CHAPTER 2

THEY STAND AMONG EQUALS: I. SPATIO-TEMPORAL DISTRIBUTION PATTERN OF NEW BIOTYPES OF WEEDY RICE (*Oryza sativa* L.) IN SELANGOR NORTH-WEST PROJECT, MALAYSIA

2.1 INTRODUCTION

Weedy rice (*Oryza sativa* L.) and other related species which prevailed involuntarily in and around rice-growing areas are regarded as weeds (Vaughan & Morishima 2003). Some instances of weedy rice can occur in rice granaries when the wild and cultivated rice grow sympatrically. Basically in these rice granaries, wild rices and the cultivated rice easily hybridize with each other as they have almost similar morphological characteristics and genetic traits. As weeds and crop plants grow sympatrically they compete with each other for space and water, and nutrients, consequently decreasing crop yields (Oka 1988).

At the same time, weedy rice can also extend it's infestation in areas without native wild rice populations (Bres-Patry *et al.* 2001). The origins of weedy rice under these conditions are currently under investigation, but they are believed to be derived from hybridization between different cultivars, selection of weedy traits present in cultivars, relics of abandoned cultivars, or to have been brought into the growing region through contaminated seed stocks (Vaughan & Morishima 2003).

Rice can regenerate via ratoons, which re-shoot from sub-soil nodes after the first crop has ripened. Ratoon occurs in perennial growth in some cultivars and some wild species when seasonal conditions allow it to grow. In areas with a long growing season, ratoons can produce a second harvest in a single season (Street & Bollich 2003).

Oryza sativa cultivars exist and adapted in a wide range of habitats. Different cultivars are grown widely throughout the world, from latitude 50°N in China to 35°S in New South Wales and Argentina, in tropical, temperate, lowland and highland regions and on a wide range of soil types (Vaughan 1994). The species displays high level of adaptability, and this enables it to colonize new areas easily. However, individual cultivars do not span the entire geographic and environmental range, that are limited to specific ecological niches.

Weedy rice populations have been reported in many paddy areas in the world where the crop is directly seeded (Pandey & Velasco 2002; Azmi & Baki 2003). Weedy rice has a lot of accessions including those from various species, namely, *Oryza sativa, O. spontanea, O. barthii, O. longistimata, O. granulata, O. officinalis, O. rufipogon syn. O. fatua, O. fatua var. longe-aristata, O. nivara, O. ridleyi, O. meyeriana, O. perennis, or O. punctata and O. minuta*. Table 2.1 shows some weedy and wild rice aggregates which are found in Asia. Tang & Morishima (1996) reported that some weedy rice varieties found in Japan, Brazil, USA and upper Yangtze valley of China mimic the rice crop comprising primarily the indica-like type and at the same time they have low levels of seed dormancy and seed shattering. It is believed that the weedy rice may have the relationship with the cultivated rice. The weedy rice accessions or biotypes were highly polymorphic but display strong crop mimicry with the cultivated counterparts suggesting natural hybridization with rice (Noldin *et al.* 1999). Fig. 2.1 shows wide distribution of weedy rice infesting rice fields in the world.

In West Africa and the Sahel, the wild species namely *O. barthii and O. longistimata* became one of the worst weeds in rice granaries. While *Oryza officinalis, O. rufipogon, O. nivara, and* weedy accessions of *O. sativa* attack rigorously the rice fields of Vietnam, Malaysia, and other South-East Asian countries (Chin *et al.* 2000; Watanabe *et al.* 2000; Baki 2006b).

Weedy rice in most temperate countries such as European countries and America are called as red rice according to the pigmentation of the pericarp (Ferrero 2003). In the Americas, red rice is a common weed in most irrigated rice-growing areas, spreading primarily and harshly contaminates the rice seeds (Noldin 2000).

Table 2.1. Weedy and wild rice aggregates in selected rice-growing areas of Asia (modified from Baki (2005).)

Countries	Weedy Rice Aggregates/ Wild Rice Species	References
Bangladesh	*Oryza sativa, O. rufipogon, O. officinalis*	Karim, R.U. *(pers.comms.*)
Cambodia	*Oryza officinalis, O. ridleyi*	FAO (2005).
China	*Oryza sativa, O. rufipogon, O. Officinalis*, *O. sativa f. spontanea, O. meyeriana*	Oka (1991); Zhang 2000)
India	*O. officinalis O. sativa* f. *spontanea, O. rufipogon, O. nivara, O.granulata, O. minuta*	Vaughan (1989)
Indonesia	*Oryza sativa, O. rufipogon. O. officinalis, O. ridleyi*	Soerjani *et al.* (1987); Soekisman, T. (*pers.comm*.
Japan	*Oryza nivara, O. rufipogon, O. sativa* f. *spontanea*	FAO (2005), Sato (2000)
Korea	*Oryza sativa* ssp. *indica, O. sativa* ssp. *japonica, O. sativa* ssp. *japonica* (long-grain type); *O. sativa* ssp. *japonica* (short-grain type); *O. sativa* ssp. *japonica* (Local Korean *japonica)*	Choi (2000).
Laos	*Oryza officinalis, O. ridleyi, O. Nivara, O. rufipogon, O. granulata, O. sativa* f. spontanea*, O. minuta*	Appa Rao *et al.* (2000); Oka (1991)
Malaysia	*Oryza sativa, O. rufipogon. O. officinalis, O. ridleyi, O. meyeriana, O. minuta*	Abdullah, M.Z. (*pers. comms.).*
Myanmar	*Oryza officinalis, O. ridleyi, O. barthii, O.granulata, O. meyeriana, O. rufipogon*	Vaughan (1989).
Nepal	*Oryza officinalis, O. sativa* f. *spontanea, O. rufipogon, O. nivara, O.granulata, Hygroryza aristata*	Gupta & Upadhyay (2000).
Pakistan	*Oryza sativa, O. rufipogon*	Oka (1991); FAO (2005)
Papua New Guinea	*O. officinalis, O. ridleyi, O. australiensis, O. meriodinalis*	Vaughan (1989).
Philippines	*O. rufipogon, O. officinalis*	Obien, S.R. (*pers.comms.*)
Sri Lanka	*O. eichingeri, O. sativa* f. *spontanea*	Marambe & Amarasinghe 2000)
Taiwan	*O. sativa* f. *spontanea*	FAO (2005).
Thailand	*Oryza officinalis, O. ridleyi, O. officinalis*, *O. sativa* f. *spontanea, O. nivara,O. ridleyi, O. granulata*	Vongsaroj (2000).
Vietnam	*Oryza sativa, O. rufipogon. O. nivara, O. officinalis*	Bui (2000); Chin *et al. (*2003).

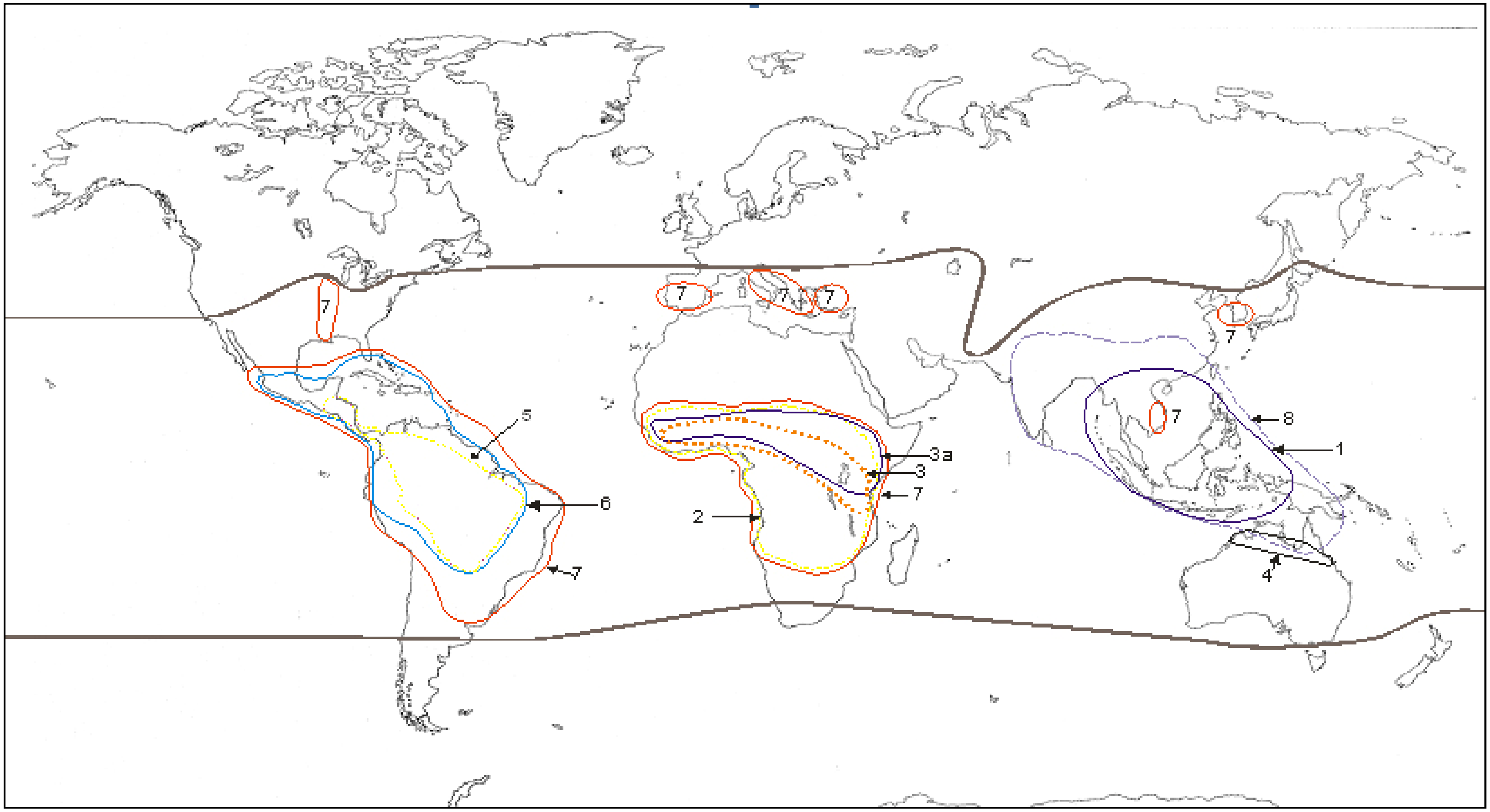


Fig. 2.1. Wild and weedy rice distribution in the world 1. Weedy rice *(Oryza sativa),* 2. *O.brachyantha,* 3. *O. eichingeri,* 3a. *O. barthii,* 4. *O. australensis,* 5. *O. alta*, 6. *O. glumaepedulla*, 7. Red rice (*Oryza sativa),* 8. *O. rufipogon, O. officinalis, O. ridleyi.* The lines across the globe represent the northern and southern latitudinal extremes where rice can be grown (modified from Baki 2005).

Vaughan *et al.* (2001) and Gealy *et al.* (2000) used DNA markers to demonstrate red rice populations in America were actually a collection of indica-like red rice (*Oryza sativa*), japonica-like red rice (*Oryza sativa*), *O. nivara*, and *O. rufipogon*. These are in general concurring with classification based on morphological traits. In Uruguay, Federici *et al*. (2001) demonstrated that straw-hull awnless and black-hull awned red rice clustered into genetically distinct groups with the cultivated rice using amplified fragment-linked polymorphisms (AFLP). In Italy, Ferrero (2001) have engaged microsatellites markers to show that Mediterranean red rice was closely related to japonica rice; whereas the Brazilian red rice was most related to indica rice. In many world rice-production areas, domestic rice cultivation and the range of sexually compatible relatives can overlap (Gealy *et al*. 2003).

The spread of weedy rice became significant due to the shifting of rice culture from transplanting to direct seeding (Azmi *et al*. 2000). In Malaysia and the neighbouring countries such as Thailand, Vietnam, Philippines and others, the practices of dry-seeding culture using seeds from previous season are thought to be the most important factors causing infestation of weedy rice in rice crop (Sadohara *et al.* 2000). At the moment, weedy rice infestation is seriously increasing with the spread of direct-seeding rice in tropical Asia (Moody 1994). Rice seedling in dry-seeded granaries grows unstably because the growth and establishment are influenced by many uncertain variables such as rainfall and climate. Most of the time, the weedy rice seeds are contaminating the seeds and this volunteer seedlings sometimes compensate poor establishment of such dry seeded rice. In many cases, weedy rice occurs with the emergence of volunteer seedlings.

