polygonum phlebijum	(0.77)						

District: Syangja							
VDC							
1) Dahathum		2) Walling		3) Sorek		4) Khilung Deurali	
Chenopodium album	(15.68)	Soliva anthemifolia	(27.9)	Polygonum hydropiper	(37.0)	Polypogom fugax	(26.95)
Cynodon dactylon	(14.37)	Vicia sativa	(16.4)	Stellaria media	(17.2)	Stellaria media	(10.8)

Melilotus parviflora	(11.95)	Chenopodium album	(10.5)	Vicia sativa	(8.5)	Cynodon dactylon	(9.08)
Vicia sativa	(10.2)	Stellaria media	(9.67)	Soliva anthemifolia	(6.7)	Melilotus parviflora	(9.04)
Unidentified (Z)	(9.03)	Cynodon dactylon	(7.55)	Chenopodium album	(6.6)	Vicia sativa	(8.49)
Alopecuros sp.	(7.98)	Polypogom fugax	(5.5)	Alopecuros sp.	(5.6)	Chenopodium album	(8.2)
Stellaria media	(5.82)	Melilotus parviflora	(4.35)	Polypogom fugax	(4.7)	Phalaris minor	(5.55)
Polypogom fugax	(4.73)	Lactuca sp.	(3.38)	Gnaphalium sp.	(2.9)	Gnaphalium sp.	(4.79)
Lactuca sp.	(4.66)	Alopecuros sp.	(3.04)	Cynodon dactylon	(2.4)	Solanum nigrum	(3.29)
Phalaris minor	(3.99)	Phalaris minor	(2.22)	Lathyrus aphaca	(1.8)	Unidentified (Z)	(2.61)
Gnaphalium sp.	(3.05)	Polygonum hydropiper	(1.84)	Phalaris minor	(1.2)	Lactuca sp.	(2.32)
Drymaria cordata	(3.05)	Polygonum sp.	(1.65)	Lactuca sp.	(1.2)	Polygonum sp.	(2.0)
Oxalis corniculata	(1.25)	Oxalis corniculata	(1.35)	Fimbristylis littoralis	(1.0)	Fumaria parviflora	(1.83)
Fumaria parviflora	(1.06)	Mazus sp.	(1.18)	Cardamine pratense	(0.7)	Alopecuros sp.	(1.62)
Ageratum conyzoides	(1.06)	Gnaphalium sp.	(1.06)	Unidentified (Z)	(0.6)	Ageratum conyzoides	(1.43)
Equisitum sp.	(0.99)	Unidentified (Z)	(1.06)	Fumaria parviflora	(0.6)	Drymaria cordata	(0.58)
Cardamine pratense	(0.64)	Lathyrus aphaca	(0.54)	Melilotus parviflora	(0.6)	Equisitum sp.	(0.53)
Polygonum	(0.50)	Equisitum sp.	(0.54)	Oxalis corniculata	(0.6)	Convolvulos arvensis	(0.47)
		Fumaria parviflora	(0.53)			Unidentified	(0.44)

District: Bhaktapur							
VDC							
1) Chitapol		2) Sipadol		3) Nangkhel		4) Bageswari	
Poa annua	(30.5)	Poa annua	(46.0)	Solivanathemifolia	(22.17)	Alopecuros sp.	(43.72)
Phalaris minor	(25.0)	Unidentified	(8.99)	Poa annua	(21.54)	Phalaris minor	(14.69)
Chenopodium album	(11.2)	Chenopodium album	(8.72)	Phalaris minor	(13.78)	Chenopodium album	(9.24)
Alopecuros sp.	(6.07)	Phalaris minor	(8.2)	Alopecuros sp.	(8.74)	Unidentified (K)	(6.48)
Soliva athemifolia	(5.21)	Polygonum sp.	(5.55)	Chenopodium album	(7.76)	Soliva athemifolia	(4.42)
Avena fatua	(5.1)	Vicia hirsute	(5.32)	Unidentified (K)	(5.05)	Avena fatua	(3.73)
Stellaria media	(4.33)	Lamium amplexicaule	(4.96)	Polygonum sp.	(4.58)	Polygonum sp.	(2.51)
Vicia hirsuta	(4.18)	Steilaria media	(4.39)	Steilaria media	(14.47)	Vicia sativa	(1.97)
Unidentified (K)	(3.6)	Cannabis sativa	(2.07)	Vicia hirsuta	(2.92)	Rumex sp.	(0.80)
Lamium amplexicaule	(2.07)	Alopecuros sp.	(2.07)	Avena fatua	(2.68)		
Vicia sativa	(2.05)	Rumex sp.	(1.97)	Cannabis sativa	(2.50)		
Gnaphalium sp.	(0.75)	Cardamine pratense	(1.4)	Gnaphalium sp.	(1.11)		
		Soliva athemifolia	(0.68)	Medicago denticulatus	(0.62)		
				Equisitum sp.	(0.62)		
				Rumex sp.	(0.59)		
				Vicia sativa	(0.56)		

