Pilot Survey of Agri-Input Dealers in Battambang Province Cambodia



Figure 1. Input dealers were asked to indicate pesticide products most in demand by farmers

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Abstract

A Pilot Survey of agri-input dealers was carried out in Battambang province in July 2026. Previous surveys have shown that up to 80% of farmers in Battambang province rely on input dealers for advice on fertiliser and pesticide use in rice. It was also found that farmers were not following recommended practices for the type and timing of application of fertilisers. It was concluded that the source of incorrect advice might be the input dealers. The purpose of this pilot survey was to assess the quality of advice being provided by input dealers and if certification of agri-input dealers can assist in the delivery of correct advice on the use of agricultural chemicals to smallholder farming households in Cambodia. Thirty-four input dealers were included in the survey from seven districts in Battambang province: Aek Phnum; Banan; Battambang; Bavel; Koas Krala; Rukhak Kiri; and Sangkae. Agri-input dealerships were found to be primarily small to medium sized family businesses with an average of 94 regular customers and having an average of two sub-dealers. The average age of owner/managers was 38 years and ranged from 18 to 67 years old. Forty-six percent of owner/managers had completed upper secondary education, 21% lower-secondary, 18% primary and 15% had some type of tertiary qualification such as in business or financial management. According to input dealers, farmers were their primary source of information on choice of fertiliser and pesticide and dealers stocked the products that farmers asked for. There were 46 different company brands of fertiliser and 28 different combinations of N-P-K were used in rice. Ninety-three percent of input dealers suggested that urea (46-0-0) should be included in the first application to the rice crop whereas application of urea is not recommended at this time. Most pesticides were registered with the General Directorate of Agriculture (GDA) and less than 5% of labels were not in Khmer language. Although the Cambodian pesticide law includes a label template, few labels were found to be compliant. Many labels could be considered as not fit-for-purpose because of non-relevant comic-style pictures and incorrect pictures of insect pests. There were 43 active ingredients for insecticides, 27 for herbicides and 36 for fungicide/bactericides. However, in all cases, there appeared to be over-reliance on a narrow range of modes of action (MoA) with a consequent risk of evolution of pesticide resistance, especially in insect pests and weeds. Only 13% of labels displayed the resistance management mode of action (MoA) Group Codes. There were no extremely hazardous ingredients (WHO Class Ia) on display in the stores. However, the insecticide abamectin (WHO Class Ib) was on sale in all districts. Input dealers were asked how they would rate communication and training preferences. The most popular communication preferences were: smart phone apps; in-store posters; social media; chat groups; leaflets; in-store videos. Television and radio were ranked the least popular. When they were asked if they would consider attending a certificate course for agri-input dealers, 29 input dealers said yes and only four said no.

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Acknowledgement of institutional independence and use of findings

This pilot survey was conducted and documented by the ASR (Cambodia) as an independent research initiative, with financial support from the Nurture Project. The partner is responsible for the survey design and implementation, data collection and analysis, interpretation of results, and the findings and recommendations presented in this report. The findings reflect the partner's research and professional assessment and should not be interpreted as the official position or independently validated conclusions of the Nurture Project.

Nurture Project's financial support was intended to enable the partner to undertake the pilot survey and generate evidence to inform potential improvements in agricultural input advisory services for smallholder farmers. The report and its recommendations are intended to contribute to further technical discussion and consideration by relevant stakeholders.

The recommendations particularly those concerning pesticide labelling, agricultural input regulation, dealer certification, and digital advisory services, may require further technical assessment, consultation, and validation with relevant national government institutions, including the General Directorate of Agronomy (GDA) and other competent authorities. Such follow-up should take into account the recommendations and technical perspectives provided by the Provincial Department of Agriculture, Forestry and Fisheries (PDAFF) in Battambang as well as applicable national policies, regulations, and technical standards.

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Recommendations

1. Extend the survey of agri-input dealers, together with their most influential farmer customers, to represent the main rice producing provinces in Cambodia. This would provide the foundation field data to support the development of digital advisory applications for recommendations on fertiliser and pesticide use.
2. Existing mobile phone applications using QR codes or built-in scanners should be adapted to Cambodian conditions to deliver pesticide and fertiliser recommendations and verify product safety in Khmer language. Examples of existing applications include BSWM FertRight[1] for site-specific nutrient rates and Balinashak Sahayika[2] for pest identification and management.
3. QR codes should be adapted for Cambodian pesticide labels to provide instant digital access in Khmer language, to product safety data sheets, batch traceability numbers, manufacturing and expiry dates, and official usage instructions or instructional videos.
4. Provide technical assistance to the GDA to review all existing and proposed pesticide labels to ensure that labels comply with the approved label format and specifically to:
    - Remove comic-cartoon style illustrations which do not contribute to technical knowledge about the product;
    - Photos of the target pests are not specified in the Cambodian pesticide label format and should be deleted. Such information can be provided by accessing the QR Code;
    - Photos on the label are often misleading by depicting random images including those of beneficial organisms that should be preserved;
    - Include the resistance management mode of action (MoA) Group/s as specified on the Cambodian label template.
5. Encourage MAFF to make available the current "real-time" registration status of fertilisers and pesticides on-line.

[1] https://www.bswm.da.gov.ph/bswm-helps/
[2] https://play.google.com/store/apps/details?id=com.khan.pesticide_assistance&hl=km

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Introduction

The green revolution was an initiative to apply modern science to address an evolving food crisis in Asia in the 1960s (Hazel, 2009). The speed and scale with which it solved the food problem was unprecedented and it contributed to a substantial reduction in poverty and enabled broader economic growth in many Asian countries. Improved cereal varieties, fertilisers, irrigation, and modern pest control methods were the foundation of the green revolution. It also required a supporting economic and policy environment. Even with the success of the green revolution, there are remaining social and environmental problems that need to be resolved and a continuing need to increase yields to meet Asia's growing food needs.

On the negative side, intensive monocropping of rice has caused degradation of the paddy micro environment and reductions in rice yield in many irrigated areas in Asia (Pingali and Rosegrant, 1994). Problems include increased pest outbreaks, mining of soil nutrients, reductions in nutrient-carrying capacity of the soil and reduction in soil physical and chemical quality. Emerging sustainability problems in intensive rice cultivation show the need for a greater understanding of the physical, biological and ecological consequences of agricultural intensification and greater research attention to long-term management of the agricultural resource base.

The green revolution is regarded as extending from 1966 to 1992 followed by a post-green revolution from 1993. Cambodia largely missed out on the green revolution as a result of social disruption and physical destruction that occurred as the Vietnam War spilled across the border. Cambodia was bombed relentlessly by the US between 1969 and 1973 and during that period, an estimated half a million tonnes of munitions were dropped on Cambodia (Denning, 2023). Prior to the US-backed Lon Nol regime (1970 to 1975), the area planted to rice in Cambodia was around 2.2 million hectares with an average yield of 1,153 kg/ha. The Lon Nol regime drew Cambodia into the Vietnam war and the area of rice declined to 0.555 million hectares during this period. Cambodia's rice production was 3.8 million tonnes in 1970 and it wasn't until 1999 that production had recovered to the 1970 level. Since 1999, the area of rice has steadily increased to 3.897 million ha with an average yield of 3,644 kg/ha and total production of 14.2 million tonnes in 2024 (FAO, 2026a) (Figure 2).

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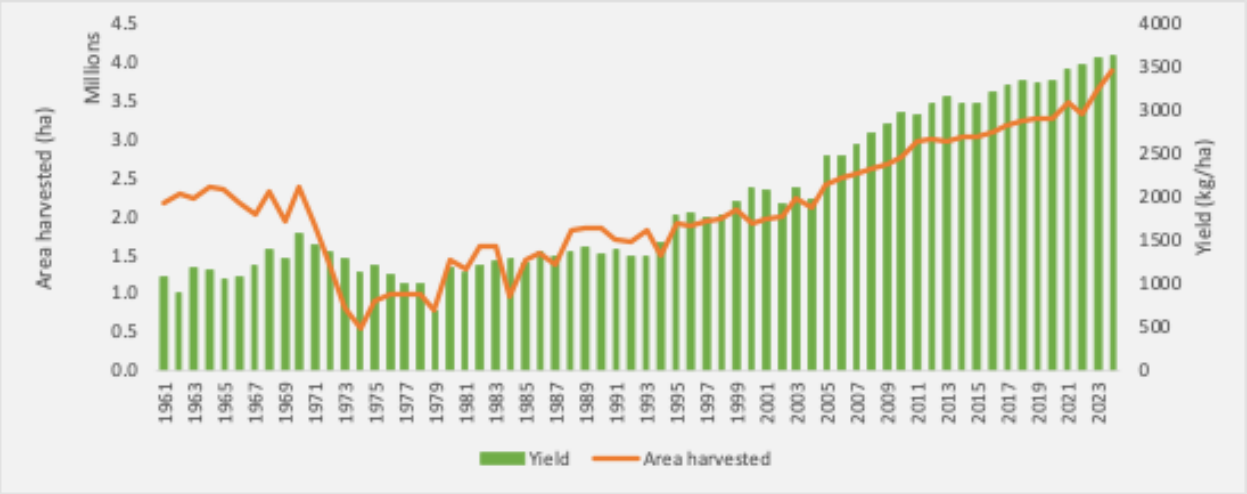


Figure 2. Trend in area harvested and yield of rice in Cambodia from 1961 to 2024 (FAO, 2026a)

The share of Cambodia's agriculture sector of gross domestic product (GDP) has decreased from 33.9 percent to 20.8 percent within the past 10 years and crop production now represents 59% of total agricultural production (Anon., 2023). The share of agricultural labour in total employment dropped from 54% in 2010 to 35% in 2020 and is forecast to decrease to around 23 to 25% by 2030. This decrease in the availability of labour has contributed to the relentless increase in the mechanisation of agricultural production in Cambodia (Chhun et al., 2015). For example, in Kampong Chhnang province, 2-wheel tractors began to replace draught animals for rice cultivation in 2010 and this was followed by the increased use of 4-wheel tractors from 2015 (Figure 3) (Kimkong et al., 2023). At the beginning of the 12 year period, 97% of farmers were using draught animals for cultivation of rice and at the end of the period, 97% of farmers rere relying on tractors for rice cultivation.

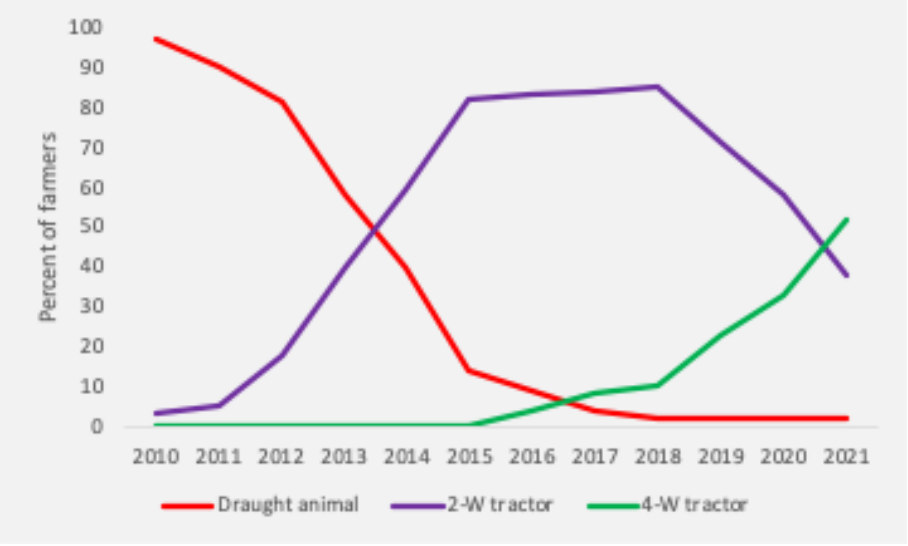


Figure 3. Transition from draught animal to tractors for rice cultivation in Kampong Chhnang province, redrawn from Kimkong et al. (2023)

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Use of chemical fertilisers in rice

In 2023, Cambodia imported 139,830 tonnes of fertiliser nitrogen (N); 59,153 tonnes of phosphorus (P_2O_5); and 11,516 tonnes of potassium (K_2O) (FAO, 2026b). Phosphorus imports began to increase in the year 2000 but imports of nitrogen only began to increase rapidly in 2010 and overtook P imports at that time. In contrast, imports of potassium have increased gradually. By 2023, nitrogen accounted for 66%, phosphorus 28% and potassium 5% of imports.

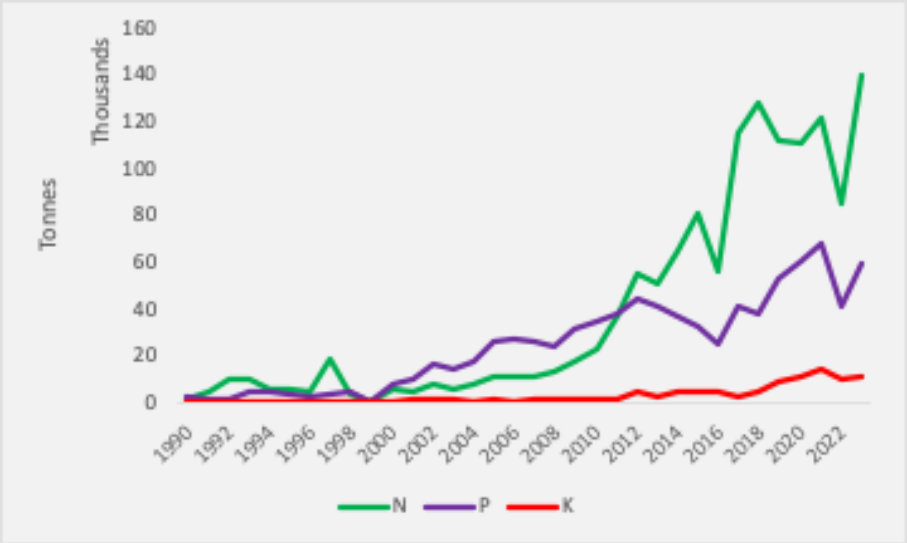


Figure 4. Trend in imports of fertiliser nutrients (N, P_2O_5, K_2O) into Cambodia between 1990 and 2023 (FAO, 2026b)

In the 1990s, some form of fertiliser was applied by more than 80% of rice farmers in Cambodia. All fertilisers were applied manually. Farmyard manure was transported in animal-drawn carts during the dry season and dumped in strategic piles in the fields. Spreading of manure was done by water movement and during land preparation. Inorganic fertilisers were hand-broadcast and, where necessary, incorporated by harrowing. Complete fertilisers were usually incorporated while urea was topdressed (Rickman et al., 1997).