In 1987, weedy rice was first observed in Sekinchan, Selangor in Malaysia and later spread to all rice granaries in Peninsular Malaysia (Wahab & Suhaimi 1991). It is one of the most serious threats in paddy field and rice production in Malaysia. It early growth and easy shattering has been the most unwanted traits of weedy rice. Weedy rice in rice-growing field in Malaysia usually grows taller than cultivated rice and easily identified.

In the largest rice granary area in Malaysia, weedy rice in Muda region was present in 82% of the farm blocks in 2001, while in 2002 no less than 59% of the farm blocks having at least a 10% infested. The overall infestation stood at 91% of the farm blocks were infested by weedy rice in 2005 with 88% of the farm blocks having at least a 10% infestation (Baki *et al*. 2000; Baki 2006b). Rice grain yield was reduced to 3.2 ton/ha in seriously infested fields where weedy rice occupied 35% of total rice plants (Azmi *et al*. 2000).

Azmi & Baki (2003) has reported that there were insignificant occurrences of weedy rice in 1995 in Peninsular Malaysia's rice granaries, but by 1996 there were more than 19,900 ha of the granaries were infested by this unwanted weedy rice. Consequently in 1997 it was almost 3 times increment of infestation in these areas prevailed (Table 2.2.). Fortunately, the infestation number dropped in the new millennia especially in Selangor North West Project, and this was principally attributed to successful weeds control by farmers and consistent campaigns and advice by the government and other related organizations to alleviate the problem in the area (Azmi and Baki 2003; Azmi 2004; Baki 2008).

Weedy rice populations are phenotypically variable in growth traits. Several morphological variants have been identified with respect to leaf colour, plant type and grain characteristics. Cluster analysis of Random Amplified Polymorphic DNA (RAPD) bonding patterns revealed that weedy rice is genetically more similar to cultivated rice at the DNA level than wild rice (Labrada 2003).

Table 2.2. Estimates of weedy rice infestations in Peninsular Malaysia from 1995 to 2002

Granary	Area (ha)	DEGREE OF INFESTATION (ha)										
		1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2005**	**2007**
MADA**	96459	?	300	225	<50	992	1104	1340	2,321	1110	980	1867
Pulau Pinang	14846	-	-	40	87	95	91	390	458	480	770	890
Perak[a]	42966	-	n**	n**	n	550	1107	1530	1593	1666	2367	2569
Selangor**	18320	n	9660	36664	11,256	399	113	200	210	220	178	1007
Negeri Sembilan	1095	n	-	-	-	-	-	950	150	-	-	-
Johor/Pahang[b]	1267	-	-	-	-	-	100	250	280	-	-	-
Terengganu	14405	-	10000	12000	Uk	Uk	750	1687	3122	2890	3890	4523
Kelantan[c]	38740	-	-	-	-	-	-	10	10	58	380	879
Total	**228098**	n	**19960**	**48929**	**11393**	**2036**	**3265**	**6357**	**8144**	**6424**	**8565**	**11735**

** First detected: MADA 1990; Selangor 1987; [a]Krian-Sungai Manik, Perak -1996; Seberang Perak -1997; [b]Endau Rompin, [c]Inside & outside KADA; n – Negligible acreage; - Not detectable; Uk Unknown.

The cultural practices of direct- and volunteer seeding in 1980's is suspected to be the most plausible causes for the origin and spread of weedy rice in Malaysia (Azmi 2005a). Use of contaminated rice seeds and movement of farm machinery between granaries are also factors related to this problem. Since 1987 when weedy rice was first detected in Tanjung Karang rice field, weedy rice has terrorized to other rice granaries in Peninsular Malaysia. The infestation was spread to MADA in 1990, Besut in 1995, Sungai Manik/Kerian in 1996, Seberang Prai in 1997, Seberang Perak and Kemubu in 2001 (Baki 2006b**)** (Fig.2.2)

Seed longevity in the soil is an additional character that enables population persistence over cropping seasons. Furthermore, the inherent seed dormancy in some variants of weedy rice makes control measures more difficult in rice cultivation. Therefore, holistic control measures have to be developed which integrate indirect control such as thorough land preparation, high quality seeds, appropriate seeding rate and crop establishment technique. Direct control to prepared land also can apply such as pre-emergence and pre-planting herbicides, manual weeding and rouging. Regulatory based measures on farm machinery movement and ensuring production of high quality seeds need to be undertaken.

Based on a survey by Azmi *et al.* (2004) by conducting interview with farmers in the Muda and Tanjung Karang rice areas, the weedy rice infestation was more serious in dry seeded rice fields and less so in wet seeded fields. Seedling establishment in dry seeded fields is noted more unstable because it is subjected to the vagaries of uncertain rainfall.

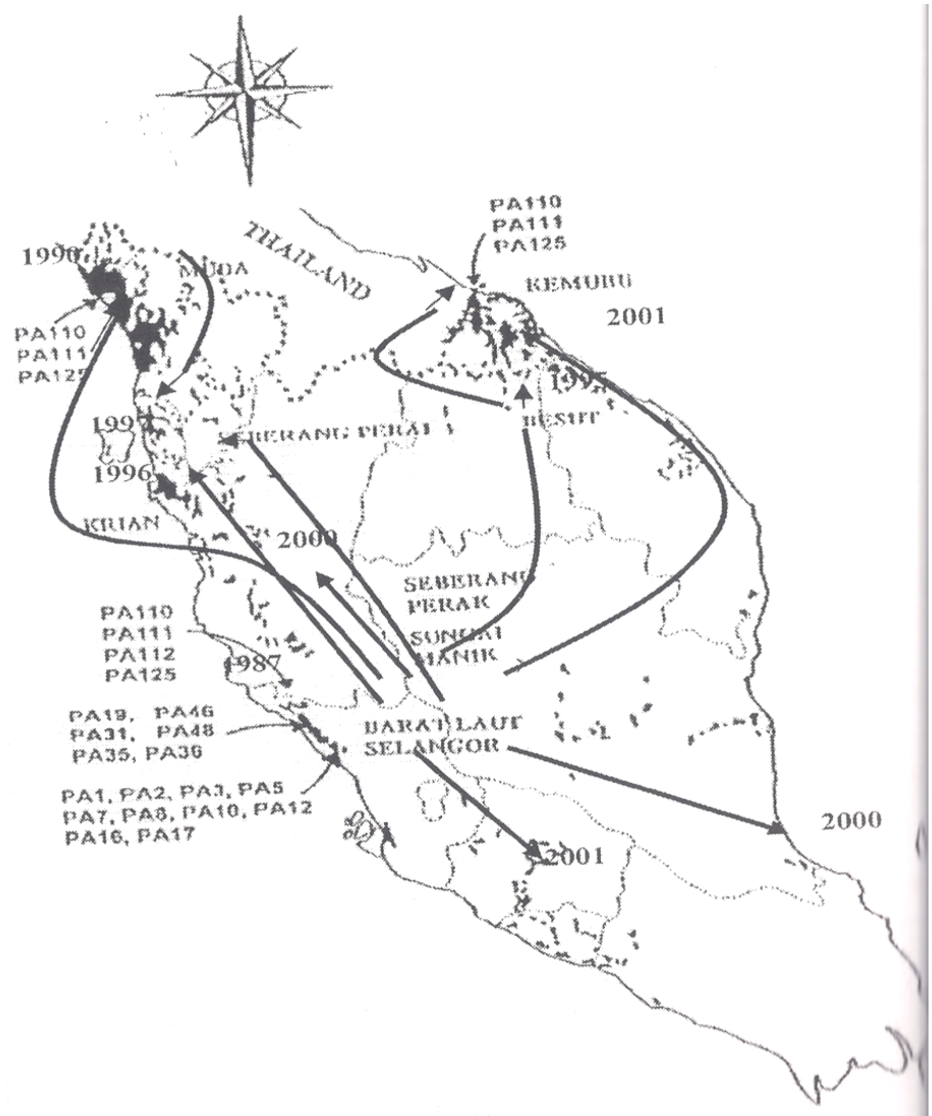


Fig. 2.2. Possible paths of invasion (indicated by arrows) by weedy rices in the Malaysian rice granaries. Adapted from Baki 2006a.

However, it was observed that the new biotype accessions stand as tall as the other cultivated rice which it becomes a new threat for the rice production in Malaysia (Baki 2008). Generally, these new biotypes of weedy rice display crop mimicry similar as the existing cultivated rice, namely, MR220, MR219, and MR84.

The work reported in this chapter was with the objectives of enlisting the new biotypes of weedy rice (NBWR) and their spatial pattern of distribution in the farm blocks of Selangor's North West Project, Malaysia based on quantitative and dispersion indices.

2.2 MATERIALS AND METHODS

A series of surveys was conducted in 2006-2008 in the rice granaries of Selangor North-West Project (PBLS) to assess the population of these new biotype accessions importance value index, variance-to-mean ratio (VMR), Lloyd's mean crowding values (m*) and Lloyd's patchiness (Ip) index.

A farm block map of paddy field areas from Sawah Sempadan to Bagan Terap is shown in Fig. 2.3. It consists of area according of their borders and watering period for each block. Surveys were conducted during harvesting period for every farm blocks for three consecutive seasons from 2006-2008. Surveys were conducted during harvesting period three consecutive seasons in 2006-2008 (Table 2.3).

Identification and separation on these accessions were based on the shattering capacity, grain colouring, awned or awnless, plant height as well as the colour of the pericarp. The taller biotype of weedy rices can easily be differentiated from cultivated rice because weedy rice is much taller than the cultivated rice and NBWR itself. However, because of the similarity in plant height, it is very difficult to differentiate between NBWR and cultivated rice. In this case, five identification keys have been used to identify NBWR in the field as shown in Table 2.4.

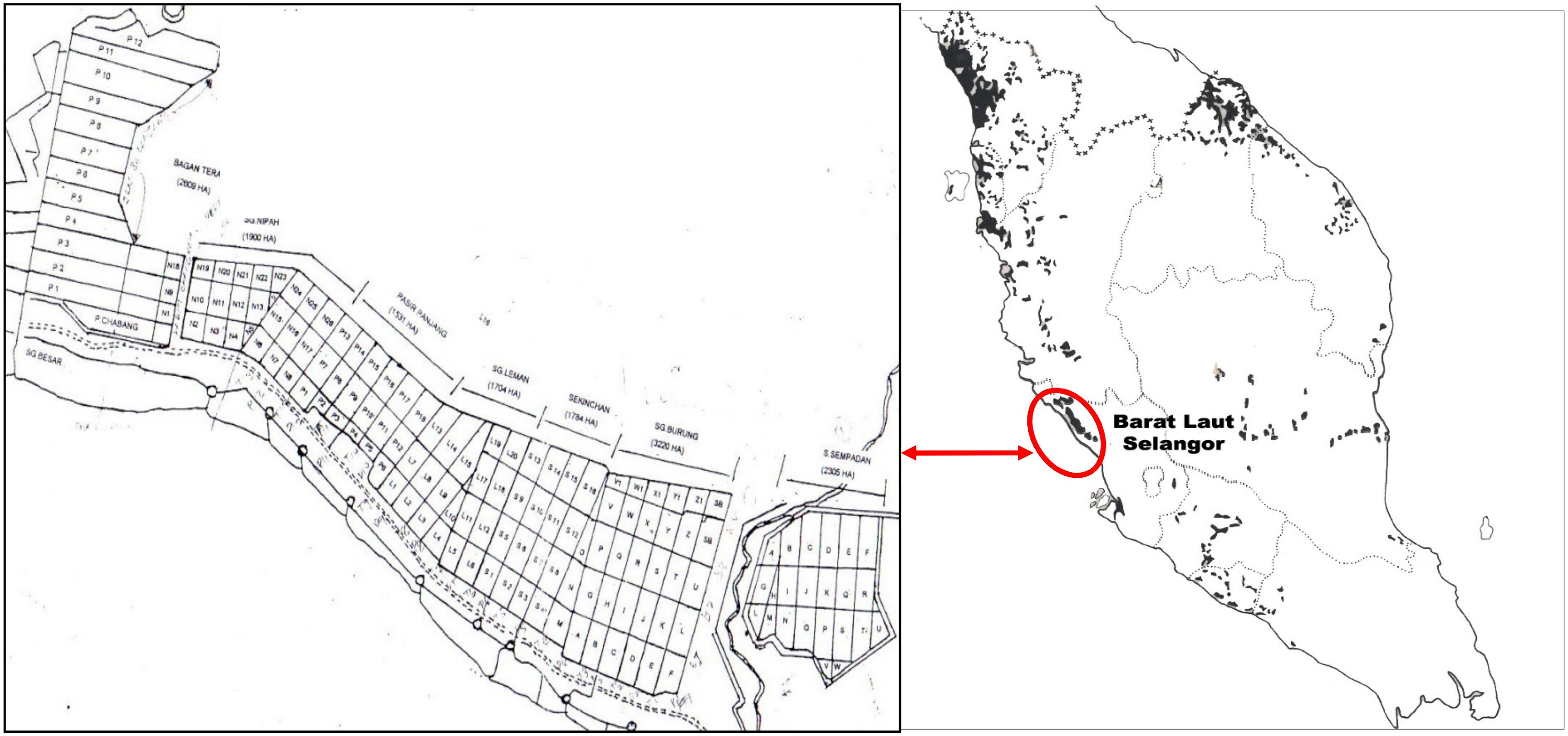


Fig. 2.3. Map of Peninsular Malaysia and Selangor North West Project (PBLS) area where the study was done. Source: Selangor Agriculture Department, Sungai Burung.