Values in the bracket indicate percent Summed Dominant Ratio (SDR) of weeds.

P. minor is spreading in almost all the surveyed districts. The numbers of *P. minor*/m^2 ranged from 8 to 95. The highest numbers/m^2 were recorded in Rupandehi with significant populations also found in Dhankuta, Sunsari, and Bhaktapur Table 5.

Table 5. Average population of *P. minor* per unit area (m^2) in different districts

District	*Phalaris minor*	District	*Phalaris minor*
Banke	20 (16)	Chitwan	8 (8)
Rupandehi	95 (23)	Dhankuta	60 (8)
Parsa	19 (32)	Syangja	9 (20)
Sunsari	55 (29)	Bhaktapur	52 (54)
Dang	19 (41)		

Figures within parenthesis show the number of farmers.

Depending on the district, *P. minor* has been spelled by different names. It is locally known as Gahun ka mama (Banke), Jwate (Dang), Ghodjawa (Rupandehi), Ledai and Madhuwaine (Parsa), Ragate and Tagonaicha (Bhaktpur), and Tauke and Thulomatte (Syangja).

Farmers' perceptions: In seven districts, both grass and broadleaf weeds were reported as significant problems in wheat. In Bhaktapur, farmers' were most concerned with grassy weeds, while in Chitwan, broad-leaf weeds were the major problem weeds Table 6. In all districts except Chitwan, *P. minor* was reported as a problem weed but severity rankings differed districts.

Table 6. Ranking of three major weeds of wheat crop as perceived by the farmers in different districts

Banke	Dang	Rupand	Sunsari	Parsa	Dhankuta	Chitwan	Syangja	Bhaktapur	Rank
C. album	*P.minor*	*P. minor*	*C. album*	*P.minor*	*S. media*	*C. album*	*P. minor*	*P.minor*	1
P. minor	*C. album*	*L.aphaca*	*Rumex sp.*	*A.arvensis*	*C. album*	*Fumaria sp.*	*P. fugox*	*A. fatua*	2
Fumaria sp.	*M. denticulata*	*Vicia sp.*	*P.minor*	*C. album*	*P.minor*	*Ageratum sp.*	*Vicia sp.*	*Alopecuros sp.*	3

Yield losses caused by *P. minor*: Farmers estimated that wheat yield losses due to weeds ranged from 10 to 50% depending upon the weed population severity. Fifty-six percent of farmers said *P. minor* could reduce 10-50% yield in wheat while 44% of growers were not able to determine actual losses due to *P. minor*.

Farmer's awareness of *P. minor*: Most of the farmers were unaware of *P. minor* as a problem weed. Sometimes they were confused and gave the same local name for two plant groups. This weed is frequently used for livestock feed in mid-hills of the surveyed districts. Farmers of Banke district were aware of this weed and felt that *Phalaris* is a problem weed in lentil and chickpea as well as in wheat. Farmers do not know exactly when this weed was introduced in their wheat crop but estimate that it occurred within the last 6 years. However, more than 20% of farmers in Syangja, Bhaktapur, Parsa, Rupandehi and Dang districts indicated that *P. minor* had been present in their fields for more than a decade.