Most lowland rice in Battambang province is grown on soils of the Toul Samroung soil group (White et al., 1997) and the recommended fertiliser application for rice on this soil group is 86-13-8 (N-P-K) kg/ha (Blair and Blair, 2014). Chhun et al. (2020) found that 95% of rice farmers in Battambang province used fertiliser on rice in the wet season. Urea (82%) was the most commonly used fertiliser, followed by di-ammonium phosphate (DAP, 52%), ammonium phosphate (27%), N:P:K fertilisers (12%), and muriate of potash (8%). The average fertiliser applied in the wet season was 44-11-4 (N-P-K) kg/ha. However, the 90th percentile of farmers applied 88-22-5 (N-P-K) kg/ha which is comparable with the recommendation for the Toul Samroung soil group (Blair and Blair, 2014).

According to the International Rice Research Institute (IRRI), for direct seeded rice crops, the first fertiliser application should be 10–14 days after crop establishment when there is water in the field (IRRI, 2015). At this stage, all P, K, and 10% of N should be applied. The balance of N

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(urea) should be applied in two equal portions at 30 days (late tillering) and 50–60 days after emergence (panicle initiation). Alternatively, NurulNahar et al. (2025) recommended application of 20% of N at topdressing at the 3-leaf stage, 30% at active tillering and 50% at panicle initiation to obtain the best balance between crop demand, uptake efficiency and minimisation of environmental degradation.

The average yield of rice in Cambodia in 2024 was 3.64 t/ha produced over 3,897,096 ha (FAO, 2026c). In a survey of 100 households, Chhun et al. (2020) found that the average paddy yield in Battambang province was 3,300 kg/ha in 2017 with the 10th decile being 2,500 kg/ha and the 90th decile being 4,600 kg/ha. However, the experimental yield potential of Cambodian short-duration rice varieties is 6,000 kg/ha or more (Men et al., 2001).

Crop yield gaps are defined as the difference between a "potential yield" or a "water-limited potential yield" and the "farm yield" over a specified time and location of interest (Stuart et al., 2016). "Farm yield" (FY), or "actual yield", is the mean yield achieved by farmers in a given location. This calculation has been done for 100 farms in four communes in Battambang province (Chhun et al., 2020). "Potential yield" (PY) is the yield of a crop grown in environments to which it is adapted with non-limiting water and nutrient conditions, and effective control of biotic stresses. Following this definition, PY in rice-based systems can be estimated using field experiments and this is called the "experimental potential yield". For example, the Cambodian short-duration variety Chul'sa has an experimental potential yield of 6.0 t/ha and the medium-duration photoperiod sensitive varieties such as Phka Rumduol, 5,500 kg/ha (Men et al., 2001).

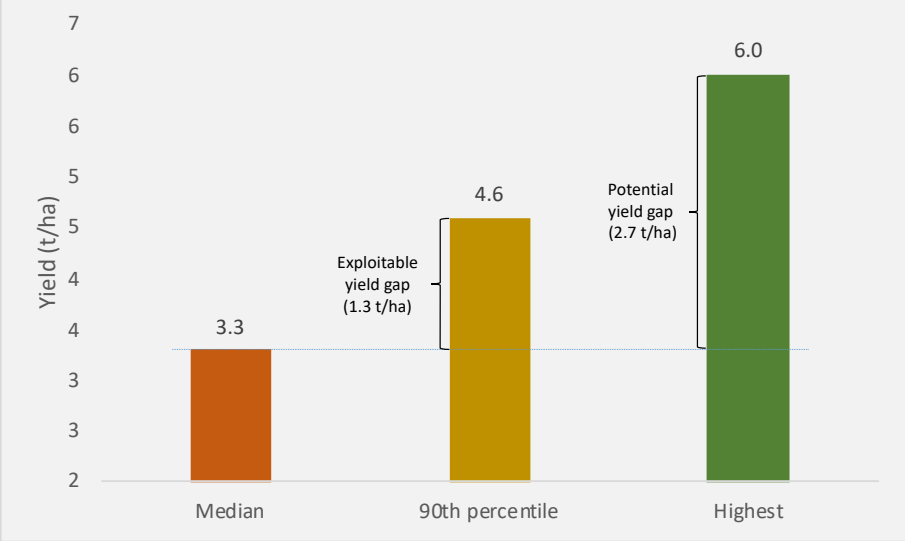


Figure 5. The exploitable yield gap for rice in Battambang province

If the exploitable yield gap of 40% were to be closed, an additional 5.7 million tonnes of rice could be produced Nationally. Assuming a conservative price of $150/t, the potential exists for rice farmers to produce an additional gross income of $852 million at the National level. On-farm demonstrations in Battambang province show that correct application rate and timing of N topdressing would contribute substantially to closing the exploitable yield gap for rice.

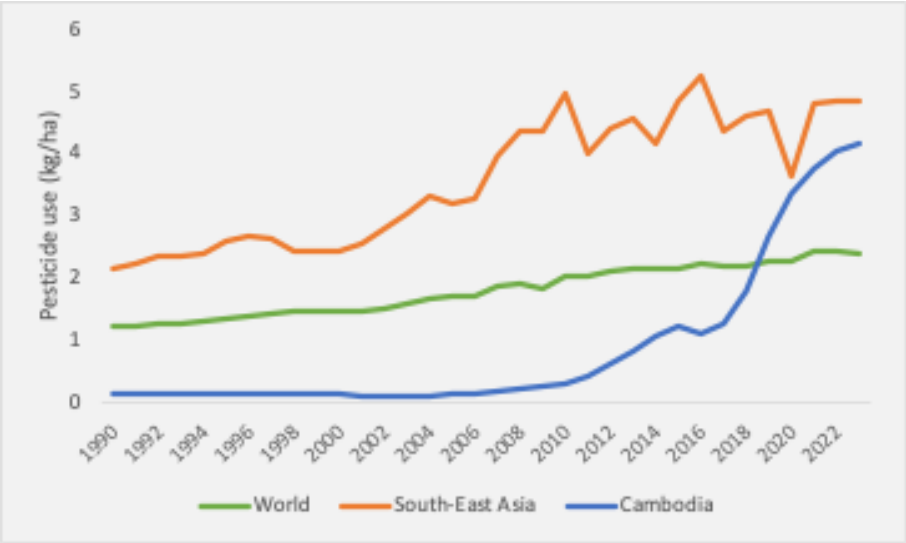
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Smallholder rice farmers in Battambang province risk continued loss of money from mis-application of fertiliser unless a way is found to convince input sellers and service providers that they will benefit financially as well as farmers from the adoption of correct fertiliser application techniques. Further effort is required to determine how correct fertiliser practices for rice can be adopted.

Use of pesticides in rice

In the 1990s, insecticides and rodenticides were the most commonly used pesticides in Cambodia while herbicides were used in some provinces (Jahn et al., 1997). Of those farmers using pesticides, 69-100% used insecticides but fungicide use was extremely rare. About 40-100% of dry season farmers and 8-50% of wet season farmers used pesticides. At the time, about 30 different insecticides were available in Cambodia. The most commonly used insecticides used in rice at that time were in the WHO hazard class I (WHO, 2020). In most provinces, methyl parathion was the most common pesticide used. These insecticides are no longer registered for use in Cambodia and a pocket guide for inspectors on banned and restricted pesticides was developed by the project of Capacity Building for Quality Standard Control of Agricultural Materials (Chemical fertilizers and Pesticides) " QCAM/JICA-MAFF " of Japan International Cooperation Agency (JICA) and the Ministry of Agriculture, Forestry and Fisheries (MAFF) (QCAM, 2020).

Pesticide use in Cambodia lagged behind South East Asia (SEA) until pesticide imports began to increase rapidly after 2016 when Cambodia used 1.1 kg/ha compared with 5.2 kg/ha for SEA. By 2023, pesticide use in Cambodia rose above the global average and reached 4.2 kg/ha compared with 4.8 kg/ha for SEA (FAO, 2026d). Despite the dramatic increase in pesticide use in Cambodia, there has been a lack of evidence of refinement of government regulation or extension to help ensure the safe and efficaceous use of pesticides in the face of the increased usage (Figure 6). As a consequence, smallholder farmers appear to have come to depend on village agri-input dealers for detailed advice on the use of fertilisers and pesticides in the absence of government extension services.



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Figure 6. Trend in pesticide use in Cambodia compared with South-East Asia and the World

As with many developing countries, agri-input dealers in Cambodia appear to be the primary source of advice on fertilisers and pesticides at the village level. However, agri-input dealers tend to have a limited understanding of agronomy, plant nutrition, chemical fertilisers or how they can be used most effectively (Bureau-Point et al., 2024).

In Cambodia, the law on the Management of Pesticide and Fertiliser was proclaimed in 2012 to control the use and trade of pesticides and fertilisers (MAFF, 2012). The Ministry of Agriculture, Forestry and Fisheries (MAFF) became responsible for the management of pesticides and fertilisers through the Department of Agricultural Legislation (DAL) up until June 2023 when regulation of agricultural inputs was transferred to the General Directorate of Agriculture (GDA). GDA is now also responsible for training of agri-input dealers at the district department of agriculture office level and this training is mandatory to get a licence certificate for their businesses, valid for three years. This training is focussed on compliance with the legislation and does not include how to use agricultural chemicals effectively and safely.

In developed countries such as Australia, State Departments of Agriculture had historically been the major providers of production-oriented agricultural advisory services up until the 1990s. However government funding for agricultural advisory services began to decline in the 1990s and State agencies maintained their research programs but the private sector began to take on the role of agricultural advisory service providers (Marsh and Pannell, 2000). In addition to having a sales merchandising team, agri-business companies in Australia began to employ specialist agronomists who combined trial work with the provision of advice to individual farmers, often, but not always, linked to merchandise sales. Companies producing and distributing agricultural chemicals also had large merchandising teams and often involved in on-farm trial work when developing new products.

In most developing countries, agricultural “extension” services were envisioned but not delivered in the period following the “green revolution” of the 1960s. As a consequence, agri-input dealers have become defacto agricultural advisory providers to smallholder farmers at the village level in most developing countries. There is an opportunity to build institutional mechanisms to empower agri-input dealers as credible advisors but this idea has been slow to get traction. In some developing countries, governments have begun to appreciate the capacity of agri-input dealers to transfer technology to farmers at the village level. For example, in Uganda, the training and certification of agri-input dealers has been recognised as a means of delivery of research-based advice to smallholder farmers (Tambo et al., 2024). The Department of Agricultural Extension (DAE) within the Ministry of Agriculture, Forestry and Fisheries (MAFF) was established in 1995 with the mandate of developing a demand-driven, district-implemented, provincially-managed and centrally-overseen “extension” system intended to be decentralised at provincial level through provincial departments of agriculture and implemented through District Agriculture Offices (DAOs) and field “extension” agents (Soeun, 2012).

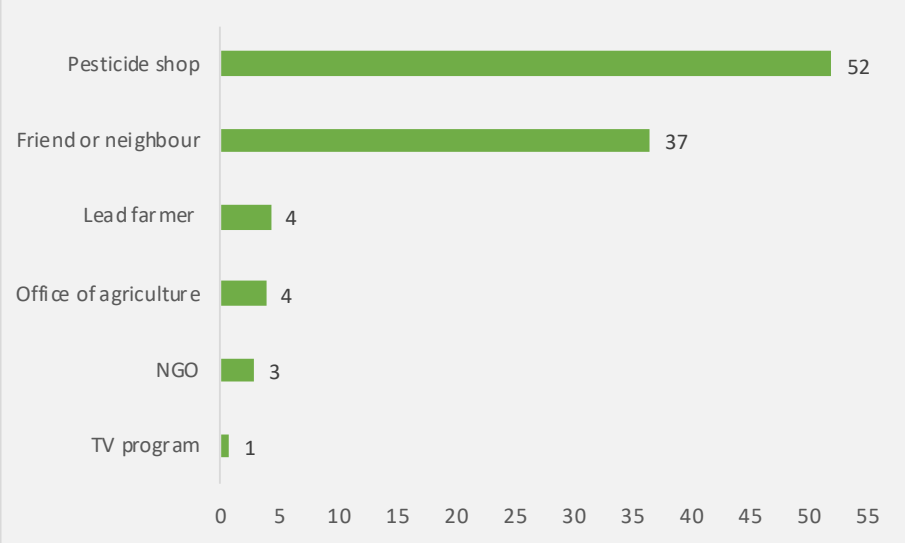
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Although Cambodia's "extension system" exists, limited resources are available to provide an "extension service" at the district level and "field extension agents" are not in evidence at the local village level. Extension materials for rice are mentioned for topics such as soil management, variety selection, crop diversification, post-harvest management but not on the safe and efficacious use of agricultural chemicals such as fertiliser and pesticides. There is no evidence of these "extension materials" being accessible to input dealers or farmers in any format.