Table 2.3.: Survey schedule for each farm block in three consecutive seasons.

	Farm Blocks	Season 1	Season 2	Season 3
1	Sawah Sempadan	November 2006	April 2007	November 2007
2	Sungai Burung	December 2006	May 2007	December 2007
3	Sekinchan/Pasir Panjang/ Sungai Nipah	January 2007	June 2007	January 2008
4	Bagan Terap	February 2007	July 2007	February 2008

Table 2.4. Identification keys for new biotypes of weedy rice in the field.

Identification Keys	Characteristics	
Grain shattering percentage	>50% of grain shattering	<50% of grain shattering
Pericarp colour	Red pericarp	White pericarp
Awn existence	Awn	Awnless
Panicle type	Open	Close
Seed length	Long (more than 1cm)	Short (less than 1cm)

In the selected area for each farm block, transect was made through the paddy block. In every 10 meter long, a 1m x 1m quadrate was placed on the transect line. Then all existing NBWR in the quadrate were counted according to the identification keys as stated. All the information was then transferred to data sheet.

A quantitative index suggested by Kim & Moody (1983) was performed. The quantitative indices are coverage area percentage, existence percentage, relative density, relative dominance, relative frequency, relative patchiness and importance value. Dominance of NBWR in the community can be determined by importance value (*IV*) (Kim & Moody 1983).

Density	=	individual species number / sample area (m^2)
Relative density (x)	=	density for each species / total densities
Dominance	=	coverage area percentage / total sampling area
Relative dominance (y)	=	dominance for each species / total dominance
Frequency	=	number of block with the existence species / total block
Relative frequency (z)	=	frequency for each species / total frequency
Importance value (*IV*) index	=	(x) + (y) + (z)

The mean (m) and variance (v) values of each accession for each quadrate were calculated to determine three dispersion indices: variance-to-mean ratio (VMR), Lloyd's Mean Crowding (m*) and Lloyd's patchiness (lp) (Lloyd 1967).

Lloyd's Mean Crowding (m*) and Lloyd's patchiness (lp) can be calculated using the equation below:

$m^* = \sum_{i}^{Q} Xi\ (Xi-1) / (\Sigma\ Xi)$

and; $lp = m^*/m$

where; Q = quadrate number

Xi = number of accession for quadrate *i*

m = mean of each accession

Variance-to-mean ratio (VMR) is to determine the deviation of accession from the unity. A random distribution would indicate that that the variance and mean are the same. Therefore, we would expect a variance-mean ratio around 1. Values other than 1 would indicate a non-random distribution (Young & Young 1998). The VMR is a good measurement of the degree of randomness of a given phenomenon. This technique is also commonly used in currency management. The VMR is a particular case of the more general Fano factor, with the window chosen to be infinity.

Lloyd's patchiness (lp) index will show the distribution pattern of the accessions. If lp value is equal to 1, it indicates random distribution pattern. The uniform distribution will be indicated when the value of Ip is < 1 and if lp value is > 1, it indicates a clustered pattern of distribution.

The random pattern shows any point is equally likely to occur at any location and the position of any point is not affected by the position of any other point. There is no apparent ordering of the distribution. Uniform pattern shows every point is as far from all of its neighbours as possible and cluster pattern shows many points are concentrated close together and large areas that contain very few points.

2.3 RESULTS AND DISCUSSION

2.3.1 NBWR Entities and General Prevalence.

Throughout the three seasons in the farm blocks of PBLS from Sawah Sempadan to Bagan Terap, 16 accessions of NBWR were identified based on their special traits, *viz.* panicle type, pericarp colour, presence or absence of awn, seed type and degree of grain shattering based on the key morphological traits (Table 2.5). These groups are shown in Table 2.6. Further, these accessions exhibited a combination of morphological traits from open panicle, grain with awns, red pericarp, short grain type, to those with grain shattering habit no less than 50%. Others mimic the commercial rices with close panicle, awnless grains, white pericarp, long or short grain-type. Most accessions displayed varying degrees of grain shattering in excess of 50%, except Acc9 and Acc12.

Figs. 2.4, 2.5, and 2.6 show some of the traits of new weedy rice accessions in the farm blocks of PBLS. Invariably, the NBWRs strongly mimic commercial rices standing as equals with MR84, MR219, MR220 and MR 235. This is especially so in terms of plant height and flag leaf. Five or six years ago, weedy rice accessions in Peninsular Malaysia were typically the taller phenotypes, easily recognizable after maximum tillering stage, or even so during booting or grain-filling stage with continuous panicle slashing by farmers at milky- or grain-filling stage so as to prevent or reduce seed rain, leaving those NBWRs intact, allowing them to proliferate unabated (Fig. 2.7).

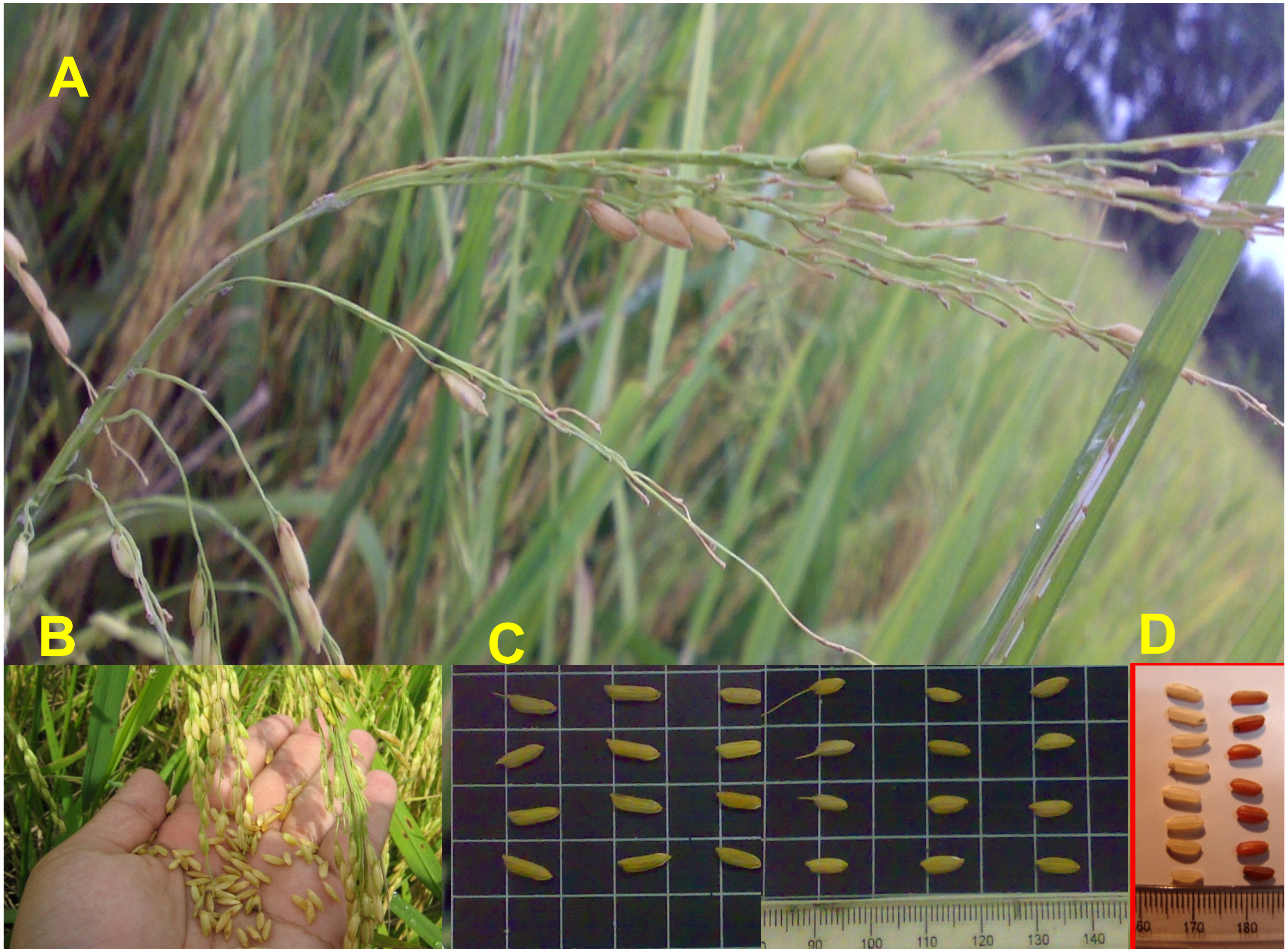
Fig. 2.8 illustrates the seasonal dynamics on the prevalence of dominant NBWR accessions. While Bagan Terap farm block, for example, did not record any measurable changes in the dominant NBWR accessions over seasons, the Sungai Leman farm block recorded season-mediated changes in the dominant NBWR accessions. Sungai Leman started with NBWR Acc3, Acc4, Acc5, Acc7, Acc8, and Acc12 in season 1 of 2006/2007,

Table 2.5. Key morphological traits of new biotypes of weedy rice in the field.

Morphological traits	NBWR’s	
Grain shattering percentage	>50% of grain shattering	<50% of grain shattering
Pericarp colour	Red pericarp	White pericarp
Awn existence	Awn	Awnless
Panicle type	Open	Close
Seed size (length)	Long (more than 1cm)	Short (less than 1cm)

Table 2.6. Key morphological traits of prevailing new biotypes of weed rices in South West Project, Selangor, Malaysia.