Source of *P. minor* introduction: Forty-five percent of the farmers did not know the source of introduction of this weed in their fields. However, 22% said it came from shared seed, 28% said through certified seed purchased outside and 5% said from other sources, eg movement with irrigation water. *P. minor* was used for livestock feed in almost all districts. Farmers cut the weed after it starts heading when they can separate it from wheat.

Management: Although *P. minor* was seen as spreading and increasing in wheat fields, weeding was generally not practiced in almost all the surveyed districts, largely due to the inability of farmers to differentiate between wheat and *P. minor* seedlings in the vegetative stage. Due to the fact that many growers do not have row-planters and wheat seed is, broadcast by hand identification is extremely difficult. Weeding is done mainly during the heading stage when *P. minor* can be distinguished from the wheat plants due to its distinctive seed heads. *P. minor* is then pulled from the field to feed livestock. In addition to yield losses caused by competition from *P. minor*, the act of physical removal close to wheat

harvest increases crop damage. Survey results indicated that 42% of farmers were not weeding the wheat crop, 43% cut the weed for livestock feed, and 2% are using herbicides to control weeds.

CONCLUSION

P. minor was recorded from almost all the surveyed districts and VDCs with varied population. The number of this weeds are increasing in wheat crop where the rice-wheat system has been practiced for long time. This mapping study will certainly benefit the researchers, extensionists, students, and farmers in the future. Future strategies need to focus on specific methods of increasing growers' abilities to identify *P. minor* at early growth stages when it is particularly difficult to differentiate from wheat seedlings. It is suggested that frequent monitoring of weeds in different tillage and weed management practices should be initiated to visualize the weed shifts in the future. It is recommended that efforts be made to increase farmers' awareness of the negative impact of this weed on yields and quality of wheat through training and field visits of the infested sites.

ACKNOWLEDGMENTS

Our sincere thank goes to TP Pokhrel, Nepal Agriculture Research Council and SL Shrestha, Agronomy Division for their encouragement and valuable support. We acknowledge the financial support of the Soil Management-Collabarative Research Support Program (SM-CRSP), Cornell University, USA. We highly appreciate B Adhikari, CIMMYT/Nepal for his help in data analysis and SK Rai, Soil Science Division for mapping of the data. We are very thankful to R Ghimire, T Adhikari and A Millar for their help throughout the survey period. Our thanks go to Pramila Khatri for word processing.

REFERENCES

Basel EH and HS Berlin. 1981. Grass weeds - 2 CIBA - GEIGY Ltd. Basle, Switzerland, pp115.

Malla ML and JD Ranjit. 1980. Weed Control Expt in Wheat and Barley. **In:** *Proceeding 8th Winter Crop Workshop*. 4-5 Sept 1980, NWDP Bhairahawa. Pp. 179-183.

MOAC. 2002/03. *Statistical information on Nepalese agriculture*. Agri-Business Promotion and Statistics Division, Ministry of Agriculture and Co-operative, HMG/N, Kathmandu, Nepal.

Ranjit JD. 1981. Weed control trial in wheat. **In:** *Proceeding Wheat Research Report* held at NWDP, Bhairahawa August 1982. Pp. 211-218.

Ranjit JD. 1983. Weed control trial in wheat. Paper presented at *11th Winter Crop Workshop*, 3-5 Sept 1984. NWDP, Bhairahawa.

Ranjit JD. 1997. Weeds and weed management in rice-wheat system. **In:** *Proceedings of the Rice-Wheat Research end-of-Project Workshop* held at Kathmandu, Nepal from 1-3 Oct 1997. Pp. 23-30.

Rao AN. 1985. *Vegetation Analysis*. Lecture presented at first weed science training course. IRRI, Philippines.

Sen DN. 1981. *Ecological approaches to Indian weeds*. Geobios International, India.

Yaduraju NT. 1997. *Phalaris minor* a grassy weed in rice-wheat system. *ICAR News*. P. 12.