Cambodian rice farmers get their advice on agricultural chemicals primarily from the supply chain for products (Martin et al., 2021). Therefore, it is not "extension agents" but pesticide sellers whom farmers interact with the most for pest management recommendations. Sellers especially those living within the villages were the most accessible to farmers for direct consultation regarding pest management. Input dealers varied widely in their knowledge of agricultural chemicals.

Advisory staff from pesticide companies help input dealers when they cannot answer farmers' questions. Company agents also establish technology in on-farm demonstrations. Demonstration farmers test the product and share the knowledge about it to other farmers. Private advisors also go to see the field, talk with farmers and give recommendations. It therefore follows that the sellers of inputs, distributors and importers should be engaged to ensure delivery of correct information on use of agricultural chemicals for rice in Cambodia.

Martin et al., 2021) found that there were significant differences between communes for use of herbicides and it is postulated that these differences might be traced to different advice being given by individual agri-input dealers within these communes. This expectation is based on the sources of advice sought by the households for the use of herbicides which showed agri-input dealers were the main source of advice outside the farm household. This is consistent with the findings of Chem (2023) where 89% of decisions on pesticide use are based on advice from the pesticide shop, friend or neighbour (Figure 7).



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Figure 7. Sources of information for pest and disease control (redrawn from Chem, 2023).

The purpose of this pilot survey is to determine if certification of agri-input dealers can assist in the delivery of correct advice on the use of agricultural chemicals to smallholder farming households in Cambodia. Objectives:

1. Describe the nature of agri-input dealerships in terms of management, products sold and scale of operation;
2. Document the level of education of agri-input dealers and their level of technical knowledge of the agricultural chemical products they sell and advise on;
3. Design and produce posters and leaflets for display in-store to explain the savings possible from application of correct fertiliser combinations to rice;
4. Determine the potential for the establishment of a certificate course for agri-input dealers to ensure their advice is consistent with scientific knowledge and government recommendations.

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Method

A total of 34 input dealers were interviewed in seven districts of Battambang province (Table 1): Aek Phnum (2); Banan (4); Battambang (6); Bavel (5); Koas Krala (5); Rukhak Kiri (6); and Sangkae (6). Input dealers were mostly selected at random or chosen from a list provided by Nurture. The dealers selected were in areas with access to scheme irrigation as well as areas with no access to irrigation such as parts of Sangkae and Rukhak Kiri districts (Figure 8).

Table 1. Location of input shops included in the study

Shop No.	District	Latitude (N)	Longitude (E)
1	Battambang	13.105520	103.192854
2	Battambang	13.110311	103.175627
3	Battambang		Declined interview
4	Battambang	13.105339	103.192866
5	Banan	13.113220	103.029273
6	Banan	13.084161	103.001135
7	Banan	13.029418	103.100747
8	Banan	13.027902	103.093558
9	Battambang	13.057953	103.148379
10	Battambang	13.061657	103.148049
11	Battambang	13.066479	103.144844
12	Sangkae	13.084476	103.274437
13	Sangkae	13.093072	103.280849
14	Sangkae	12.936360	103.317830
15	Sangkae	12.928486	103.253673
16	Sangkae	12.922303	103.281022
17	Aek Phnum	13.155548	103.225369
18	Aek Phnum	13.170536	103.238543
19	Koas Krala	12.864168	103.285351
20	Koas Krala	12.864168	103.285351
21	Koas Krala	12.864168	103.285351
22	Koas Krala	12.809746	103.263716
23	Sangkae	12.939044	103.353513
24	Rukhak Kiri	12.752686	103.434050
25	Rukhak Kiri	12.644303	103.389050
26	Rukhak Kiri	12.601289	103.490866
27	Rukhak Kiri	12.602623	103.491089
28	Rukhak Kiri	12.580555	103.455588
29	Rukhak Kiri	12.582234	103.455579
30	Bavel	13.317750	102.865528
31	Bavel	13.252955	102.875176
32	Bavel	13.253789	102.875761
33	Bavel	13.185981	102.835054
34	Bavel	13.317741	102.865526

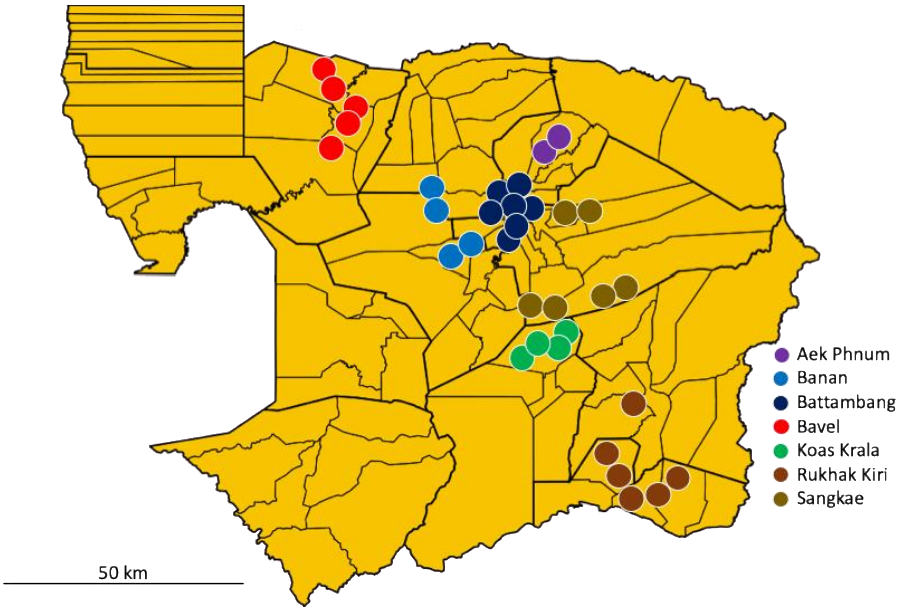


Figure 8. Appoximate location of input shops in the seven districts included in the study

The purpose of the survey was explained to the store owner/manager and they were asked if they would agree to participate. Details of questions asked are as follows:

1. General information on business: name; phone number; name of business owner; respondent details (name, responsibility, age, gender); number of staff (male and female); number of regular customers; and number of sub-dealers.
2. Level of education of the Owner/Manager.
3. Description of business and year commenced trading.
4. Inputs sold (% of input selling income): animal feed; fertilisers; fungicides; hand tools; herbicides; insecticides; PPE; seeds; spray machines; veterinary products etc.
5. Interviewees were asked to provide additional details about their business: member of association; current licence with GDA; aware of IPM; sell IPM products; aware of biopesticides; sell biopesticide; sell hazardous products; know people poisoned by pesticide.
6. Types of training received relevant to the business during the past five years: name of training; provider; date; duration (days); relevance - (low, medium, high).
7. Source of inputs purchased (%): input dealer in Battambang; order from Phnom Penh; import from Vietnam; distributor comes to shop; chemical company; online.
8. Provision of advice on agricultural chemicals to farmers: which product to use; time of application; rate of application.
9. Sources of information on the use of agri-chemicals: agricultural cooperative; commune agriculture officer; chemical company; product distributor; NGO; farmers; government; internet; other input dealer; radio; label; social media; television.
10. Types, price and amounts of fertiliser sold. Which fertilisers are recommended for application during rice growth stages: first; second, third etc.
11. What herbicides are sold for use in rice at the shop and what are the prices?

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12. What insecticides are sold for use in rice at the shop and what are the prices?
13. What fungicide/bactericides are sold for use in rice at the shop and what are the prices?
14. Have you received technical support from PDAFF, UNIFI, EWS-KT, other? If “yes”, do you intend to continue to disseminate technical knowledge and practices to farmers?
15. What would motivate or encourage you to continue providing technical advice and support to farmers? Increased sales or financial incentive or business opportunities; Improved relationships with farmers; Recognition from the community or local authorities; Technical support from experts or project staff; Additional training or refresher courses needed; Demonstration materials or extension tools supported.
16. How would you rate the following communication and training methods as priorities for you and/or your farmer customers for rice production? One-on-one training for staff at the shop; Posters for display in shop; Videos for display in shop; Leaflets for hand-out in shop; Smart phone apps; social media: Facebook, TikTok etc; Chat groups - Telegram groups; Radio; Television.
17. Would you consider attending a certificate course for agri-input dealers?

Results and discussion

Business profile of input stores

Agri-input dealerships in Battambang province were found to be primarily small to medium sized family businesses with an average of 94 regular customers and having an average of two sub-dealers. The average age of owner-managers was 38 years and ranged from 18 to 67 years old. Forty-six percent of owner/managers had completed upper secondary education, 21% lower-secondary, 18% primary and 15% had some type of tertiary qualification such as in business or financial management (Figure 9).

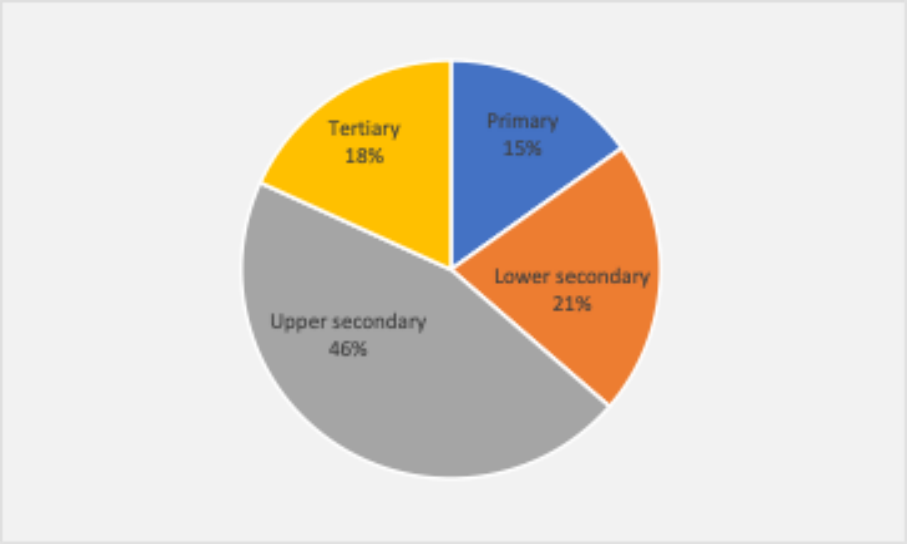


Figure 9. Level of education of the owner/manager

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The average number of years stores had been in business was seven with one business having been operating for 36 years. In addition to fertiliser and pesticide, somes stores sold seeds (11), spray machines (10), hand tools (8), animal feed (7), personal protective equipment (PPE) (4), veterinary products (1). It is important to note that only four dealers sold PPE.

Forty-six percent of dealers said they sold hazardous products (presumably referring to pesticides) (Figure 10). Although, 29% of dealers claimed to be aware of biopesticides and 21% claimed to be aware pf IPM, no relevant products were observed in any of the stores visited.

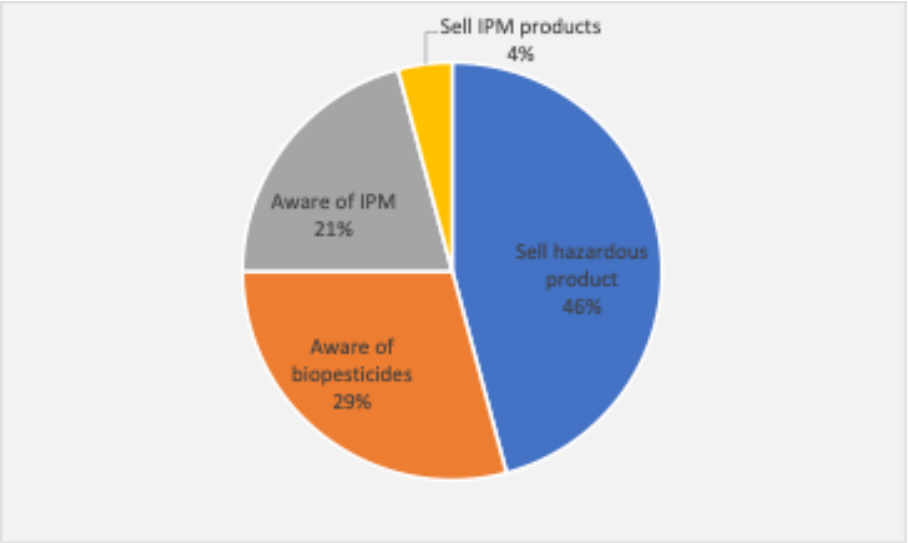


Figure 10. Availability of biological and IPM products

Sources of information

Input dealers were asked about where they sourced information on the use of agricultural chemicals. The sources included: farmers; Agricultural Cooperatives (ACs); other input dealers; Commune Agriculture Officers (CAOs); Internet; product label; chemical company; distributor; radio; social media; Non Governmental Organisation (NGO); Government Officer; and Television (Figure 11). All dealers mentioned farmers as a source of information on agricultural chemicals. Most dealers mentioned that they stocked products in accordance with farmer demand. NGO, Government Officer and Television were not mentioned. Only two dealers mentioned the pesticide label as a source of information.