Accessions	Panicle Type	Pericarp Colour	Awn	Seed Type	Shattering %
Acc 1	Open	Red	Awned	Short	>50%
Acc 2	Open	Red	Awned	Long	>50%
Acc 3	Open	Red	Awnless	Short	>50%
Acc 4	Open	Red	Awnless	Long	>50%
Acc 5	Open	White	Awned	Short	>50%
Acc 6	Open	White	Awned	Long	>50%
Acc 7	Open	White	Awnless	Short	>50%
Acc 8	Open	White	Awnless	Long	>50%
Acc 9	Open	Red	Awned	Long	<50%
Acc 10	Close	Red	Awned	Long	>50%
Acc 11	Open	Red	Awnless	Long	<50%
Acc 12	Close	Red	Awnless	Long	>50%
Acc 13	Close	White	Awned	Short	>50%
Acc 14	Close	White	Awned	Long	>50%
Acc 15	Close	White	Awnless	Short	>50%
Acc 16	Close	White	Awnless	Long	>50%



Figs. 2.4. (A) Panicle of NBWR with heavy grain shattering taking place. Inserts (B) shattered grains; (C) range of grain shapes and sizes; (D) range of colour of pericarps**.**

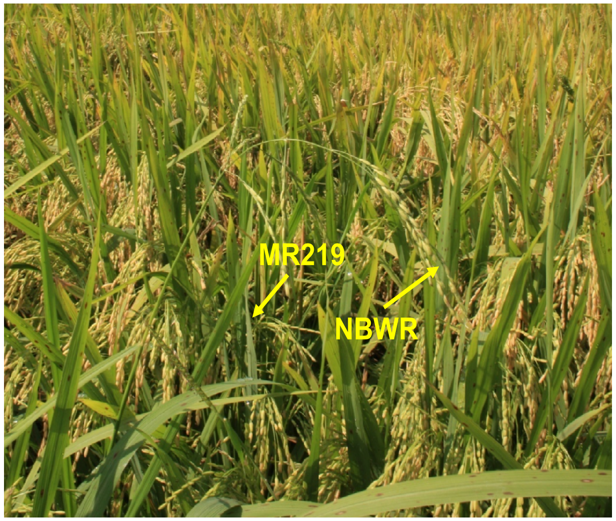


Fig. 2.5. Cultivated rice var. MR219 stands as tall as NBWR in PBLS, Malaysia.

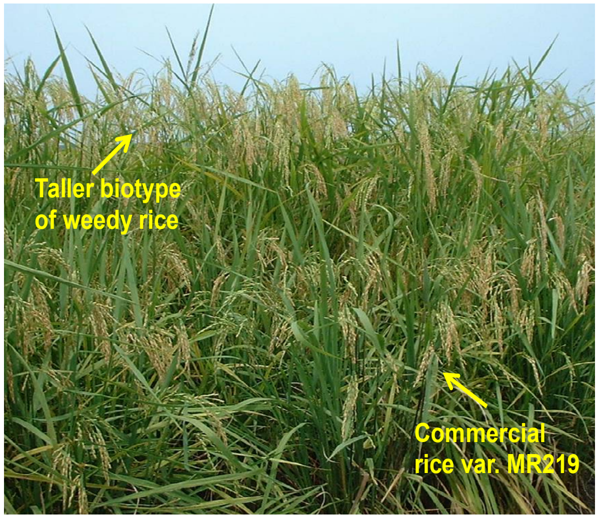


Fig. 2.6. Weedy rice previously grows taller than commercial rice in PBLS, Selangor.

Fig. 2.7. Cutting/slashing/roughing activities practiced by the farmers to control taller biotype of weedy rices in PBLS, Selangor.

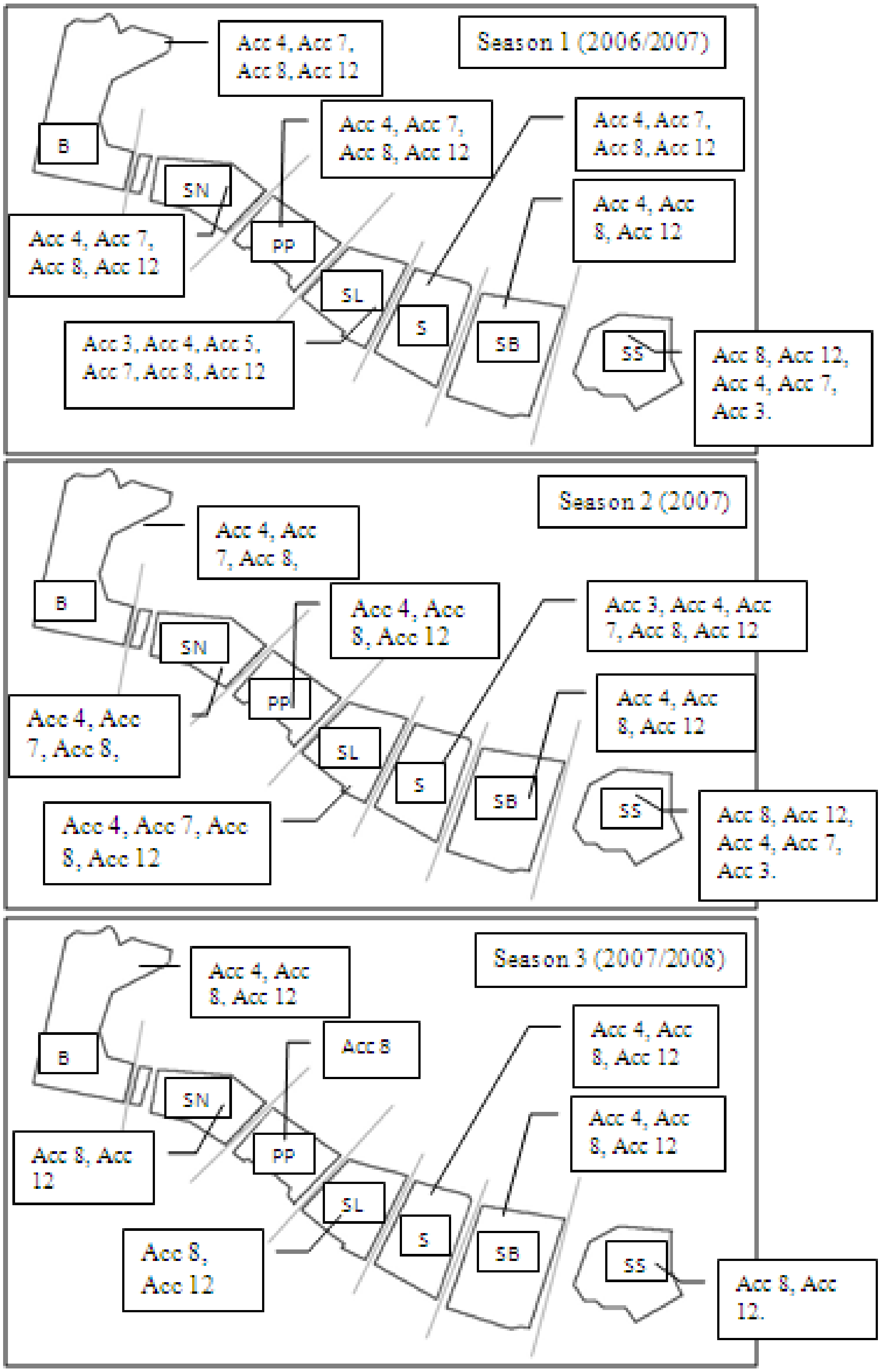


Fig. 2.8. The spatial distributions of the most common new biotypes of weed rice accessions in 2006-2008 seasons in rice granaries of South West Project, Selangor, Malaysia. Farm Blocks - SS, Sawah Sempadan; SB, Sungai Burong; S, Sekinchan, SL, Sungai Leman; P, Pasir Panjang; SN, Sungai Nipah; BT, Bagan Terap. Acc 1, Acc 2… Acc 12 – Weed rice accessions.

but no measurable records of Acc3 and Acc5 were shown in season 2 of 2007. In season 3 of 2007/2008, only Acc8 and Acc12 prevailed in the farm block. In Sawah Sempadan farm block, season 3 of 2007/2008 saw much reduced prevalence of NBWRs leaving only Acc8 and Acc12. Studies by Azmi *et al.* (2007) indicated that such dynamics in the prevalence of weedy rices in Malaysian granaries was very much influenced by control methods being employed by farmers, and those that employed integrate weed management protocols in their weed management regimes, witnessed much reduced infestations of weedy rices.

Fig. 2.9 shows the farm block- and season-mediated differences population counts for each NBWR. Acc8 has the highest population count in all farm blocks of the PBLS granary for all seasons, while Acc9 and Acc11 displayed the lowest counts. Acc8 also registered the highest population counts in all farm blocks from Sawah Sempadan to Bagan Terap, and again Acc9 and Acc11 have the lowest prevalence. Infestations of other accessions are fluctuated through the farm blocks over seasons. In Sawah Sempadan, most accessions showed a general decline throughout the three seasons except for Acc10, with slight increase from season 1 to season 2 of 2006/2007. Sungai Burung farm block has a higher population for all accessions in season 2 compared to Season 1 and Season 3. Sungai Burung has the lowest number of NBWR in Season 3. Sekinchan farm block has recorded the lowest number of NBWR (<0.001 plants/m^2) for three seasons. This is probably because farm management and crop care in this farm block is nearly optimum, thereby leaving only small numbers of NBWRs unattended or removed.

Population counts for season 1 of 2006/2007 showed that Acc8 was the highest for all farm blocks. Bagan Terap has the highest population for Acc8 followed by Sawah Sempadan, Sungai Leman, and Sungai Nipah. Acc12 also has a high population counts. Sawah Sempadan recorded the highest population for Acc12 followed by Bagan Terap. Other farm blocks also show a high density values for Acc12 with over 0.05 except for

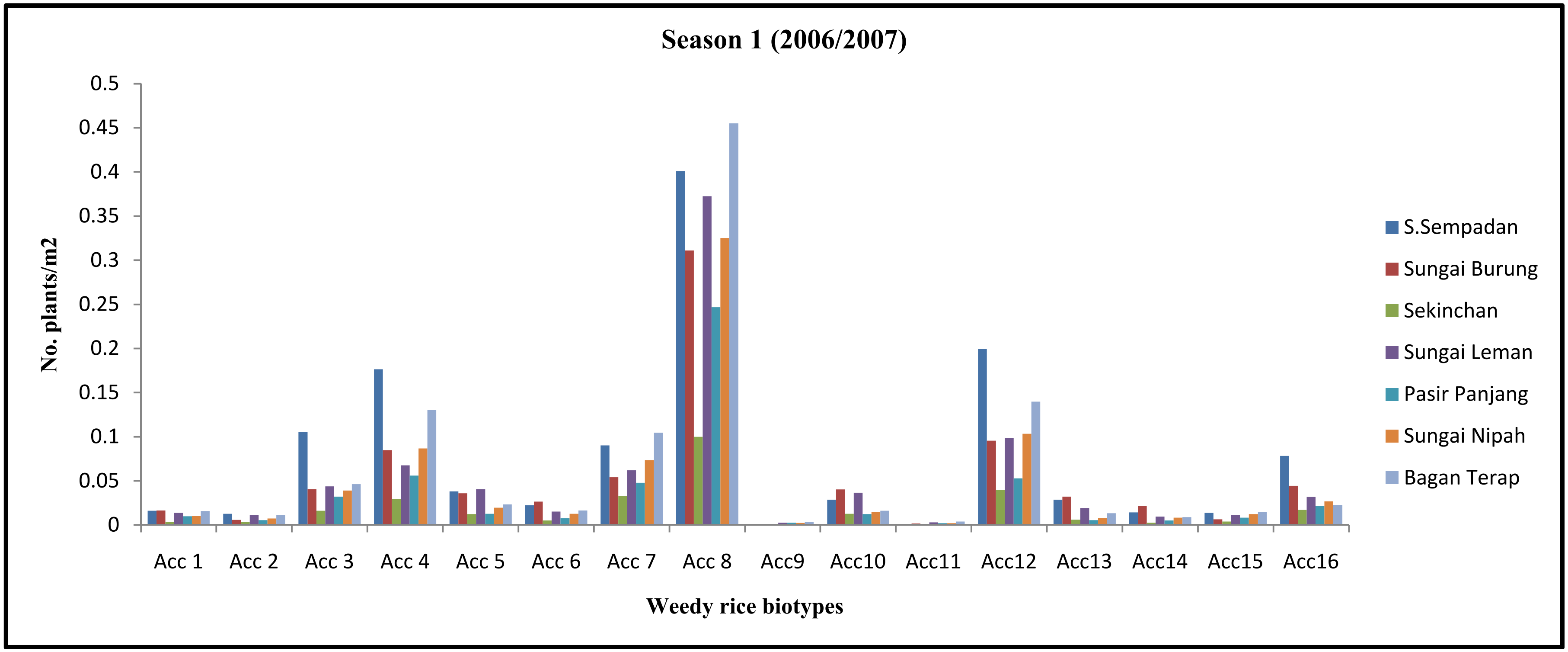


Fig. 2.9a. Population counts (no. plants/m^2) of weedy rice accessions in different farm blocks in 2006/2007 seasons in Selangor's North West Project, Malaysia.

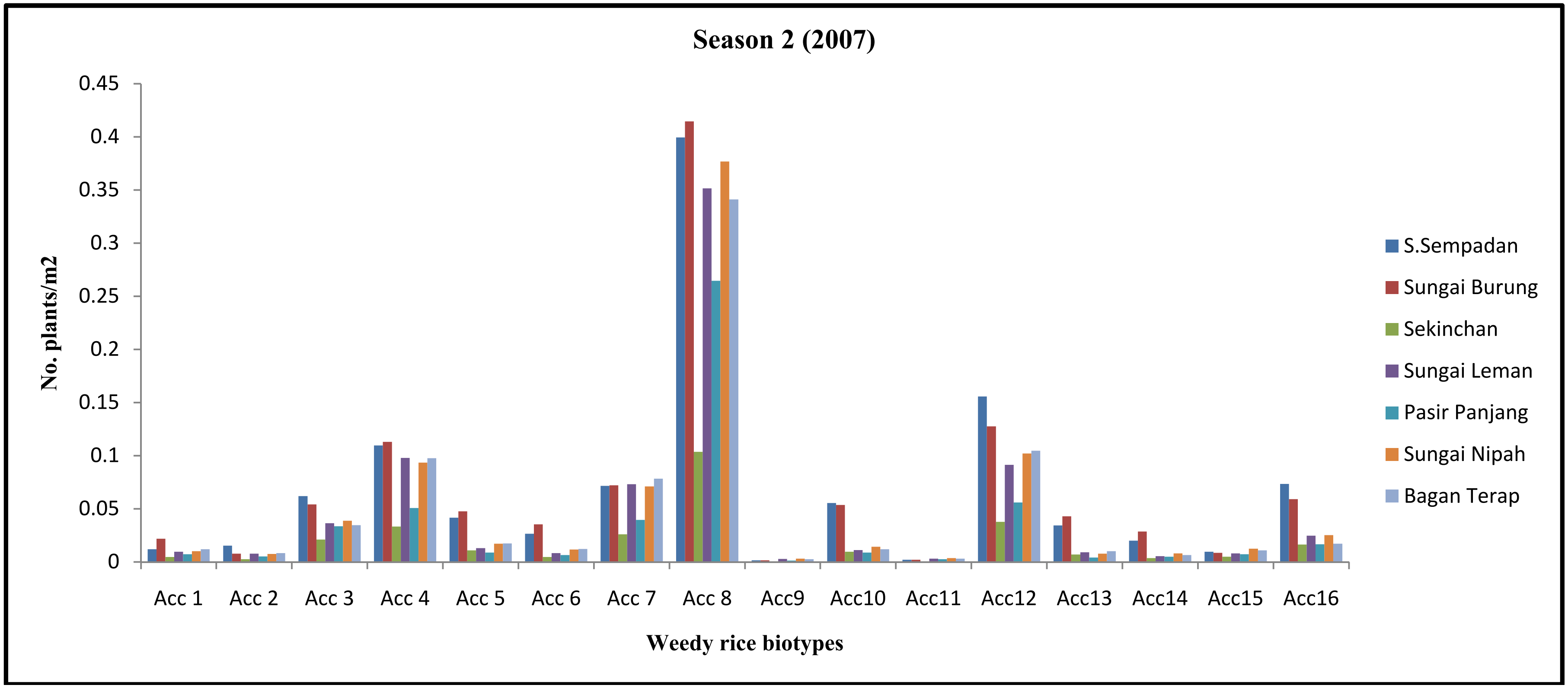


Fig. 2.9b. Population counts (no. plants/m^2) of weedy rice accessions in different farm blocks in 2007 seasons in Selangor's North West Project, Malaysia.

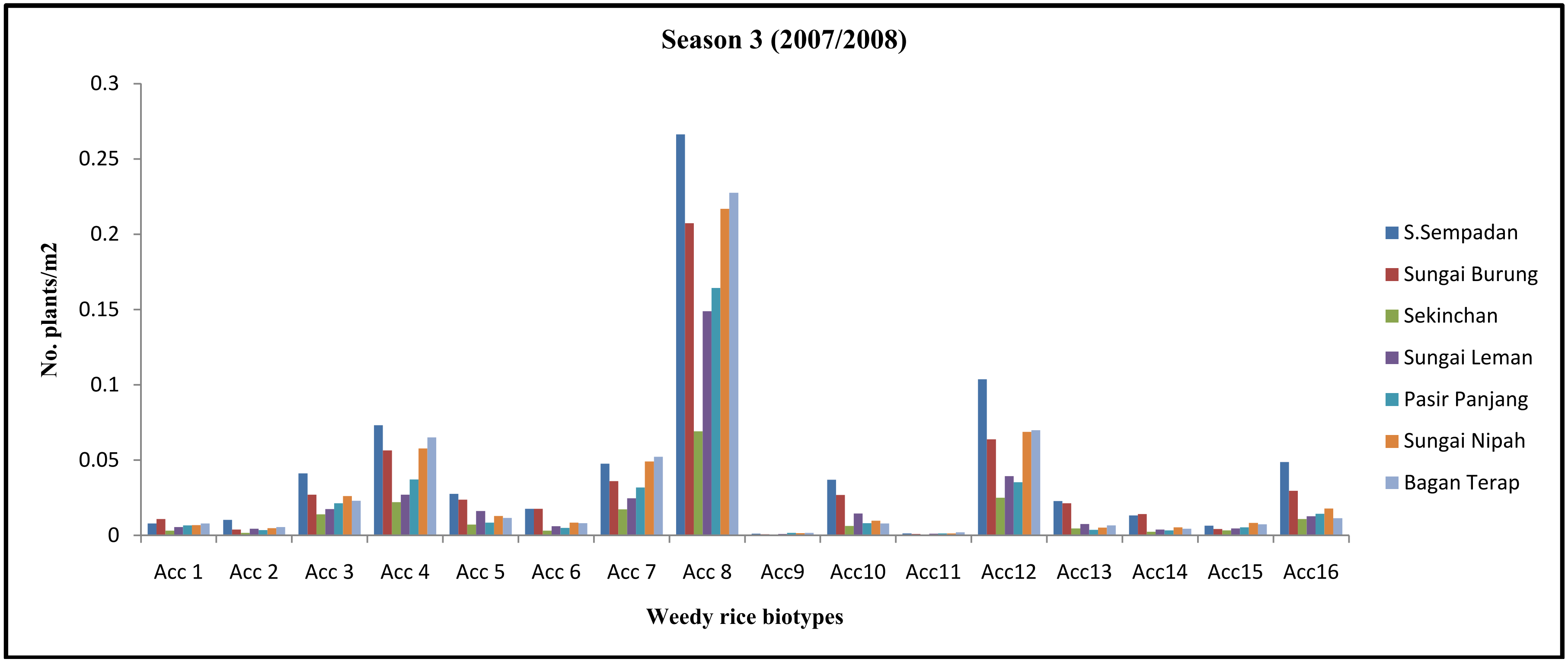


Fig. 2.9c. Population counts (no. plants/m^2) of weedy rice accessions in different farm blocks in 2007/2008 seasons in Selangor's North West Project, Malaysia.

Sekinchan. Acc4 and Acc7 have recorded population more than 0.05 for most farm blocks. However in Sekinchan, both accessions show lesser population. Sawah Sempadan and Bagan Terap have the highest population for Acc4 and Acc7.

Infestations of most accessions did not change significantly in season 2. Most accessions have almost unchanged value in population in this season. Acc8 remains the highest in all farm blocks while Acc3, Acc4, Acc12 and Acc16 increase to over 0.05 as comparison with season 1. Sungai Burung also shows the highest population for Acc8, Acc4 and Acc7.

The population counts of NBWR, irrespective of accessions, decreased in season 3 of 2007/2008 for all farm blocks. Only Acc4, Acc8 and Acc12 have population over than 0.05 in most farm blocks. Even the highest value is not exceeding 0.3 as compared to previous seasons.

2.3.2 Seasonal Prevalence.

Importance value (IV) is a measure of dominance of species in an area (Kim & Moody 1983). The higher IV will show the more dominant of the accessions. Fig. 2.10 shows IV index for three seasons. IV was used to compare the dominance stature of NBWR in each season.

In season 1, Acc8 has the highest value for IV. All farm blocks show Acc8 as the most dominated NBWR in their area. Pasir Panjang shows the highest importance value for Acc8 among the rest. Sungai Leman, Bagan Terap and followed by Sungai Nipah were the next dominant accession for Acc8 in season 1 after Pasir Panjang. Acc12 is the next accession which has a high importance value in season 1 with Sawah Sempadan noted the highest value for this accession. However, the value seems not have a large different between other farm blocks. Acc4 also has a similar pattern with Acc12 in this season.

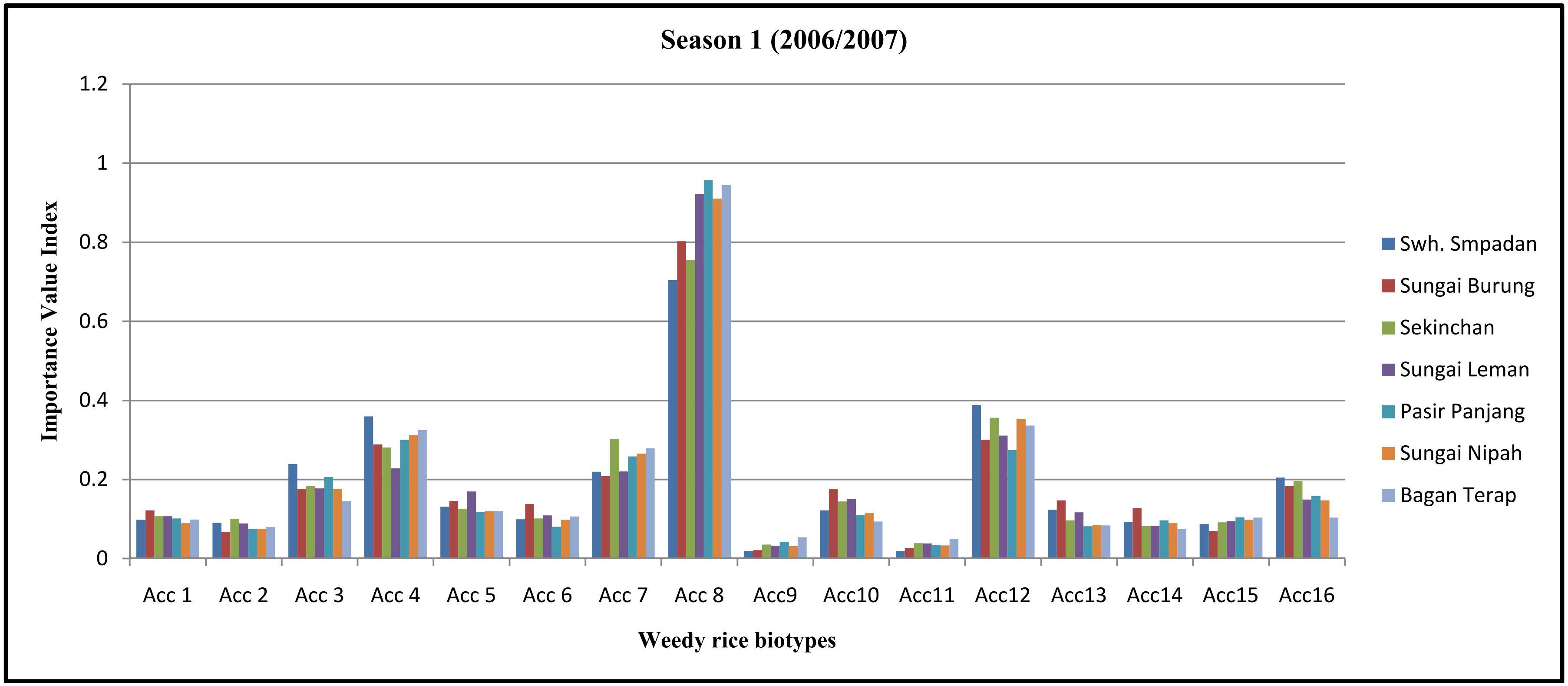


Fig. 2.10a. Importance value index values of weedy rice accessions in different farm blocks and growing seasons of 2006/2007 in Selangor's North West Project, Malaysia.