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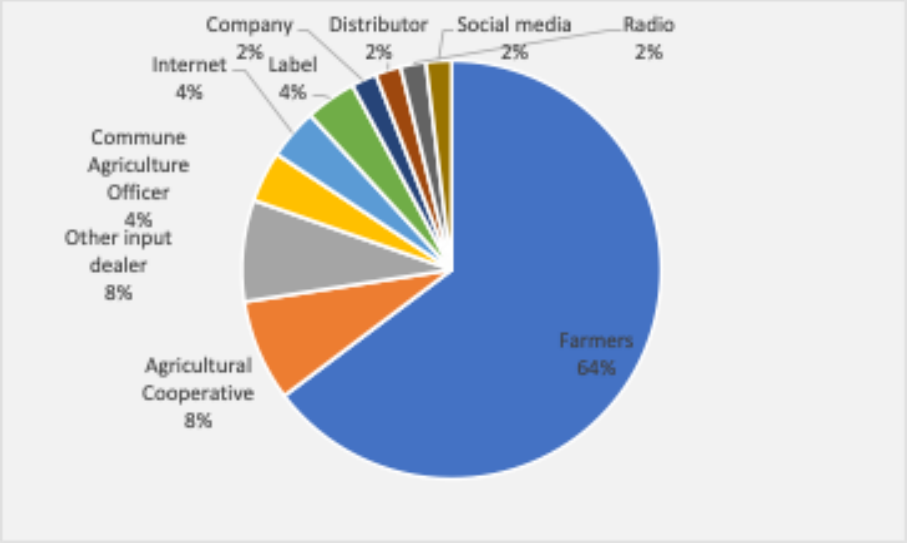


Figure 11. Sources of information on the use of agricultural chemicals

Fertiliser advice provided to farmers by dealers

The timing of fertiliser applications should be in accordance with growth requirements of the rice plant (Moldenhauer and Slaton, 2001). Phosphorous (P) is an essential plant nutrient especially important for root development and tillering and potassium (K) is an essential plant nutrient that improves root growth and plant vigour. Therefore, it is important to apply P and K as basal fertiiser. Rice takes up little nitrogen (N) until tillering and most N is taken up between tillering and flowering (IRRI, 2026). Therefore, urea (N) should be applied at tillering and up to panicle initiation for maximum nitrogen-uptake efficiency (Figure 12). Urea N applied before tillering is at risk of loss from leaching.

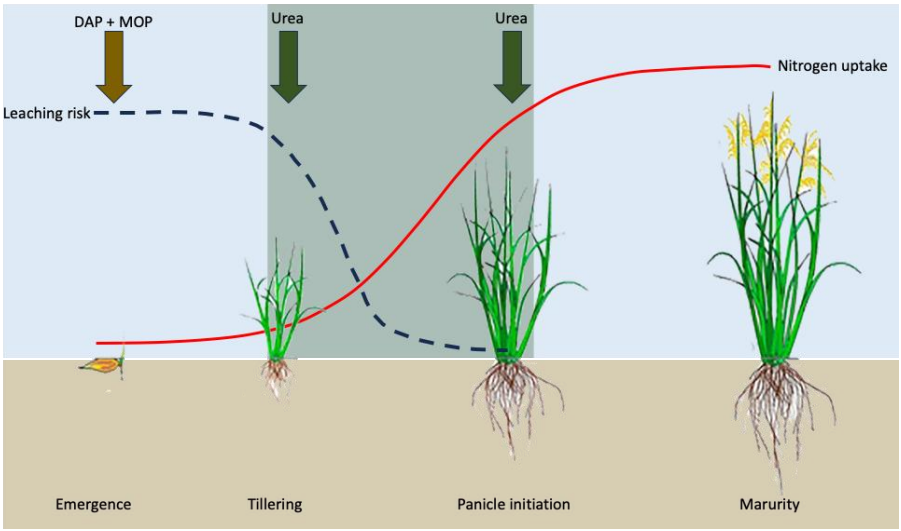


Figure 12. Recommended type and timing of fertiliser application during the rice crop growth cycle

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According to the International Rice Research Institute (IRRI, 2015), for direct seeded rice crops, the first fertiliser application should be 10–14 days after crop establishment when there is water in the field. At this time, all P, K, and 10% of N should be applied. The balance of N (urea) should be applied in two equal portions at 30 days (late tillering) and 50–60 days after emergence (panicle initiation) (IRRI, 2015). Alternatively, NurulNahar et al. (2025) recommended application of 20% of N at topdressing at the 3-leaf stage, 30% at active tillering and 50% at panicle initiation to obtain the best balance between crop demand, uptake efficiency and minimisation of environmental degradation.

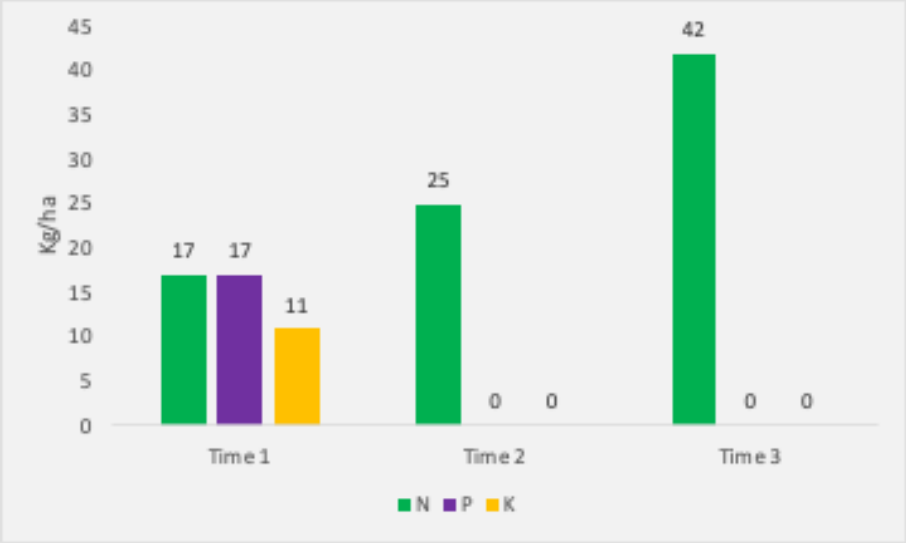


Figure 13. Recommended fertiliser rate and timing for direct-seeded rice

Forty-six company brands of fertiliser were found in the input stores included in the survey. According to input dealers, 28 different combinations of N-P-K were used in rice. The six most commonly recommended fertilisers by dealers were: urea (46-0-0); DAP (18-46-0); 27-12-6; 20-20-15; 20-8-20; and MoP (0-0-60). The application timing advice for the fertilisers was not consistent with scientific recommendations for rice (Figure 14):

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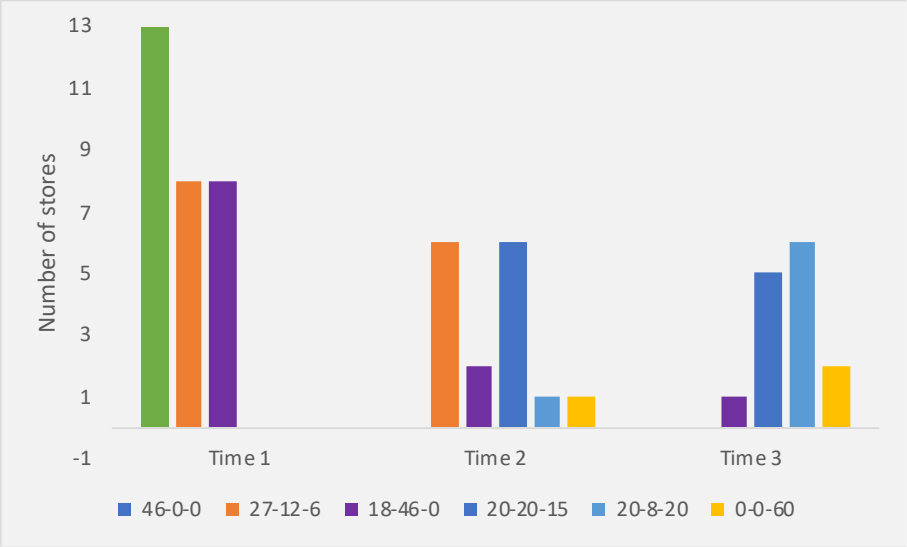


Figure 14. Input dealer recommendations for fertiliser application in rice

Based on the results of the survey and supported by agricultural research carried out in Cambodia, the dealer recommendations show a strong emphasis to applying complete fertilisers (like 20-20-15, 16-16-16) at all three timings, which contrasts with accepted scientific recommendations that advocate for a split-application strategy focused on specific nutrients at each growth stage (Kong et al., 2020). The choice and timing of N-P-K fertiliser combinations recommended by dealers was not consistent with the "accepted" scientific approach to rice fertilisation (Table 2).

Table 2. Dealer recommendation for application timing of fertiliser N-P-K compared with the accepted scientific recommendation

Aplication timing	Accepted scientific recommendation	Dealer recommendation
Sowing/basal	Focus on Phosphorus (P) and Potassium (K) for root and early plant development. Use DAP and MoP fertilisers at modest rates.	Dealers stock complete fertilisers like 16-16-16, 20-20-15, and 15-15-15, which fits the common practice of applying a balanced "starter" fertiliser.
Tillering	Primary focus on Nitrogen (N) to promote tillering and plant vigour. Urea (46-0-0) is common. Application rate is often based on the crop's appearance (e.g., leaf colour).	Dealers heavily promote complete fertilisers like 20-20-15 and 16-16-16 at this stage, which may supply unnecessary P and K.
Panicle initiation	Primarily Nitrogen (N), with some Potassium (K) is applied if needed. This final N top-dressing supports grain formation and filling.	Most dealers promote complete fertilisers for application at panicle initiation which supply unnecessary P and K and insufficient N.

Convenience vs. precision: the dealer recommendations lean toward selling complete fertilisers (e.g., 20-20-15, 15-5-15) at all three timings. While this is a "one-stop-shop" solution, it leads to applying Phosphorus (P) and Potassium (K) when the rice plant doesn't need them, wasting money and potentially harming the environment.

Accepted practice is nuanced: scientifically sound nutrient management for rice in Cambodia is a split-application strategy. This approach provides the right nutrient in the right amount at the right time. For example, a soil-specific recommendation for a common sandy soil (Prateah Lang)

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might be modest total rates of 40-60 kg N/ha, 23-29 kg P_2O_5/ha, and 20-30 kg K_2O/ha, all split across the three timings.

Dealers as a source of information: The data reflect that dealers are a primary point of contact for farmers. Their recommendations, while convenient, may not always align with the most efficient or cost-effective nutrient management strategy.

The fertiliser dataset is a powerful snapshot of the agricultural supply market in Battambang province. It reveals a market oriented towards selling complete fertiliser blends, which offers convenience but may not be scientifically optimal. In contrast, accepted agronomic science strongly supports a split-application method—using a balanced fertiliser at sowing and focusing primarily on nitrogen top-dressings at tillering and panicle initiation to maximise yield and economic return.

Prices of fertilisers ranged from $0.70/kg for 0-0-60, $0.80 for 46-0-0 to $0.82/kg for 18-46-0. The rice crop requires nitrogen (N) during active growth (application times two and three). Application of fertilisers with lower amounts of N compared with urea at times two and three comes at a cost. The cost of 100 kg urea (46 kg N) is $174. Topdressing with 27-12-6 to give the same amount of N as urea is $289 and is up to $456 for DAP (Table 3).

Table 3. Cost per unit of N for different fertilisers compared with urea

Fertiliser	N%	Price/kg	Cost/46 kg N
DAP	18	0.82	$456
20-8-20	20	0.82	$410
20-20-15	20	0.74	$370
27-12-6	27	0.78	$289
Urea	46	0.80	$174

Application of fertilisers with low N content at tillering and panicle emergence are not only more expensive than urea but are not likely to achieve the expected yield response.

Pesticides use in Battambang province

Farmers in Battambang province are faced with a range of pests of rice including weeds, plant diseases, insects, snails, crabs and rodents. According to farmers, the order of importance of pests in the province are shown in Figure 15 (Flor et al., 2020).

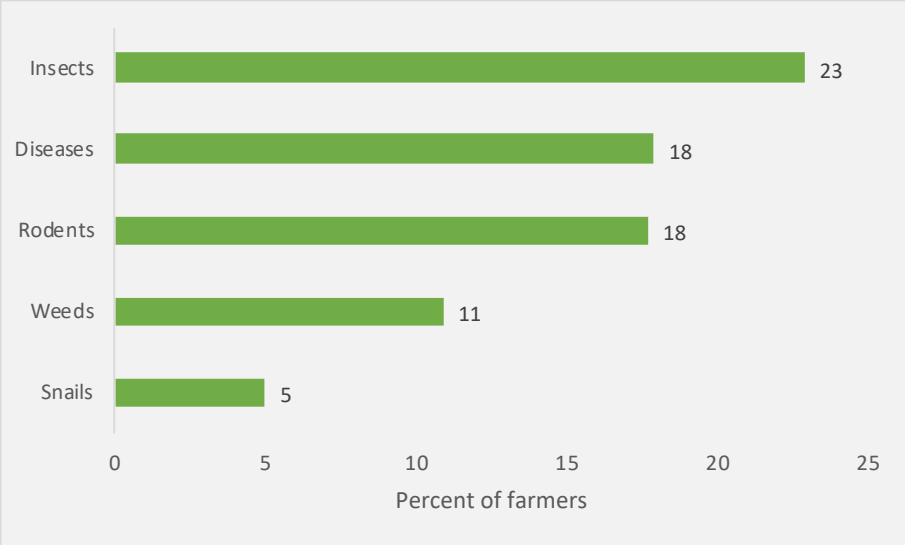


Figure 15. The main pests of rice in Battambang province according to rice farmers

Insecticides used and implications for insect pest management in rice

Flor et al. (2020) collected data on pest management practices of farmers in a 2016 survey of rice production practices in Cambodia. The survey included 80 farmers in Battambang province. According to farmers, rice stem borer (*Chilo suppressalis, Scirpophaga incertulas*) and rice leaffolder (*Cnaphalocrocis medinalis*) were responsible for the greatest economic damage to rice production (Table 4).

Table 4. Insect pests identified by farmers as causing damage to rice in Battambang province (Flor et al., 2020)

Common name	*Scientific name*	Farmers (%)
Rice stem borers	*Chilo suppressalis, Scirpophaga incertulas*	47
Rice leaffolder	*Cnaphalocrocis medinalis*	25
Brown planthopper	*Nilaparvata lugens*	14
Rice bug	*Leptocorisa oratorius, Leptocorisa acuta*	1

In our survey of 34 input dealers, the insecticides most often recommended for rice were abamectin (26) and alpha cypermethrin (21). It should be noted that abamectin is used to control golden apple snails (*Pomacea* spp.) as well as insect pests and that alpha cypermethrin is used to contol rice field crabs (*Somanniathelphusa* spp.) as well as insect pests.

Dealers stock a wide and diverse range of insecticide products. This indicates that the recommendations farmers receive might not be uniform. Dealers appear to offer a broad selection but most dealers claim they stock products as per farmer-demand. Insecticide products on sale include:

- Products with single active ingredients include abamectin, acetamiprid, chlorfenapyr, fipronil, indoxacarb, lufenuron, permethrin, profenofos, sulfoxaflor and thiamethoxam.
- The majority of the insecticide products sold are combinations of two or three active ingredients, such as:

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- abamectin + spirotetramat;
- beta-cypermethrin + profenofos + thiamethoxam;
- chlorantraniliprole + emamectin-benzoate;
- chlorfenapyr + indoxacarb + thiamethoxam;
- emamectin-benzoate + cypermethrin;
- profenofos + lambda-cyhalothrin;
- thiamethoxam + lambda-cyhalothrin.

The product availability, and thus the implicit "recommendations," differ geographically. While many products are widespread, the data reveal specific patterns. For example:

- Widely available products: Some products like abamectin and alpha cypermethrin are stocked by dealers in multiple districts (Battambang, Banan, Sangkae, Koas Krala, Moung Roussey, Rukhak Kiri, Bavel).
- Products with regional patterns: The pre-mix chlorantraniliprole + emamectin-benzoate appears mainly in the eastern districts of Sangkae and Aek Phnum, but not in Bavel or Banan.
- Products appearing in specific locations: beta-cypermethrin + profenofos + thiamethoxam is recorded only in the village of "Robas Mongkol" in the Moung Roussey district. methoxyfenozide is recorded in the "Bavel Muoy" and "Prey Tralach" villages, but not elsewhere.

This patchwork of product availability suggests that the mix of products stocked by local dealers can vary significantly from one village to the next, even within the same commune. Varying demands of farmers might be a causal factor.

The observed pattern of product diversity, combined with the known practices of Cambodian farmers, presents a high risk for the development of insecticide resistance. Here's a breakdown of the implications:

1. Heavy reliance on chemical controls: Studies show that Cambodian rice farmers consider insecticides indispensable and often rely on them exclusively for pest management (Flor et al., 2020). This high selection pressure is the primary driver of resistance.
2. Tank-mixing creates high selection pressure: It's common for farmers to mix multiple insecticides in a single application to control multiple pests (Bureau-Point et al., 2024). For instance, a farmer might combine a product for stem borers with one for planthoppers. This practice exposes pest populations to several active ingredients at once, dramatically increasing the selection pressure for multi-resistant individuals.
3. Diverse product availability does not mean diverse MoA: While the number of products is large, they may belong to a limited number of MoA groups. For example, many products are pyrethroids (Group 3A) or organophosphates (Group 1B) . If a dealer recommends a pre-mix containing two pyrethroids, and a farmer tanks-mixes it with another pyrethroid from a different dealer, they are using overlapping MoAs, accelerating resistance without gaining extra control.

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4. Risk of cross-resistance: Some active ingredients share resistance mechanisms. For example, research indicates that the novel MoA Group 4C (sulfoxaflor) is not cross-resistant to neonicotinoids (Group 4A), making it valuable . However, if a dealer recommends both a neonicotinoid and sulfoxaflor as interchangeable options, it can still contribute to resistance if not managed carefully.
5. A "lock-in" situation: The combination of farmer reliance, dealer influence, and the availability of many products, often with overlapping MoAs, creates a "pesticide lock-in" (Flor et al., 2020). This makes it difficult for individual farmers to adopt more sustainable practices, even if they are aware of the risks, because their current methods are reinforced by the advice and products available from their local dealers.

Based on the dataset and classified using the standard IRAC (Insecticide Resistance Action Committee) system, the key active ingredients found in the products sold are shown in Table 5. Many of the active ingredients, while in different commercial products, share the same MoA groups. For instance, a dealer may stock several different pyrethroid-based products (Group 3A) and several different neonicotinoid-based products (Group 4A). The key to good resistance management is to rotate products from different MoA groups.

The essentials of insecticide resistance management are:

- Rotate modes of action: avoid using products from the same IRAC group repeatedly. Rotate between different groups (e.g., Group 28, Group 6, Group 18) to delay the development of resistance .
- Avoid broad-spectrum insecticides: using broad-spectrum insecticides can eliminate natural enemies (beneficial insects that prey on pests), potentially leading to secondary pest outbreaks like planthoppers . Reserve their use for high infestations.
- Monitor pest populations: regularly scout fields for pests. Apply insecticides only when pest populations reach the economic threshold level to avoid unnecessary applications .
- Follow label instructions: Always read and follow the product label for correct dosage, application timing, and safety precautions.

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Table 5. MoA grouping for insecticide products found in shops

Active Ingredient(s)	Target pest	IRAC Group	Resistance risk
Abamectin	Mites, Leafminers, Snails	6	Moderate
Acetamiprid	Planthoppers, Leafhoppers	4A	High
Alpha Cypermethrin	Rice Bug (*Leptocorisa* spp.), Stem Borers, Crabs	3A	High
Benfuracarb	Planthoppers, Stem Borers	1A	Moderate-High
Beta-cypermethrin + Profenofos + Thiamethoxam	Stem Borers, Planthoppers, Leaf folders	3A + 1B + 4A	High
Buprofezin + Imidacloprid	Planthoppers, Leafhoppers	16 + 4A	High
Chlorantraniliprole	Stem Borers, Leaf folder	28	High
Chlorantraniliprole + Chlorfenapyr	Stem Borers, Leaf folder	28 + 13	Moderate-High
Chlorantraniliprole + Emamectin-benzoate	Stem Borers, Leaf folder	28 + 6	Moderate-High
Chlorantraniliprole + Lufenuron	Stem Borers, Leaf folder	28 + 15	Moderate-High
Chlorfenapyr	Stem Borers, Leaf folder, Mites	13	Low-Moderate
Chlorpyrifos + Abamectin + Lufenuron	Stem Borers, Mites	18 + 6 +15	Moderate-High
Cypermethrin	Rice Bug, Stem Borers	3A	Moderate
Deltamethrin	Stem Borers, Rice Bug	3A	High
Dinotefuran + Pymetrozine	Planthoppers	4A + 9B	High
Emamectin-benzoate	Leaf folder, Stem Borers	6	Moderate
Emamectin-benzoate + Indoxacarb	Leaf folder, Stem Borers	6 + 22	Moderate
Fipronil	Stem Borers, Planthoppers	2B	High
Imidacloprid	Planthoppers, Leafhoppers	4A	High
Lambda Cyhalothrin + Thiamethoxam	Stem Borers, Planthoppers	3A + 4A	High
Methoxyfenozide	Leaf folder, Stem Borers	18	Low-Moderate
Nitenpyram + Pymetrazine	Planthoppers, Leafhoppers	4A + 9B	High
Permethrin	Broad spectrum	3A	High
Profenofos	Stem Borers, Leaf folder	1B	Moderate-High
Spinetoram	Leaf folder, Stem Borers	5	Moderate
Sulfoxaflor	Planthoppers, Rice Bug	4C	High
Thiamethoxam	Planthoppers, Leaf folder	4A	High
Tolfenpyrad + Thiamethoxam	Planthoppers, Leaf folder, Stem Borers	21A + 4A	High
Triflumezopyrim	Planthoppers (BPH)	4E	High

Herbicides used and implications for weed management in rice

In a previous survey in Battambang province, farmers were asked to rank the major weed species present in their rice fields with the aid of photographs and a total of 30 species was recognised (Martin et al., 2021). According to farmers, the 10 most important weeds of rice in Battambang province are shown in Figure 16.

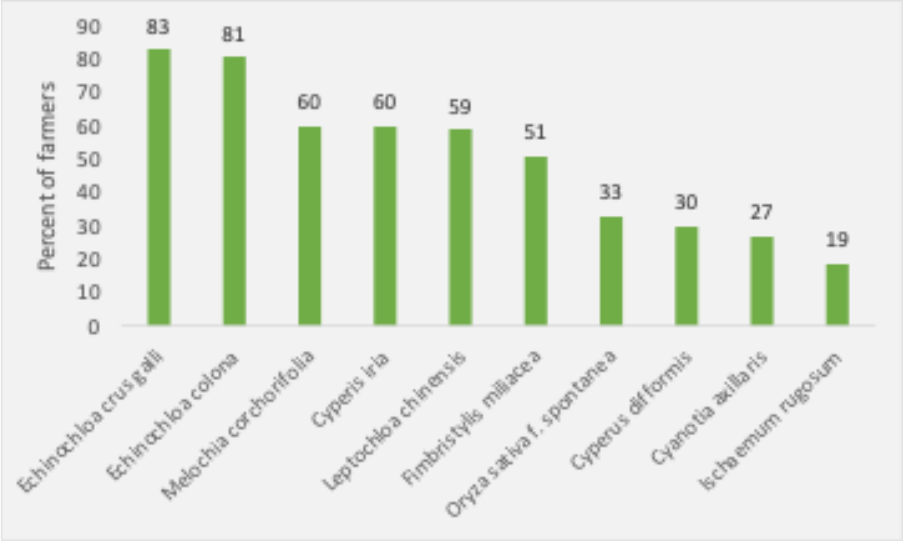
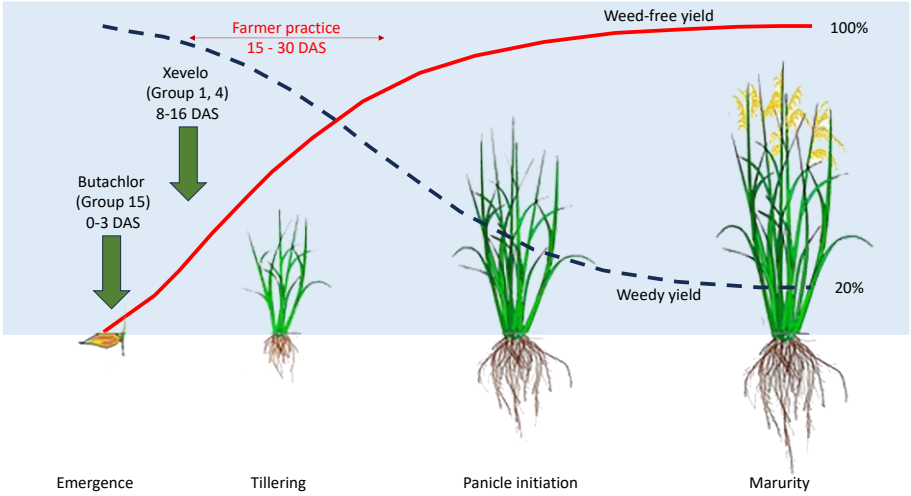


Figure 16. The 10 most important weeds of rice in Battambang province according to farmers

Butachlor applied as a post-sowing pre-emergence herbicide 0-3 days after sowing (DAS) gave better weed control compared with bispyribac-sodium applied 29 DAS in Battambang province (Martin et al., 2020) . It has also been shown that weed competition in direct-seeded rice during the period 10-45 DAS caused a maximum reduction in paddy yield. Hence the crop needs to be kept weed-free through this period to avoid significant yield losses from weeds (Safdar et al., 2023) (Figure 17). Farmer practice in Battambang province is to apply post-emergence herbicides 15 to 30 DAS. This is too late and will result in yield loss from competition by weeds.



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Figure 17. Timing of herbicide application is critical to avoid yield losses from weeds

Input dealers in Battambang province are stocking a wide variety of single active ingredients and mixtures of herbicides. Across all shops, 24 different herbicide products (single or pre-mixed) were recorded. The most frequently recommended single products were 2,4-D (used in 20 shops) and bispyribac-sodium (used in 24 shops). No two shops have the exact same "recommendation profile." Even shops in the same village often recommend different products.

There was a noticeable difference in products on sale between districts. For example, penoxulam was only found in Banan and Sangkae districts, while metamifop + cyhalofop was found only in Sangkae and Rukhak Kiri. Profoxydim was found exclusively in Sangkae district. Some communes had distinct "signatures." In Tuol Ta Aek (Battambang), the focus was on 2,4-D and bispyribac-sodium. In Thipakdei (Koas Krala), dealers stocked cyhalofop-butyl + halosulfuron-methyl and fenoxaprop-P-ethyl, which are rare elsewhere.

At the village level, shops stocked different choices of herbicide products. For example, in Bavel Muoy village (Bavel market):

- Shop #31 recommended 2,4-D, bispyribac-sodium, cyhalofop-butyl, florpyrauxifen+cyhalofop, and metsulfuron+pyrazosulfuron;
- Shop #32 recommended 2,4-D, bispyribac-sodium, florpyrauxifen + cyhalofop, and quinchlorac + pyrazosulfuron + fenoxaprop;
- Shop #34 recommended only 2,4-D, bispyribac-sodium, and butachlor.

This means that farmers in the same village are getting very different advice from different dealers. This pattern of recommendations has serious negative implications for herbicide resistance management:

1. Over-reliance on a few active ingredients where, despite the long list of products on sale, 2,4-D and bispyribac-sodium predominate in ~60–70% of shops. Overusing the same two modes of action (MoA) across a wide area has the potential to rapidly select for weeds resistant to these chemicals.
2. There appears to be no awareness of the need for rotation of MoA Groups for herbicides among inpug dealers. Resistance management requires rotating between different MoA groups (e.g., Group 4, Group 2, Group 15). In this survey, many shops recommend the same few MoAs repeatedly. For example, Shop #1 stocks only 2,4-D (Group 4), bispyribac (Group 2), and butachlor+propanil (Group 15, 5) – but no rotation advice is evident.
3. Pre-mixed "cocktails" are offered without strategy. Many dealers recommend complex multi-way mixes (e.g., 3-active mixtures). While mixtures can delay resistance if the components are effective but here they appear to be offered haphazardly. Some mixes combine multiple Group 2 herbicides (e.g., metsulfuron + pyrazosulfuron), which is counterproductive because they share the same MoA and do not provide any resistance management benefit.