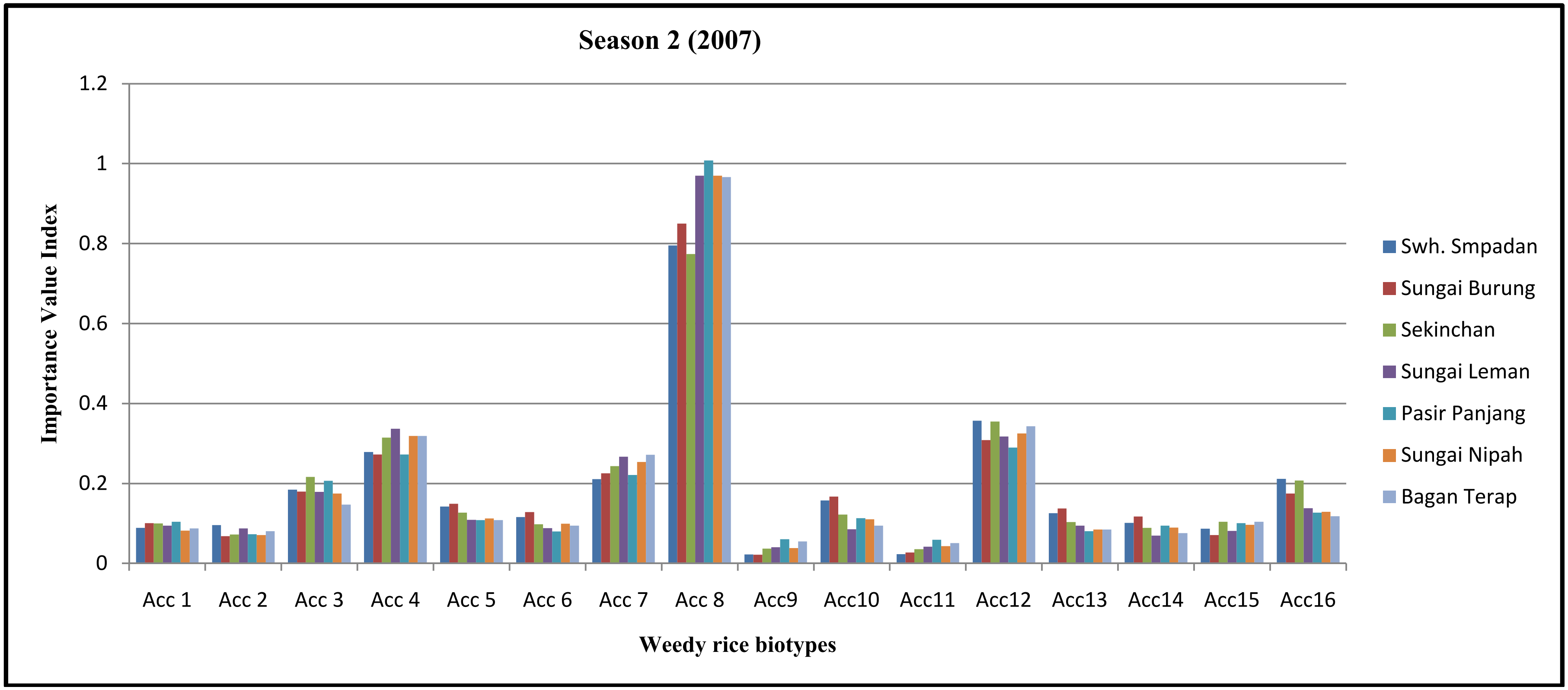


Fig. 2.10b. Importance value index values of weedy rice accessions in different farm blocks and growing seasons of 2007 in Selangor's North West Project, Malaysia.

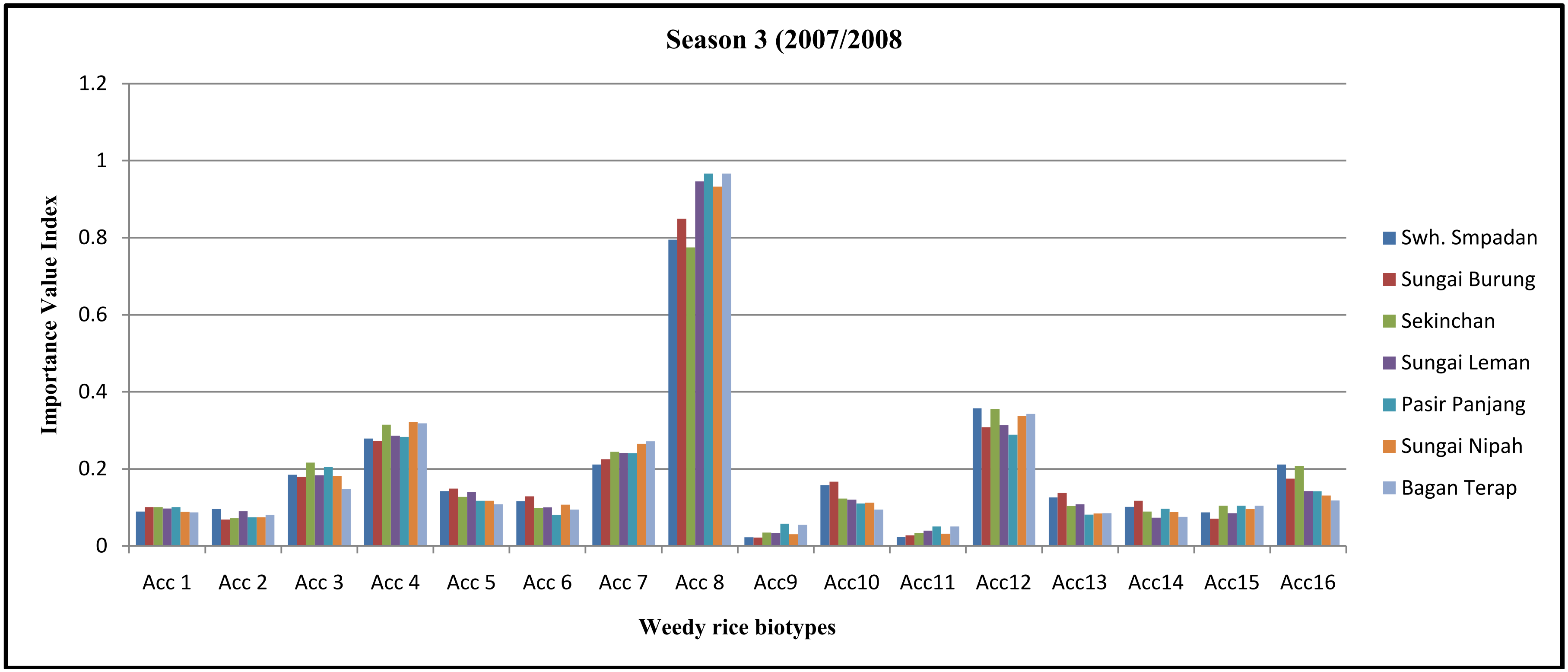


Fig. 2.10c. Importance value index values of weedy rice accessions in different farm blocks and growing seasons of 2007/2008 in Selangor's North West Project, Malaysia.

Sawah Sempadan shows the highest value while Sungai Leman is the lowest. Other farm blocks noted the same value among each other. Fig. 2.8 also shows that Sekinchan has the highest value of IV for Acc7 in this season. We can conclude that in season 1, the most dominant accession of NBWR is Acc8 in all farm blocks. The IV index for Acc8 shows the value nearly to 1.0. Acc12, Acc4, Acc7 and Acc3 also have a high IV index but the value not even reaching 0.5 while others show a low IV index (the least dominant) with Acc9 and Acc11 are the lowest in all farm blocks.

In season 2, Acc8 again registered the highest value for IV at all farm blocks. Still, Acc8 in Pasir Panjang displayed the highest importance value among the other farm blocks. Sungai Leman, Bagan Terap and Sungai Nipah were the next dominant accession for Acc8 in season 2 after Pasir Panjang. Acc12 is the next accession which has a high importance value in season 1 with Sawah Sempadan, Sekinchan and Bagan Terap noted the highest value for this accession. The similar pattern to Acc12 also occurs in Acc4 and Acc7 for this season. Sungai Leman shows the highest value for Acc4 while Bagan Terap for Acc7. The result in season 2 shows us the most dominant accession of NBWR is Acc8 in all farm blocks. The IV index for Acc8 shows the value nearly to 1.0, comparable as in season 1. Acc12, Acc4, Acc7 and Acc3 also have a high IV index but the value not even reaching 0.5 while others show a low IV index (the least dominant) with Acc9 and Acc11 are the lowest in all farm blocks.

A quite similar pattern of IV index values in Season 3 comparative with season 1 and 2 with Acc8 has the highest value for IV. All farm blocks show Acc8 as the most dominated NBWR in their area for this season. However, Bagan Terap shows the highest importance value for Acc8 among the rest even though Acc8 dominated the most at Pasir Panjang in season 1 and 2. Pasir Panjang, Sungai Leman and followed by Sungai Nipah were the next dominant accession for Acc8 in Season 3. Acc12, Acc4 and Acc7 are the next accessions which have a high importance value in season 3 with Bagan Terap noted the highest value for Acc7, Sungai Nipah and Bagan Terap for Acc4 and Sawah Sempadan for Acc12. We can conclude that in season 3, the most dominant accession of NBWR is still the Acc8 in all farm blocks.

Acc8 followed by Acc4, Acc7 and Acc12 are the following accessions with a high IV index values. There were the most dominant accessions compared with other NBWRs based on importance value index (IV) values in seasons 1, 2 and 3 of 2006/2008. The NBWRs had dominated most farm blocks of PBLS, with Sawah Sempadan, Sungai Nipah and Bagan Terap recording heaviest infestations.

2.3.3 Spatial distribution patterns

Table 2.7 shows a variance-to-mean ratio (VMR) for NBWR in PBLS for three seasons of 2006-2008. The VMR values are indicative of whether the pattern of distribution of NBWR of being random, non-random, or regular (Young & Young 1998).

In probability theory and statistics, the variance-to-mean ratio (VMR), like the coefficient of variation, is a measure of the dispersion of a probability distribution. It is defined as the ratio of the variance σ^2 to the mean μ:

$$VMR = \frac{\sigma^2}{\mu}.$$

The Poisson distribution has equal variance and mean, giving it a VMR = 1. The geometric distribution and the negative binomial distribution have VMR > 1, while the binomial distribution has VMR < 1. This means that if the distribution is random, it can be modeled by the Poisson process or its multidimensional analogues so the VMR is about 1.0. If the VMR >1.0 correspond to existence of "clumps" or “clustered”. Smaller values

Table 2.7. Variance-to-Mean Ratio values of weedy rice accessions in different farm blocks of rice granaries, Selangor's North West Project, Malaysia.

Accessions	SS*	SB	S	SL	PP	SN	BT
Acc 1	1.06	0.93	1.22	0.69	0.59	1.11	1.26
Acc 2	1.12	0.72	1.30	0.49	0.74	1.12	0.82
Acc 3	3.07	2.37	3.32	1.57	2.01	2.84	5.65
Acc 4	6.79	4.01	5.98	2.91	5.14	5.09	4.01
Acc 5	3.77	3.97	5.40	3.31	1.23	1.88	1.13
Acc 6	2.29	2.27	1.36	1.05	1.27	1.32	0.80
Acc 7	3.62	2.23	4.72	1.96	4.06	6.31	3.77
Acc 8	19.09	9.62	28.15	5.59	5.57	7.68	5.63
Acc 9	1.55	1.66	3.33	0.98	1.63	1.79	0.57
Acc10	5.63	4.96	4.91	2.73	0.66	1.27	0.79
Acc11	2.14	1.61	0.67	0.66	2.34	1.61	0.92
Acc12	8.35	5.28	6.55	2.23	2.58	3.06	2.44
Acc13	2.93	2.78	2.62	0.99	0.94	0.54	0.90
Acc14	1.44	1.57	1.16	0.84	0.28	0.52	0.92
Acc15	0.57	0.63	1.33	0.87	0.91	1.63	0.46
Acc16	4.58	2.98	3.60	0.99	1.86	2.84	1.94

*Farm Blocks - SS, Sawah Sempadan; SB, Sungai Burung; S, Sekinchan; SL, Sungai Leman; PP, Pasir Panjang; SN, Sungai Nipah; BT, Bagan Terap.