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4. Local advice is inconsistent indicating that there is no local resistance strategy because dealers in the same village recommend different products, there is no coordinated, community-wide resistance management plan.
5. There is no evidence of the promotion of cultural practices such as crop rotation, mechanical weeding to reduce reliance on herbicides.

The survey results suggest the need for training programs for dealers on Mode of Action (MoA) rotation and the "Weed Seed Bank" concept. It would also be useful to to encourage village-level "herbicide use groups" so that farmers in the same commune coordinate their MoA choices across seasons (e.g., reduce reliance on Group 1 and 2 post-emergence herbicides by alternating with pre-emegence herbicides such as butachlor, pretilachlor (Group 15). In the absence of advisory services at the village level, these options are not realistic. An alternative is the adaptation of weed identification Applications for use by farmers and QR codes for herbicide labels that provide recommendations for use in rice. The herbicide products found in shops are grouped by the HRAC (Herbicide Resistance Action Committee) classification, which is the global standard for resistance management (Table 6).

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Table 6. MoA grouping for herbicide products found in shops

Active Ingredient(s)	Target weeds	HRAC Group	Resistance risk
2,4-D	Broadleaf weeds (e.g., *Melochia corchorifolia*)	4	Moderate-High
Bispyribac-sodium	Grasses, sedges, broadleaf weeds	2	High
Bentazone	Broadleaf weeds, sedges	6	Low-Moderate
Bentazone + MCPA	Grasses, some broadleaf weeds	6 + 4	Low-Moderate / Moderate-High
Butachlor	Grasses, some broadleaf weeds	15	Low to Moderate
Butachlor + Propanil	Grasses, broadleaf weeds	15 + 7	Low-Moderate / Moderate-High
Cyhalofop-butyl	Grasses (e.g., *Echinochloa* spp.)	1	High
Cyhalofop-butyl + Propanil	Grasses, broadleaf weeds	1 + 7	High / Moderate-High
Cyhalofop-butyl + Halosufuron-methyl	Grasses, sedges, broadleaf weeds	1 + 2	High
Cyhalofop-butyl + Ethoxysulfuron	Grasses, sedges, broadleaf weeds	1 + 2	High
Fenoxaprop-P-ethyl	Grasses (e.g., *Echinochloa* spp.)	1	High
Fenoxaprop-P-ethyl + Pyrazosulfuron-ethyl + Mefenacet	Grasses, sedges, broadleaf weeds	1 + 2 + 15	High
Florpyrauxifen-benzyl + Cyhalofop	Broadleaf weeds, grasses	4 + 1	Moderate-High
MCPA	Broadleaf weeds	4	Moderate-High
Metamifop + Cyhalofop	Grasses	1 + 1	High
Metsulfuron-methyl + Chlorimuron-ethyl	Broadleaf weeds, sedges	2 + 2	High
Metamifop + Cyhalofop	Grasses	1 + 1	High
Metsulfuron-methyl + Chlorimuron-ethyl	Broadleaf weeds, sedges	2 + 2	High
Metsulfuron-methyl + Pyrazosulfuron-ethyl	Broadleaf weeds, sedges	2 + 2	High
Penoxulam	Grasses, sedges, broadleaf weeds	2	High
Profoxydim	Grasses (e.g., *Echinochloa* spp.)	1	High
Propanil	Grasses, broadleaf weeds	7	Moderate-High
Propanil + Clomazone	Grasses, broadleaf weeds	7 + 13	Moderate-High / Low
Pretilachlor	Grasses, some broadleaf weeds	15	Low-Moderate
Pyrazosulfuron-methyl	Grasses, sedges, broadleaf weeds	2	High
Quinclorac + Pyrazosulfuron + Fenoxaprop	Grasses, sedges, broadleaf weeds	28 + 2 + 1	

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The most critical takeaway is to avoid continuous use of ALS (Group 2) and ACCase (Group 1) inhibitors, as these are the most prevalent herbicide products in shops and are those Groups where *Echinochloa* resistance is most common. New herbicide MoA groups should be included in recommendations. The primary options are as follows:

1. Flusulfinam (Group 27) (Wang et al., 2025) is being actively promoted in Cambodia but was not observed in shops during the survey in Battambang province. The key advantages of flusulfinam are no cross-resistance with ALS or ACCase herbicides and broad-spectrum control of major grasses, including *Echinochloa crus-galli* and *Leptochloa chinensis.*
2. Although pre-emergence herbicides such as butachlor and pretilachlor are sold in some shops, they are vastly underutilised in Battambang rice cropping systems. Clomazone (Group 13) is another option for pre-emergence weed control that is available in some shops.

Direct-seeded rice, reliance on saved seed, and post-emergence-only programs aggravate the *Echinochloa* problem. The following strategies directly address these issues:

1. Combine pre- and post-emergence programs: this is a critical change. A pre-emergence application (e.g., with quinclorac) followed by a post-emergence application of a different MoA (like an HPPD inhibitor) provides season-long control and reduces selection pressure for resistance.
2. Address the seed bank: seed saved for sowing is a major source of weed contamination. Encouraging the use of weed-free seed and implementing cultural controls like stale seedbed preparation can dramatically reduce the initial *Echinochloa* population.
3. Post-emergence herbicides are generally applied too late in rice in Battambang province (). Applying post-emergence herbicides when the weed is at the 2-3 leaf stage is more effective and safer for the rice.

Fungicide/Bactericides used and implications for disease management in rice

Rice leaf blast (*Magnaporthe oryzea*) and brown leaf spot (*Bipolaris oryzae*) are the most important diseases of rice in Battambang province (Table 7). Integrated management of blast should include resistant varieties, optimised agronomic practices, precise and targeted fungicide application, and silicon fertilisation (Xu et al., 2025).

Table 7. Diseases identified by farmers as causing damage to rice in Battambang province (Flor et al., 2020)

Common name	*Scientific name*	Farmers (%)
Rice blast	*Magnaporthe grisea*	53
Brown leaf spot	*Bipolaris oryzae*	27
Bacterial leaf blight	*Xanthomonas oryzae pv. oryzae*	11
Bacterial sheath rot	*Pseudomonas fuscovaginae*	1

Thirty-six fungicide/bactericide products were found in stores (Table 8). The most commonly recommended fungicide/bactericide was isoprothiolane + pyraclostrobin + sulfur, followed by hexaconazole, tricyclazole and paclobutrazol. There is no single "standard" recommendation.

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- Single active ingredients: many dealers sell single-mode-of-action products like hexaconazole, mancozeb, tricyclazole, or kasugamycin.
- Pre-mixed combinations: a large number of products are already pre-formulated combinations (e.g., azoxystrobin + difenoconazole, copper + streptomycin + zinc sulfate, prochloraz + tebuconazole).

Dealers often stock multiple individual products, which suggests they may advise farmers to mix them on-site. For example, Shop 15 stocks gentamicin + oxytetracycline, thiophanate-methyl + isoprothiolane + tricyclazole, and tricyclazole + kasugamycin simultaneously, indicating they are offering different cocktail options to farmers depending on the problem or season.

The product portfolio varies greatly by location, even within the same district:

- Battambang district (Shops 1, 2) focuses heavily on mancozeb, carbendazim, and fluxapyroxad + pyraclostrobin;
- Sangkae district (Shops 12-16) shows a high prevalence of pyraclostrobin + tebuconazole, gentamicin + oxytetracycline, and thiodiazole copper;
- Rukhak Kiri district (Shops 25-29) has a strong preference for metalaxyl, tricyclazole, and zhongshenmycin.

Even within the same commune (Thipakdei in Koas Krala), Shops 19, 20, and 21 have completely different inventories. Shop 19 sells ningnanmycin and oxytetracycline + streptomycin, while Shop 21 sells hexaconazole and zhongshenmycin. In Prek Chik commune (Rukhak Kiri), Shop 25 sells metalaxyl, while shop 27 sells azoxystrobin + difenoconazole, hexaconazole, and kasugamycin. This indicates that recommendations are highly localised, likely based on the specific disease pressures in that village or the personal preference/knowledge of the dealer.

The implications are concerning and point to a high risk of fungicide/bactericide resistance development. Over-reliance on single MoA: Many shops sell stand-alone products like tricyclazole, hexaconazole, or kasugamycin. If farmers use these repeatedly without rotation, the target pathogens, especially blast and bacterial leaf blight will rapidly develop resistance.

High Use of QoI (p) Fungicides: Products containing azoxystrobin or pyraclostrobin (e.g., azoxystrobin + tebuconazole, pyraclostrobin + tebuconazole) are widely sold. QoI fungicides are high-risk for resistance. Using them as stand-alone or even in mixtures without proper rotation is risky.

While mixtures like pyraclostrobin + isoprothiolane + kasugamycin combine multiple modes of action (which is good for resistance management), the data show that these same mixtures are often sold alongside other stand-alone products. This creates a "mixing bowl" where a farmer might use the same MoA from multiple products without knowing it, accelerating resistance.

The data are a snapshot in time. However, the fact that many dealers stock both high-risk (QoI, DMI) and low-risk (multi-site) products simultaneously suggests that rotation is not systematically planned but rather based on what the farmer asks for or what the dealer recommends on the spot. There is no data to suggest a structured anti-resistance strategy (e.g.,

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"FRAC code rotation") is being advised. Fungicide/bactericide products are categorised by their active ingredients, target disease group, and FRAC/MoA code (Table 8).

The current situation presents significant risks for fungicide/bactericide resistance development:

- Over-reliance on single modes of action (MoA): Many products are single-active-ingredient (e.g., carbendazim, hexaconazole, tricyclazole). If a dealer recommends only one of these repeatedly for a disease, the pathogen population is under strong selection pressure to develop resistance.
- "Stacking" of similar MoAs: Some combinations are redundant. For example, azoxystrobin + difenoconazole and azoxystrobin + tebuconazole both contain a QoI (strobilurin) and a DMI (triazole). Using them interchangeably does not rotate MoAs; it just switches the DMI partner.
- Potential for mixture misuse: While pre-mixed products can delay resistance if both components are effective, many shops stock multiple mixtures that contain the same active ingredient (e.g., tricyclazole appears in five different mixtures). A farmer could easily buy two different mixtures with tricyclazole, effectively applying it at high doses without realizing it.
- Lack of structured rotation: the data shows no evidence of a deliberate, district-wide MoA rotation strategy. Each shop appears to stock what is available/cheap, rather than what is best for resistance management.

Recommendation: dealer training should emphasize MoA rotation (not just product name rotation) and the importance of using mixtures only when both components are effective against the target pathogen. MoA for fungicide/bactericide products on sale are given in Table. Key observations from the MoA table are:

1. High-risk fungicides are common: products containing QoI (strobilurins - FRAC 11) and DMI (triazoles - FRAC 3) are sold everywhere. These are at high to medium risk for resistance.
2. Multi-site products are underutilised: despite being excellent for resistance management, low-risk products like mancozeb or copper-based products are only sold in a minority of shops.
3. Bactericide resistance concern: multiple antibiotic-based bactericides (streptomycin, kasugamycin, gentamicin) are sold. Overuse of these in agriculture can lead to antibiotic resistance in environmental bacteria, which is a public health concern.
4. Redundancy: many shops sell multiple products that contain the same MoA (e.g., three different products with tricyclazole). This suggests that farmers might be buying redundant mixtures without knowing it.

Information to assist choice of fungicide/bactericide should be accessible at agricultural input shops. This could be in the form of QR Codes on product labels. Farmers should be aware of the need to rotate between FRAC groups and limiting the use of high-risk QoI and DMI fungicides to one application per season. They should also consider the use of multi-site products

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(mancozeb, copper) as protectants early in the season to reduce reliance on systemic fungicides.

Excessive use of fertiliser can increase the intensity of rice blast disease. The incidence of blast can be reduced by split nitrogen fertiliser application in two or more treatments. Application of silicon (Si) forms a physical barrier that impedes penetration by fungal pathogens and might also play an active role in the resistance to diseases (Rodrigues and Datnoff, 2005).