(VMR < 1.0) correspond to a more-uniform-than-random distribution ("even" or "uniform").

Table 2.7 shows the VMR value of all accessions in all farm blocks throughout the 3 consecutive seasons. Most accessions show VMR value more than one giving an indication that most accessions have a clump or clustered distribution. The accessions Acc3, Acc4, Acc7, Acc8 and Acc12 have this type of distribution in all farm blocks throughout all seasons. Other accessions also showed almost the same pattern. Only in a few farm blocks, some accessions have either random or uniform distribution.

The accessions which have VMR values equal to or nearly to one are Acc1 (in Sawah Sempadan, Sungai Burung and Sungai Nipah), Acc2 (in Sawah Sempadan and Sungai Nipah), Acc5 (Bagan Terap), Acc6 (in Sungai Leman), Acc9 (in Sungai Leman), Acc11 (in Bagan Terap), Acc13 (in Sungai Leman, Pasir Panjang and Bagan Terap), Acc14 (in Sekinchan and Bagan Terap), Acc15 (in Pasir Panjang) and Acc16 (in Sungai Leman). In this case, these accessions were random distributed in the farm blocks.

The accessions which have VMR values < 1 are Acc1 (in Sungai Leman and Pasir Panjang), Acc2 (in Sungai Burung, Sungai Leman, Pasir Panjang and Bagan Terap), Acc6 (in Bagan Terap), Acc9 (in Bagan Terap), Acc10 (Pasir Panjang and Bagan Terap), Acc11 (in Sekinchan and Sungai Leman), Acc13 (Sungai Nipah), Acc14 (in Sungai Leman, Pasir Panjang and Sungai Nipah) and Acc15 (in Sawah Sempadan, Sungai Burung, Sungai Leman and Bagan Terap). The VMR values for these accessions indicate that the accessions have uniform distribution in farm blocks.

In Sawah Sempadan, all accessions show a spatial or temporal cluster distribution except for Acc1, Acc2 and Acc15 which show random distribution. A nearly same pattern with Sawah Sempadan is shown in Sungai Burung. Only for Acc15 which shows a uniform distribution. Most accessions in Sekinchan have a clump pattern. Acc1, Acc2, Acc6, Acc14 and Acc15 have a random distribution while Acc11 has a uniform distribution.

A clumped distribution was shown in Acc3, Acc4, Acc5, Acc8, Acc10 and Acc12 in Sungai Leman. Acc2 and Acc11 have an even distribution and others have a random distribution. NBWRs in Pasir Panjang farm block show a various distribution pattern. Acc1, Acc10 and Acc14 have a uniform distribution while Acc2, Acc5, Acc6, Acc13 and Acc15 have a random distribution. Others are clumped.

In the Sungai Nipah farm block, only Acc13 and Acc14 have a uniform distribution. Random distribution is shown in Acc1, Acc2, Acc6, Acc9, Acc10 and Acc11 while the others have a clump distribution. A random distribution is shown in Acc3, Acc4, Acc7, Acc8, Acc12 and Acc14 in Bagan Terap farm block. Both Acc9 and Acc15 have a uniform distribution while the rest have a clumped distribution.

Further, the relationship between mean crowding (m*) and mean density (m), we also can determine the pattern of distribution of the accessions. Table 2.8 shows the Lloyd's Ip values of NBWR in PBLS. The distribution pattern can be determined using the Iwao line from the m*/m graph. Those values located on the Iwao line are accessions displaying random distribution, while those below show that these accessions are regular. Accessions displaying values above the Iwao line are indicative of clustered or under-dispersed distribution pattern. Such relationships for the collated data are shown in Figs. 2.11, 2.12 and 2.13. The Lloyd's patchiness (lp) index and the distribution pattern of the accessions are shown in Table 2.8.

In the farm blocks of Sawah Sempadan and Sungai Burung, the pattern is almost the same. Acc5, Acc9, Acc10, Acc11 and Acc13 have lp value over the Iwao line. Only Acc15 has a uniform distribution while the others are random. At Sekinchan, all accessions have a cluster distribution except for Acc1 and Acc14 which have a random distribution.

Table 2.8. Lloyd's Patchiness Index Values of weedy rice accessions in different farm blocks of rice granaries, Selangor's North West Project, Malaysia.

Accessions	SS*	SB	S	SL	PP	SN	BT
Acc 1	1.03	0.96	1.32	0.71	0.68	1.07	1.14
Acc 2	1.05	0.63	1.83	0.42	0.63	1.10	0.82
Acc 3	1.24	1.25	1.79	1.16	1.23	1.35	1.97
Acc 4	1.39	1.26	2.09	1.34	1.54	1.35	1.22
Acc 5	1.49	1.61	3.94	1.69	1.13	1.33	1.04
Acc 6	1.35	1.35	1.52	1.03	1.24	1.18	0.87
Acc 7	1.27	1.17	2.04	1.19	1.47	1.53	1.25
Acc 8	1.33	1.21	2.92	1.15	1.14	1.15	1.09
Acc9	3.38	5.04	33.6	0.82	2.66	3.49	0.46
Acc10	1.61	1.73	3.98	1.57	0.79	1.13	0.85
Acc11	4.88	3.74	0.00	0.00	5.57	3.04	0.74
Acc12	1.35	1.33	2.08	1.15	1.23	1.15	1.09
Acc13	1.41	1.41	2.68	0.98	0.90	0.56	0.91
Acc14	1.16	1.19	1.27	0.77	0.03	0.55	0.88
Acc15	0.66	0.56	1.46	0.85	0.90	1.37	0.62
Acc16	1.36	1.33	2.15	0.99	1.29	1.52	1.39

* Farm Blocks - SS, Sawah Sempadan; SB, Sungai Burung; S, Sekinchan; SL, Sungai Leman; PP, Pasir Panjang; SN, Sungai Nipah; BT, Bagan Terap.

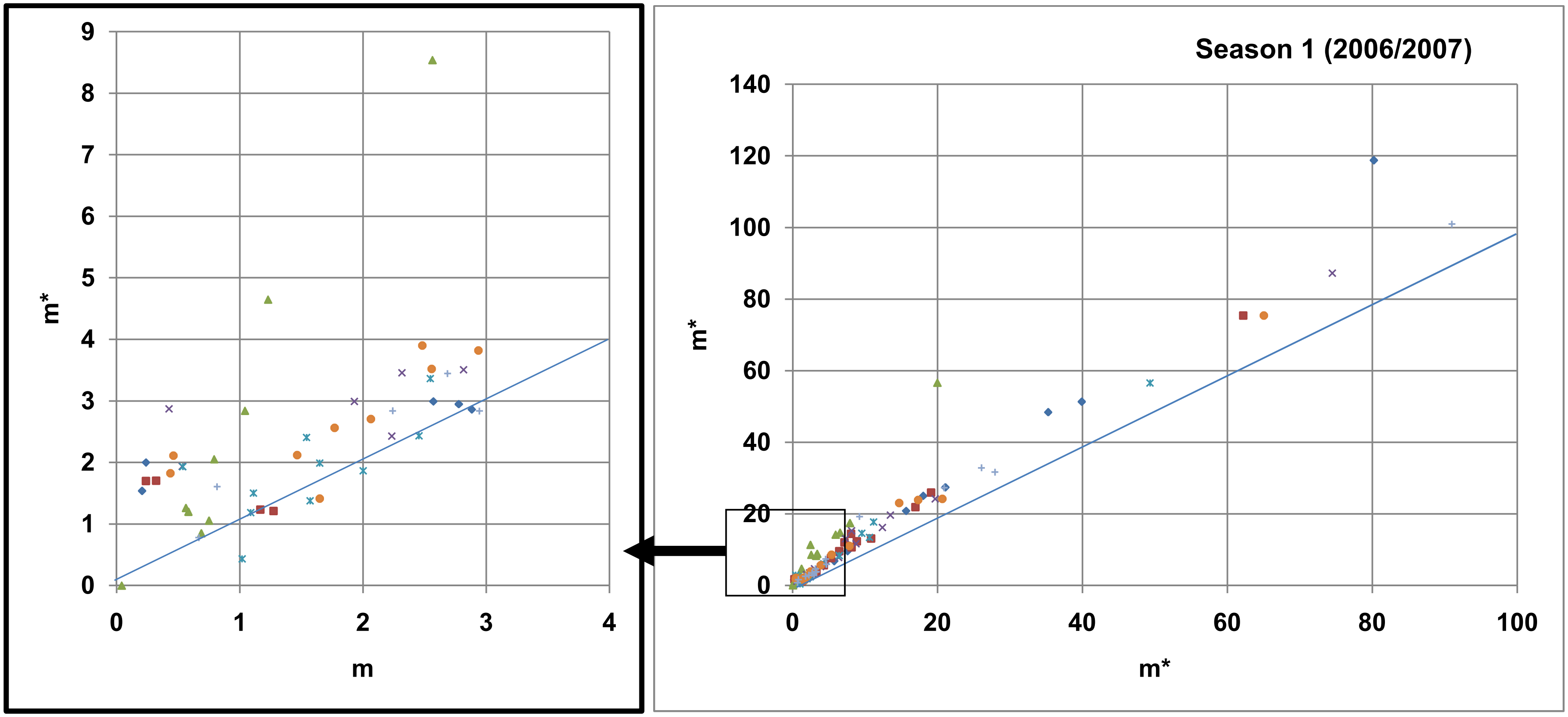


Fig. 2.11. The relationship between Lloyd's mean crowding (m*) and mean density (m) values of weedy rice for different farm blocks and growing seasons of season 1 (2006/2007) in Selangor's North West Project, Malaysia.