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Table 8. Fungicide/bactericide products categorised by active ingredients, target disease group, and FRAC/MoA code

Active Ingredient(s)	Target disease	MoA Group (FRAC Code)	Resistance Risk
Azoxystrobin + Difenoconazole	Blast, Sheath Blight, Leaf Spot	QoI (11) + DMI (3)	Medium-High
Azoxystrobin + Tebuconazole	Blast, Sheath Blight, Leaf Spot	QoI (11) + DMI (3)	Medium-High
Bismerthazole + Streptomycin	Blast, Bacterial diseases	Multi-site + Bactericide	Low / Low
Bronopol	Bacterial diseases	Bactericide	Low
Carbendazim	Sheath Blight, Leaf Spot	MBC (1)	High
Copper + Streptomycin + Zinc Sulfate	Bacterial Leaf Blight	Bactericide	Low-Medium
Copper oxychloride + Streptomycin	Bacterial Leaf Blight	Multi-site (Copper) + Antibiotic	Low-Medium
Fenoxanil + Hexaconazole	Blast, Sheath Blight	Melanin (16.1) + DMI (3)	Medium
Fenbuconazole	Sheath Blight, Leaf Spot	DMI (3)	Medium
Fluxapyroxad + Pyraclostrobin	Sheath Blight, Leaf Spot	SDHI (7) + QoI (11)	Medium-High
Gentamicin + Oxytetracycline	Bacterial Sheath Rot, BLB	Antibiotic + Antibiotic	Low-Medium
Hexaconazole	Sheath Blight, Leaf Spot	DMI (3)	Medium
Isoprothiolane	Blast	Melanin (16.1)	Medium
Kasugamycin	Blast	Protein synthesis (24)	Low-Medium
Kasugamycin + Tricyclazole	Blast	Protein synthesis (24) + Melanin (16.1)	Low-Medium
Ningnanmycin	Viral / Bacterial (broad)	Unknown (Antibiotic)	Low
Oxalinic acid + Bismerthiazole	Bacterial Leaf Blight	Bactericide	Low
Oxytetracycline + Streptomycin	Bacterial Sheath Rot, BLB	Antibiotic + Antibiotic	Low-Medium
Picoxystrobin	Sheath Blight, Leaf Spot	QoI (11)	High
Prochloraz + Tebuconazole	Sheath Blight, Leaf Spot	DMI (3) + DMI (3)	Medium-High
Propiconazole + Difenoconazole	Sheath Blight, Leaf Spot	DMI (3) + DMI (3)	Medium
Pyraclostrobin	Broad-spectrum	QoI (11)	High
Pyraclostrobin + Isoprothiolane + Kasugamycin	Blast, Sheath Blight	QoI (11) + Melanin (16.1) + Protein (24)	Low-Medium
Pyraclostrobin + Isoprothiolane + Sulfur	Blast, Sheath Blight	QoI (11) + Melanin (16.1) + Multi-site (M2)	Low
Pyraclostrobin + Tebuconazole	Blast, Sheath Blight, Leaf Spot	QoI (11) + DMI (3)	Medium-High
Saisentong	Bacterial / Fungal	Copper-based bactericide/fungicide	Low
Streptomycin + Oxytetracycline	Bacterial Sheath Rot, BLB	Antibiotic + Antibiotic	Low-Medium
Thiodiazole Copper	Bacterial Leaf Blight	Bactericide (Copper)	Low
Thiophanate-methyl + Isoprothiolane + Tricyclazole	Blast, Sheath Blight	MBC (1) + Melanin (16.1) + Melanin (16.1)	Medium-High
Thiosen Copper	Bacterial / Fungal	Multi-site (Copper)	Low
Tricyclazole	Blast	Melanin (16.1)	Medium
Tricyclazole + Azoxystrobin	Blast, Sheath Blight	Melanin (16.1) + QoI (11)	Medium-High
Tricyclazole + Hexaconazole	Blast, Sheath Blight	Melanin (16.1) + DMI (3)	Medium
Tricyclazole + Kasugamycin	Blast	Melanin (16.1) + Protein (24)	Low-Medium
Validamycin	Sheath Blight	Trehalase (26)	Low
Zinc Thiazole	Bacterial Leaf Blight	Bactericide	Low
Zhongshenmycin	Bacterial / Fungal	Antibiotic (bactericide)	Low

Registration status of tricyclazole

Several sources report that the Ministry of Agriculture, Forestry and Fisheries (MAFF) issued a proclamation to stop the importation, supply, distribution and use of fungicides containing tricyclazole in Cambodia in 2017. This action was a direct response to the European Union's (EU) stricter regulations, which are a major concern for Cambodian rice exports. In 2017, the EU significantly lowered the Maximum Residue Limit (MRL) for tricyclazole in rice to 0.01 mg/kg. This made it very difficult for Cambodian rice containing even small traces of the chemical to be exported to the EU. To protect this crucial market, the Cambodian government and rice industry have been actively working to eliminate its use.

The Cambodia Rice Federation (CRF) held workshops and issued appeals to farmers and millers urging them to stop using tricyclazole to avoid affecting rice exports. This aligns with the government's official stance. Concerns over residue levels are real, as there have been recent instances of Cambodian rice shipments being returned by the EU for exceeding pesticide limits. Despite this, registered products containing tricyclazole are currently on sale in most input stores surveyed in Battambang province (Figure 18).



Figure 18. A variety of registered fungicide products containing the active ingredient tricyclazole was found in input stores

Based on the available information, it could be assumed that tricyclazole is currently not approved for use on rice in Cambodia. The approval status of pesticides in Cambodia is determined by the Ministry of Agriculture, Forestry and Fisheries (MAFF). A search was unable to find a link to a current, official MAFF list, so the approval status of tricyclazole in Cambodia could not be determined.

The import and use of any pesticide in Cambodia requires a specific license and registration from MAFF, which must be renewed periodically. It could be assumed that the formal prohibition on tricyclazole would have been enacted through this regulatory process. Given the strong and consistent evidence from both the government and industry sources that the use of tricyclazole is prohibited to protect rice exports, it should be assumed that tricyclazole is not

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approved for use on rice in Cambodia. However, this does not appear to be the case and clarification should be sought from MAFF regarding the current registration status of triclazole in Cambodia. Furthermore, MAFF should be encouraged to make available the current "real-time" registration status of fertilisers and pesticides on-line.

Improving the dissemination of information on the use of agricultural chemicals

Flor et al. (2020) examined the pesticide use of Cambodian rice farmers and presented evidence of pesticide-reliant practices and limited use of alternatives. It shows the interaction dynamics and arrangements between farmers, pesticide sellers and company promotional staff that promote or sustain this practice. Ease of access to pesticide-based recommendations and recursive social interaction at the community level contribute to the lock-in of pesticides as the dominant technological regime. The high use of pesticides and lack of adoption of alternative technologies indicate the existence of social conditions, and mechanisms of collective action that keep the technological practices in place. Exploring the mechanism in the user context for Cambodia however, opens scope for further understanding the complexity of changing pesticide use at the community level.

Most interventions to change pesticide use target individual farmers rather than the farming community. Flor et al. (2020) showed that other stakeholders influential in decisions for pest management need to be reached. According to Flor et al., retail sellers, for example, provide a strong coordination role and directly reach farmers with timely pest management information. In this study, we found that pesticide sellers do nor fulfil this role but simply stock and sell products in response to farmer demand. Therefore pesticide sellers do not currently have capacity to change pesticide management practices. The challenge is to find a way to create change among all stakeholders regarding effective use of products, dosage, and implications of over-dosage and mis-application of N-P-K fertilisers.

With vegetable growers in Battambang province, Zhang et al., 2020 found that popular opinion leaders may be influential in promotion and dissemination of novel inputs but are not necessarily also receptive to novel technologies. Opinion leaders may be influential in local networks because they receive resources from external agencies that others need, not necessarily for providing an example for sustainable practices. External agencies channeling support only through perceived opinion leaders may be exacerbating inequalities in local communities. Farmers in brokerage positions who are not necessarily widely influential in their communities but tap into diverse knowledge pools may be more receptive to novel practices and these farmers are likely to be more suitable targets for intervention.

Chhun et al. 2020 studied crop production practices in the lowland rice systems of Battambang province in Cambodia with the objective to understand farmers' agronomic practices, especially related to weed management. As with Flor et al., Chhun et al. highlighted the need to shift the emphasis of training and educational programs focussed on individual farming households to embrace the farming community network including the input dealers who provide most of the advice on the use of fertilisers and pesticides for crop production. This is consistent with the

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findings of Ngang et al. (2025) where decisions on pesticide use are primarily based on advice from the seller and perceived efficacy of products.

Pesticide hazard classes of products for sale at input stores

The World Health Organisation (WHO) has published a recommended classification of pesticides by hazard to establish the scientific basis for assessment of the risk to human health and the environment from exposure to chemicals, through international peer review processes, as a prerequisite for the promotion of chemical safety (WHO, 2020). The WHO hazard classes are defined as:

- Ia - extremely hazardous
- Ib - highly hazardous
- II - moderately hazardous
- III - slightly hazardous
- U - unlikely to present acute hazard

The active ingredients of pesticides on sale at stores in the survey were classified as bactericides/fungicides, herbicides and insecticides. There were no extremely hazardous ingredients (Class Ia) on display in the stores. However, the insecticide abamectin (Class Ib) was on sale in all districts. Abamectin is used to control snails and crabs as well as insects in rice and is the most commonly sold insecticide for use in rice in the province. Consistent with general knowledge, the results of the survey show that the use of insecticides poses a greater risk to human health and environment compared with bactericide/fungicide and herbicide in Battambang province (Figure 19).

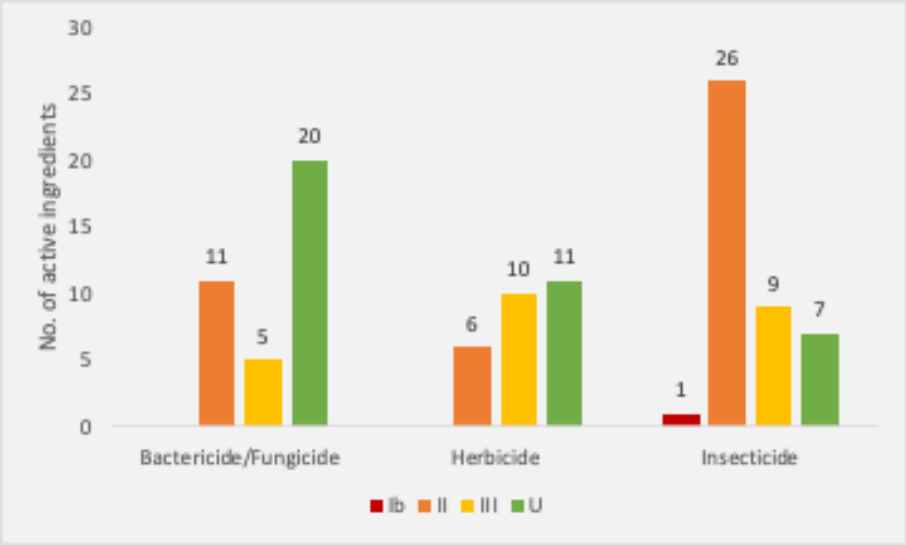


Figure 19. WHO classifications for pesticides on sale for rice in Battambang province

Adequacy of pesticide labels

The International Code of Conduct on Pesticide Management recommends a three-panel layout for labels (FAO and WHO, 2022). The main panel should identify the product, its field of use and

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essential warnings and restrictions, while the two other panels can provide directions for use, precautionary statements, storage and disposal provisions and other information. It is permissible to use pictures that show what a pest or disease looks like but these must be ones specifically targeted by the active ingredient.

Cambodia's Law on Pesticide and Fertiliser is administered by the Department of Agricultural Legislation (DAL) within the Ministry of Agriculture, Forestry and Fisheries (MAFF). DAL is responsible for registration and licensing of pesticides and fertilisers and also provides annual training to agricultural input shops through Provincial Departments of Agriculture, Forestry and Fisheries (PDAFF). The annual training of input sellers takes place at district offices of the Department of Agriculture and is mandatory to get a licence certificate for their business (valid for three years). However, input dealers interviewed explained that the training focuses on legal but not technical matters (Bureau-Point et al., 2024).

The pesticide label is intended as a legal document but directions for use and safety precautions are often crowded out by dramatic illustrations and photographs which can be misleading. Importantly, the Mode of Action (MoA) Group code number and the name of the pesticide group should appear on the label but is generally absent (Figure 40). Label designs include super heros or mythical animals symbolising power to draw attention to the power of their products (Bureau-Point et al., 2024) (Figure 41, left). There is a need for the DAL to enforce the correct use of the label design template to clearly show the active ingredient, directions for use, safety precautions and resistance management MoA Group (Figure 41, top right). This would enable more meaningful use of pesticide labels as extension aids.



Figure 40. Pesticide label template apparently from MAFF

Inadequacies regarding pesticide labels observed in the stores visited are as follows (Figure 20):

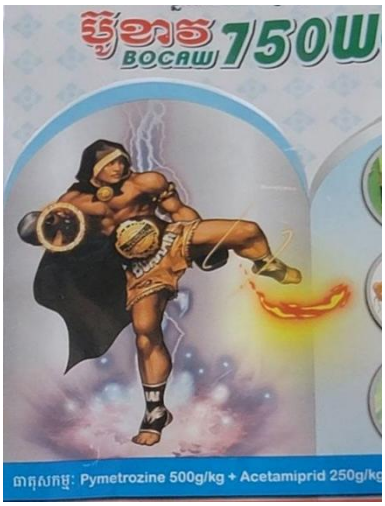
- About 5% of labels were found to be in Vietnamese or Thai language, so are not likely to be legible to dealers or farmers;

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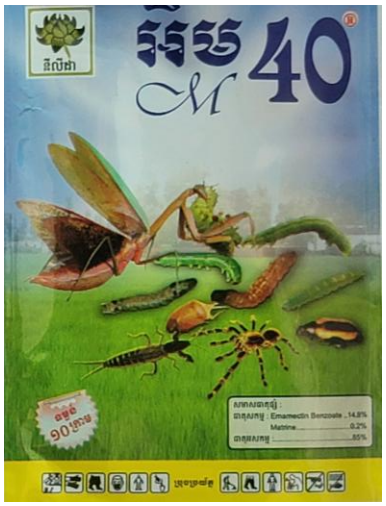
- Only 13% of labels displayed the FRAC, HRAC, IRAC MoA codes for resistance management.
- Many of the labels were dominated by comic-cartoon style illustrations which do not contribute to knowledge about the product;
- Most labels feature photos of the supposed target pests which is acceptible if the photos are kept small. However some labels feature non-target beneficial arthropods such as praying mantids, ladybird beetles and spiders which indicates ignorance or a lack of regard for IPM by manufacturers and/or the regulator.
- One label depicted a caterpillar parasitised by a brachonid wasp. This also demonstrates a lack of regard for IPM by manufacturers and the regulator.



This label is in Vietnamese but otherwise in acceptable format



Most of the space on this label is taken up by an irrelevant image



Label depicting beneficials: praying mantid and spider



This label depicts a dead caterpillar parasitised by wasp



The ladybird depicted on this label is beneficial



A label in acceptable format showing IRAC resistance group

Figure 20. Examples of compliant and non-compliant labels

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Communication and training preferences

Input dealers were asked how they would rate (low, medium and high) the following communication and training preferences: Chat groups; Leaflets for hand-out in-store; One-on-One training; Posters for display; radio programs; smart phone apps; social media; television features; videos for display in-shop. Smart phone apps were the most popular preference for communication (Figure 21).

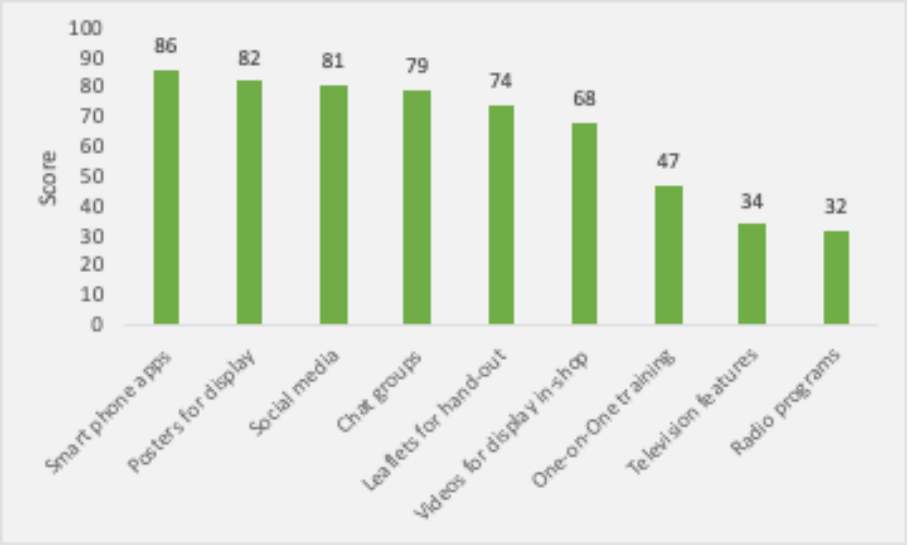


Figure 21. Communication and training preferences of input dealers

When they were asked if they would consider attending a certificate course for agri-input dealers, 29 input dealers said yes and only four said no.

Vuthy (2020) described the fertiliser supply chain in Takeo province (Figure 42). In 2012, there were about 634 traders in the province, mostly shop owners selling farm inputs. These traders also provide advice to farmers on choice, rate and timing of use for agricultural chemicals. However, although the PDA provide training on trade and safety of farm inputs, they do not provide training on effective or sustainable use of fertilisers and pesticides.

Tan et al. (2022) reported a survey of 179 agri-businesses, 82 in Banteay Meanchey and 97 in Battambang province in 2020. Businesses had an average of 67 farmer customers, 61 in Banteay Meanchey and 73 in Battambang. If these numbers were to be applied to Takeo province, input sellers would be providing advice directly to 42,478 farm households on the use of fertilisers and pesticides at the provincial level. However, it can be assumed that all rice farming households receive advice on fertiliser and pesticide inputs either directly or indirectly from input sellers and, for example, this would be 1,849 households in Kampong Prieng commune and 2,292 households in Chheu Teal commune (NCDD, 2010).

Input sellers are therefore the primary source of information on fertiliser and pesticide advice for smallholder farmers in Cambodia. This means that interventions to improve the advice on the safe and efficacious use of fertilisers must include the input supply network. Tambo et al,

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2024) found that Agro-input dealers in Uganda can play an important role in mitigating pesticide risks, given that they are the major source of pesticide and plant health information for many developing-country farmers.

Tambo et al. (2024) surveyed 557 agro-dealers in Uganda on pesticide risk reduction and the study was focussed on the perspectives of agro-dealers, rather than farmers. Agro-dealers were receptive to the concept of a certification scheme for its potential to provide training opportunities and ensure safety to human health and the environment. It would be useful to explore the possibility of developing a certification scheme for input sellers in Cambodia with a focus on site-specific nutrient management (SSNM) for fertiliser use to increase crop profitability and to reduce environmental impacts. Similarly, training on the use of lower-risk pesticides and IPM could be delivered via a certification course for input sellers.

Rather than going into a head-to-head battle with the input supply chain, MAFF can change direction and work towards a closer and more meaningful engagement with the agricultural input supply chain (Figure 43). The options for more meaningful engagement by MAFF are as follows:

- Genuine enforcement of fertiliser and pesticide label specifications. Fertiliser labels do not currently specify rates and timing for specific crops and for pesticides, the labels should be confined to the legislated specification and the misleading and incorrect comic-book style illustrations should be removed from DAL-approved labels;
- Currently, DAL training of village input sellers takes place at the district level, which is not only an inconvenience, but only relates to legal issues and licencing. DAL/PDAFF have a responsibility to also provide training to village input sellers on the safe and efficacious use of fertilisers and pesticides which they are not currently providing;
- Field promoters of agricultural chemicals appear to be under MAFF's radar and these operators need to be included in the training as provided for the input sellers;
- The Commune Agriculture Officers (CAOs) do not appear to be caught up in the DAL/PDAFF training process but they also require training in the safe and efficacious use of agricultural chemicals;
- Currently there is apparently no acknowledgement by MAFF of the role of input sellers in providing the majority of advice to farmers, especially on the use of fertilisers and pesticides. It is recommended that input sellers be offered the opportunity for training to gain certification to recognise their capacity to provide safe and efficacious use of agricultural chemicals.

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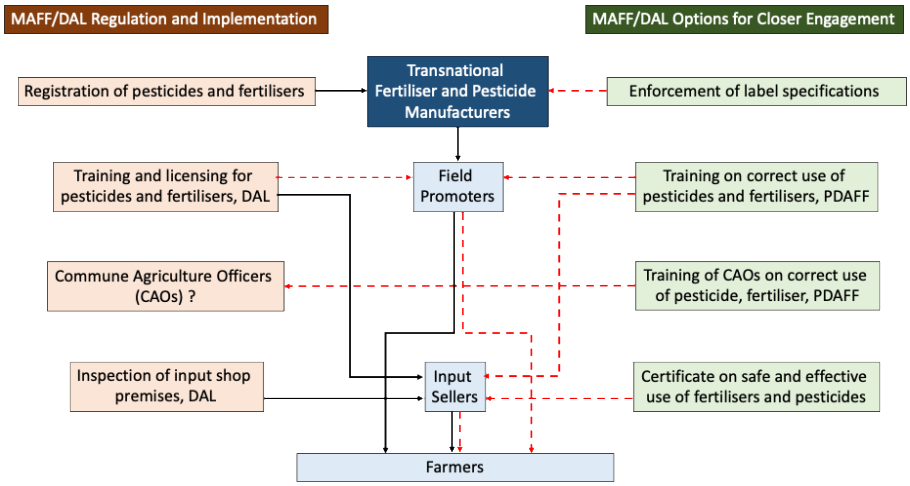


Figure 43. Potential options for closer alignment of MAFF policy and objectives with the reality of the agricultural input supply chain

Conclusions

Agri-input dealerships in Battambang province were found to be primarily small to medium sized family businesses with an average of 94 regular customers and having an average of two sub-dealers. Forty-six percent of owner/managers had completed upper secondary education, 21% lower-secondary, 18% primary and 15% had some type of tertiary qualification such as in business or financial management.

All dealers mentioned farmers as a source of information on agricultural chemicals and most dealers mentioned that they stocked products in accordance with farmer demand. Only two dealers mentioned the pesticide label as a source of information. Although, 29% of dealers claimed to be aware of biopesticides and 21% claimed to be aware pf IPM, no relevant products were observed in any of the stores visited.

Forty-six company brands of fertiliser were found in the input stores included in the survey. According to input dealers, 28 different combinations of N-P-K were used in rice. The six most commonly recommended fertilisers by dealers were: urea (46-0-0); DAP (18-46-0); 27-12-6; 20-20-15; 20-8-20; and MoP (0-0-60). The application rate and timing advice for the fertilisers was not consistent with recommendations for rice. As a consequence, farmers are being recommended fertiliser combinations that are not only costly but unlikely to achieve the desired yield increases in rice.

Insecticides were the most common pesticides stocked in stores (43 active ingredients). Herbicides were represented by 27 active ingredients and bactericide/fungicides by 36 active ingredients. With the focus on pesticide sales, pesticide sellers do not currently have capacity to change pesticide management practices. The challenge is to find a way to create change among all stakeholders in the supply chain regarding effective use of products, dosage, and implications of over-dosage and mis-application of N-P-K fertilisers.

A number of inadequacies regarding pesticide labels were observed in the stores visited:

- About 5% of labels were found to be in Vietnamese or Thai language, so are not likely to be legible to dealers or farmers;
- Only 13% of labels displayed the FRAC, HRAC, IRAC MoA codes for resistance management.
- Many of the labels were dominated by comic-cartoon style illustrations which do not contribute to knowledge about the product;
- Most labels feature photos of the supposed target pests which is acceptible if the photos are kept small. However, some labels feature non-target beneficial arthropods which indicates ignorance or a lack of regard for IPM by manufacturers and/or the regulator;
- Only 13% of labels displayed the Mode of Action Group number which is an essential requirement for resistance management.

Very few registered labels were compliant with the Cambodian label specification and these deficiencies should be addressed by the Regulator.

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Recommendations

Prior to this survey, it was known that farmers cite input dealers as the primary source of information and advice on the application of fertiliser and pesticide. Our survey revealed that input dealers also lack knowledge about the use of these products and stock products in accordance with farmer demand. So it largely amounts to "the blind leading the blind" with regard to the correct use of fertilisers and pesticides by farmers in Battambang province. Recommendations aricing from this study are as follows.

Extend the survey of input dealers to the major rice provinces of Cambodia

In a 2016 survey, Flor et al. (2020) found that Cambodian farmers observed different key pests of rice across the four provinces of Battambang, Kampong Thom, Prey Veng and Takeo. However, the data collected on pesticide use were not linked with data on observed pests. Hence, the pesticide recommendations could not be characterised as corresponding precisely to a specific pest or disease incidence. Key farmer customers should be included with input dealers to connect pesticide recommendations with the target pest in future investigations. This would provide useful information for the development of more accurate pesticide and fertiliser recommendations.

Recommendation 1: Extend the survey of agri-input dealers, together with their most influential farmer customers, to represent the main rice producing provinces in Cambodia. This would provide the foundation field data to support the development of digital advisory applications for recommendations on fertiliser and pesticide use.

Adaptation of digital advisory applications for Cambodian agricultural systems

Cambodia holds great potential for food production and has achieved food surplus through the agricultural sector. However, with other ASEAN countries, Cambodia has not reached production potential because of low productivity resulting from limited adoption of modern agricultural technology (Chou et al., 2023). Digital advisory applications play a critical role in enhancing access to information and bridging the gap between knowledge transfer and farming practices. Digital technology has the potential to assist smallholder farmers increase productivity and profitability. Digital advisory tools offer a cost-effective advisory service that promotes the adoption of new technologies, climate adaptation, and market accessibility.

Recommendation 2: Existing mobile phone applications using QR codes or built-in scanners should be adapted to Cambodian conditions to deliver pesticide and fertiliser recommendations and verify product safety in Khmer language. Examples of existing applications include BSWM FertRight[3] for site-specific nutrient rates and Balinashak Sahayika[4] for pest identification and management.

[3] https://www.bswm.da.gov.ph/bswm-helps/

[4] https://play.google.com/store/apps/details?id=com.khan.pesticide_assistance&hl=km

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QR Codes on labels to advise on safety of products and how to use them

QR codes on pesticide labels provide instant digital access to product safety data sheets, batch traceability numbers, manufacturing and expiry dates, and official usage instructions or instructional videos. Many jurisdictions now mandate or encourage these smart codes on labels to prevent counterfeiting and ensure safe application.

Recommendation 3: QR codes should be adapted for Cambodian pesticide labels to provide instant digital access in Khmer language, to product safety data sheets, batch traceability numbers, manufacturing and expiry dates, and official usage instructions or instructional videos.

Implementation of a process to improve compliance of Cambodian pesticide labels

A number of inadequacies regarding pesticide labels were observed in the stores visited:

- About 5% of labels were found to be in Vietnamese or Thai language, so are not likely to be legible to dealers or farmers;
- Many of the labels were dominated by comic-cartoon style illustrations which do not contribute to knowledge about the product;
- Many labels featured photos of the supposed target pests which is acceptable if the photos are kept small. However, some labels feature non-target beneficial arthropods which indicates ignorance or a lack of regard for IPM by manufacturers and/or the regulator;
- Only 13% of labels displayed the Mode of Action Group number which is an essential requirement for pesticide resistance management.

Recommendation 4: Provide technical assistance to the MAFF/DAL/GDA to review all existing and proposed pesticide labels to ensure that labels comply with the approved label format and specifically to:

- Remove comic-cartoon style illustrations which do not contribute to technical knowledge about the product;
- Photos of the target pests are not specified in the Cambodian pesticide label format and should be deleted. Such information can be provided by accessing the QR Code;
- Photos on the label are often misleading by depicting random images including those of beneficial organisms that should be preserved;
- Include the resistance management mode of action (MoA) Group/s as specified on the Cambodian label template.

On-line availability of the current registration status of fertilisers and pesticides

The approval status of pesticides in Cambodia is determined by the Ministry of Agriculture, Forestry and Fisheries (MAFF). A search was unable to find a link to a current, official MAFF list of registered fertilisers or pesticides.

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Recommendation 5: Encourage MAFF to make available the current "real-time" registration status of fertilisers and pesticides on-line.

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