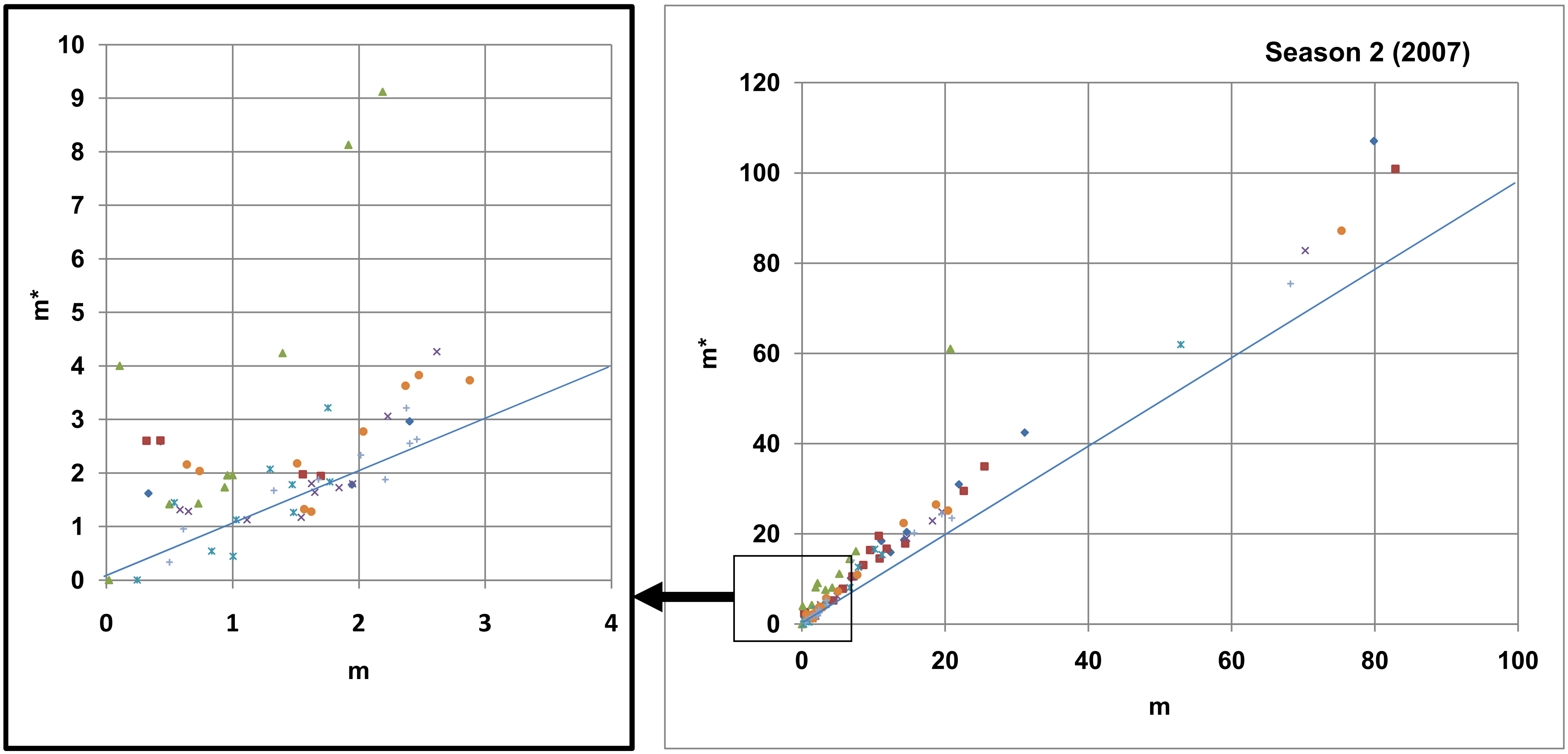


Fig. 2.12. The relationship between Lloyd's mean crowding (m*) and mean density (m) values of weedy rice for different farm blocks and growing seasons of season 2 (2007) in Selangor's North West Project, Malaysia.

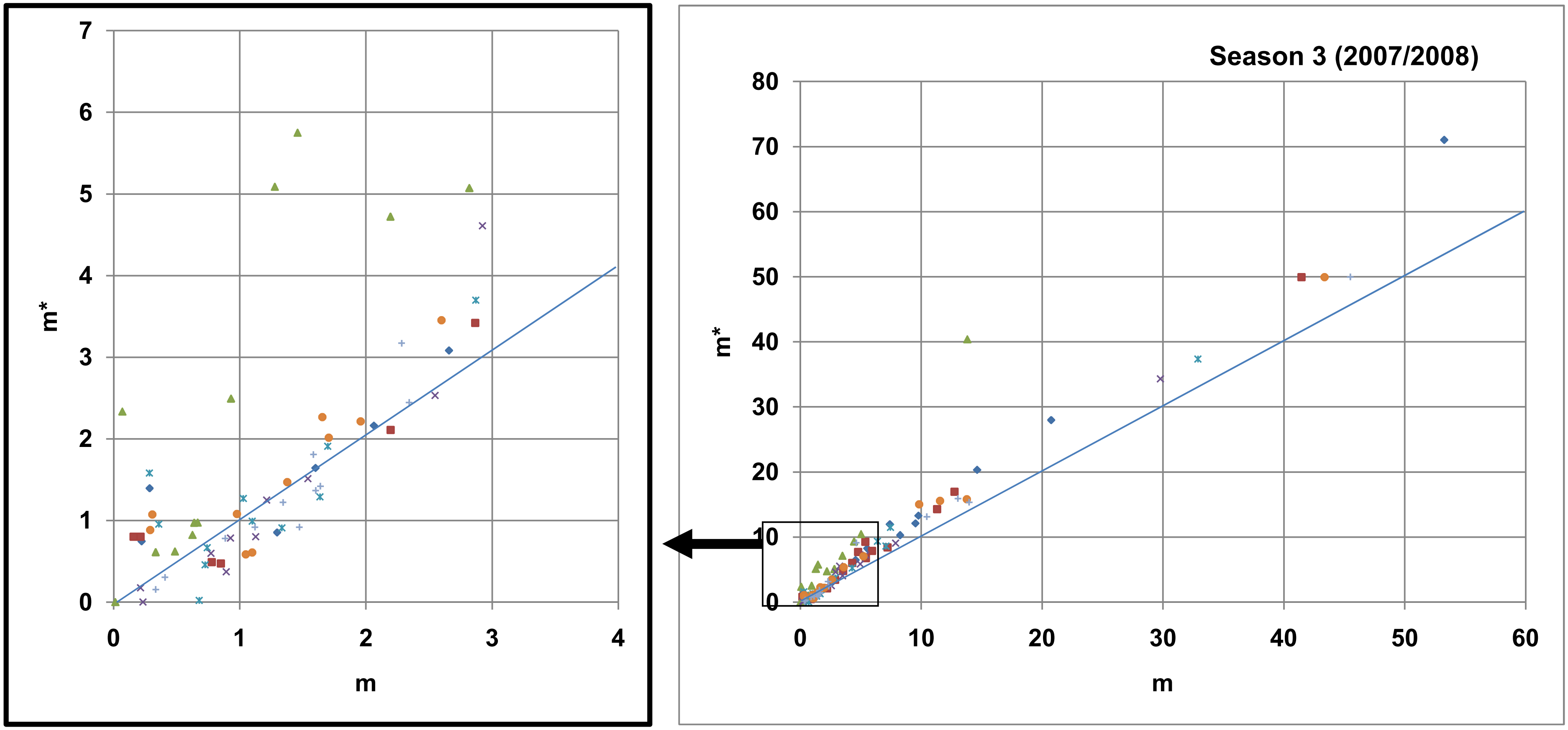


Fig. 2.13. The relationship between Lloyd's mean crowding (m*) and mean density (m) values of weedy rice for different farm blocks and growing seasons of season 3 (2007/2008) in Selangor's North West Project, Malaysia.

Most accessions in Sungai Leman have a random distribution. Only for Acc5 and Acc10 which show a cluster distribution and Acc2 with a uniform distribution.

In the Pasir Panjang farm block, a uniform distribution is shown for Acc4, Acc7, Acc9 and Acc11 while Acc1, Acc2 and Acc14 have a clustered distribution. Other weedy rice accessions have a random distribution. Most weedy rice accessions in the farm blocks of Sungai Nipah have random distribution. Only for Acc7, Acc9, Acc11 and Acc16 have a value over the Iwao line and Acc13 and Acc14 have value below the line. Almost every accession at Bagan Terap has a random distribution pattern except for Acc3 and Acc11, which have clustered distribution while Acc9 and Acc15 have uniform distribution.

The relationship between Lloyd's mean crowding (m*) and mean density (m) values of weedy rice for all different farm blocks and all growing seasons of 2006-2008 in Selangor's North West Project, Malaysia was performed. In Sawah Sempadan for season 1, weedy rice accessions which have random distribution are Acc1, Acc14 and Acc2 while others showed clustered or under dispersed distribution. Only Acc15 showed a random distribution in season 1 while others in cluster. Again in season 3 at Sawah Sempadan, most accessions showed an under dispersed distribution, whereas Acc1, Acc2 and Acc14 showed a random distribution and Acc15 have a uniform distribution.

Most accessions in Sungai Burung showed values above the Iwao line in almost all seasons, indicating that they have clustered distribution. Only a few cases in Sungai Burung showed a non-cluster distribution. A random distribution was shown in Acc1, Acc2 and Acc15 in seasons 1 and 2; and Acc1 in season 3. The following weedy rice accessions with uniform distribution were Acc2 and Acc15.

NBWR accessions found in Sekinchan were all distributed in cluster except for Acc9 in season 1 and Acc11 in season 2 and 3. Acc9 was distributed randomly in season 1 before it showed a cluster distribution in the next season. Acc11 was first found in cluster in season 1. However, it was distributed randomly in season 2 and season 3.

Various distribution patterns were found in Sungai Leman according to Lloyd's mean crowding (m*), mean density (m) values and position in Iwao line. At first, all accessions in Sungai Leman showed an under dispersed distribution pattern in first season except for Acc2 which distributed randomly. In season 2, Acc1, Acc13, Acc14 and Acc15 showed a random distribution pattern while Acc2 showed a uniform distribution. Other accessions in Sungai Leman in this season were found in cluster. Distribution pattern of NBWRs in Sungai Leman seemed to be changed in season 3. There were some accessions were found in uniform. Acc1, Acc2, Acc11, Acc14 and Acc15 were distributed uniformly in this season. NBWR's accessions were also found in cluster. Acc8, Acc4, Acc12, Acc7, Acc5, Acc10 and Acc3 were distributed in cluster or under dispersed. Other accessions were found on the Iwao line which determined as a random distribution.

NBWR's accessions only distributed either in cluster or uniform in Pasir Panjang for all 3 seasons. Only Acc15 in season 2 and Acc10 and Acc2 in season 1 and 2 were found in random in Pasir Panjang. In season 1, Acc1 and Acc14 were found in uniform while others were distributed in cluster. Season 2 showed a wide distribution patterns for the accessions. Acc9, Acc13, Acc14 and Acc1 were distributed in uniform while others showed a cluster distribution. In season 3, no accessions were found in random. Acc10, Acc1, Acc15, Acc13, Acc2 and Acc14 were distributed in uniform while other accessions were found in cluster.

Accessions in Sungai Nipah showed almost similar distribution pattern in season 1 and 2. All accessions except Acc13 and Acc14 were found in cluster distribution. Acc13 and Acc14 were distributed uniformly. Still in season 3, the same pattern was occurred as in previous seasons. Only for this time, Acc1 and Acc2 were distributed in random.

Acc2 and Acc10 in Bagan Terap for the first season showed a random distribution while Acc9 and Acc15 showed a uniform distribution. Other accessions in this season were found to be distributed in cluster. There is only Acc15 was found in uniform for season 2 and Acc9 in this season was found in random while other accessions were found under dispersed distribution. NBWR's accessions in Bagan Terap for season 3 were found in a very different pattern with other farm blocks in any seasons. Most accessions were found in uniform distribution in this particular season. Only Acc1, Acc5, Acc16, Acc3, Acc7, Acc4, Acc12 and Acc8 were found in cluster. No random distribution was found in this season.

It is believed that a close relationship between weedy rice and cultivated commercial varieties prevails, giving a strong indication that evolutionary forces are still operating in the rice ecosystems. These NBWRs are believed to have evolved from cultivated rice as parents over the years and are believed to be derived from hybridization between different cultivars, selection of weedy traits present in cultivars, relics of abandoned cultivars, or to have been brought into the growing region through contaminated seed stocks.

This study can give a rough idea of how the NBWR distribute in the Malaysian rice granaries. Management and control of this new threat must be done to make sure the prevention of this NBWR from being spread and cost a big lost for the farmers.

Areas like Sawah Sempadan, Sungai Burung, Sungai Nipah and Bagan terap should be given a very intensive care from being infested by this NBWR. As most accessions in these areas have a random distribution and grow in clump, this NBWR can reduce drastically on rice production of these areas. Farmers can study how farmers in Sekinchan and some in Sungai Leman on how they can manage their field from being infested by this NBWR. From the random observation, Sekinchan farmers applied a very intensive management to control weeds in their fields. Hand weeding and serious care since the sowing has resulted a field with nearly free of NBWR and also other weeds.

It is thought that the spread of former weedy rice became significant due to shifting from rice transplanting to direct seeding in Malaysia and neighbouring countries, the practices of dry-seeding culture associated with volunteer seeding (shattered seeds from previous season used as seed for the next season) are considered to be the most important factors causing infestation of weedy rice. In this case, a shift back to rice transplanting can be practiced again to control the weedy rice especially NBWR. Transplanting method using modified machine reduce weed infestation in most rice farms in Sekinchan. Farmers in Sekinchan use this machine to transplant paddy seedling to the field from sowing site. This technique will make sure the field will be planted with rice and free from weed seedlings. This technique is now spread to other rice farms especially in Pasir Panjang, Sungai Leman and Sungai Burung since 2007/2008 season and at Sungai Nipah and Bagan Terap in 2008 season. Even though it is quite costly but through my random survey with the farmers, they can gain more rice production up to 8-12 ton per hectare by using this method.