Chapter II

Literature Review

2.1 History and distribution

Rice blast is one of the earliest recorded diseases in the world. Ou (1985) states that Soong Ying-Shin recorded rice blast as early as 1637 in China in his book "Utilization of Natural Resources" and originally ascribed the name rice blast to "rice fever disease".

In 1704, M. Tsuchiya indicated the occurrence of rice blast in Ichikawa Prefecture of Japan in his book published in1704. Following him, rice blast was recorded in Japan by S. Miayanaga in 1788, by N. Kojima in 1793, by T. Konishi in 1809, and subsequently by others (Ou, 1985). In Japan, rice blast has been generally calle as "Imochi" or "Iiri" (Kozaka, 1995).

In 1828, rice blast was reported in Italy, where it was called as *brusone*. In the United States, Metcalf recorded the incidence of rice blast in South Carolina in 1876 (Ou, 1985; Kozaka, 1995). In 1896, Shirai first confirmed that *Pyricularia oryzae*, which was named by Cavara in Italy caused rice blast. In 1971, Herbert succeeded in culturing the perfect state of blast fungus and named *Magnaporthe grisea* (Kozaka, 1995).

In Bhutan, rice blast was officially recorded in 1984, but remained at a low level, until 1994, when it caused localized damage in Geneykha, Thimphu. However, in 1995, the disease first appeared in epidemic form in Paro, while it seemed to have developed almost simultaneously in other parts of the country (Ministry of Agriculture, 1995; Thinly, 1998).

Rice blast is not only the earliest known plant disease, but also one of the most widely distributed diseases in all rice growing regions of the world (85 countries) causing considerable yield loss of about 70-90 percent and the losses due to blast are higher in temperate regions around the world (Mehrotra, 1980; Ou, 1985; Rangaswami, 1988;

Singh, 1990). The average severity of 1995 blast epidemic in Bhutan was as high as 66 percent (Ministry of Agriculture, 1995).

2.2 Symptoms

Many authors (Mehrotra, 1980; Ou, 1985; Rangaswami, 1988; Singh, 1990) have described the symptoms of different kinds of rice blast (leaf blast, node blast, neck blast and panicle blast). The fungus attacks all above ground parts of the rice plant, although leaves and the panicle are more commonly affected. The symptom on the leaf first appears as small bluish flecks, which subsequently enlarge into spindle-shaped spots, varying in length from 0.5 centimeter to several centimeters and about 0.1 centimeter to 0.3 centimeter in diameter. Fully developed lesions reach 1 centimeter to 1.5 centimeter long, and 0.03 centimeter to 0.05 centimeter broad, and typically develop a brown margin. The leaf spots are typically elliptical with more or less pointed ends. The identification of blast could be deduced from the lesions that have usually grey or whitish spots in the center and brown or reddish brown margins. In older leaves, they remain circular, but enlarge on young leaves up to several centimeters long and 1 centimeter broad. In older spots, the center becomes grey or almost straw colored.

Symptoms also appear on the clum, node and glumes. When the node is infected, the sheath pulvinus rots and turns black and in drying often breaks apart, remaining connected by the nodal septum only. This stage is known as node blast. Blackening extends both ways up to 1 or 2 centimeters infecting neck of the panicle causing black neck or neck blast. When the areas near the grain base are infected, the neck region becomes shriveled, inhibiting the complete or partial grain set, which ultimately breaks at the neck due to weakening of the neck tissues (panicle blast). Such panicle hangs down and can be easily distinguished from the distance. Panicle blast is the most damaging stage (Ou, 1985; Singh, 1990).

Ou (1985) found out that the predominant symptom of blast disease in any given area depends upon climatic conditions. In temperate regions, the presence of long periods of drizzle or light rain, leaf blast at tillering stage is often severe and may kill the plants completely, whereas in the tropics, seedlings in the nursery are more vulnerable, but after transplanting severe infections are seldom found. Neck rot occurs wherever environmental conditions are favorable.

2.3 Predisposing factors

Blast fungus is present all the time, but the development of epidemics is depended on number of factors, of which, favorable environmental conditions and susceptible varieties are considered to trigger disease development. A drought stress in the nursery bed combined with long dew periods can favor seedling blast. A period of light rainfall, low to moderate temperature, and long dew periods of 10 hours favors blast epidemics in the transplanted rice crop. The optimum temperature for blast spore germination is about 26°C to 28°C and maximum infection occurs at 24°C to 28°C under 16-24 hours of continuous wetting. High relative humidity of 93 percent and above is reported to be necessary for infection. Initial sources of fungus inoculum are required for epidemic development, which may be from infected seeds or from infected straws and stubbles from the previous season (Hashoika, 1965; Ono, 1965; Sadasivan *et al.*, 1965; Ou, 1985; Shen and Lin, 1994; Ministry of Agriculture, 1995).

Crop management plays a critical role in the development of blast epidemics. Supply of high dose of nitrogen fertilizer, their type and method of application regardless of the phosphorus and potassium supply, predispose the crop to blast. The excessive use of quick-acting nitrogen fertilizer, such as ammonium sulphate and applying all at once, cause severe rice blast (Ou, 1985; Kurschner *et al.*, 1992; Datnoff, 1994).

In temperate regions, the fungus overwinters in straw piles, haystacks and seeds. In the field, the commonest source of primary inoculum is the straw as the fungus survives in the infected straw for one or two years under dry conditions (Ou, 1985), but are killed by moisture and microbial activities, when buried in soil or is submerged in water (Rangaswami, 1988). Blast fungus is also known to survive through the infection of collateral hosts such as grasses and is likely to play a part in the epidemiology of the disease by acting as the primary source of inoculum (Mehrotra, 1980; Rangaswami, 1988; Singh, 1990).

2.4 Management options

It is recognized that rice blast management must account the potential of management practices that are known to influence the development of epidemics. These management practices include nitrogen status, water stress, irrigation water, silicon content, straw and stubble, time of planting, and planting density (Kozaka, 1965; Okamoto, 1965; Crill *et al.*, 1982; Ou, 1985; Kranz, 1986; Marchetti and Bonman, 1989; Kim, 1994; Shahjahan, 1994; Shen and Lin, 1994; Teng, 1994). Marchetti and Bonman (1989) assert that when the "disease tetrahedron" are met: virulent pathogen, susceptible host, favorable environment and sufficient time, the disease can reach epidemic proportions rapidly over large areas as it happened in 1978 and 1984 in Korea and Egypt, respectively. Successful disease management is best achieved by employing all available technologies, be they chemical, cultural, or genetic because the effectiveness of one disease control measure is enhanced when used with others. Thus, management of any plant disease is done most successfully by employing all of the technologies available rather than relying on one or two measures, a strategy encompassed by the concept of integrated pest management (Marchetti and Bonman, 1989).

2.4.1 Chemical control

Chemical control of blast may be necessary under certain conditions depending on weather, host susceptibility or pathogen compatibility and aggressiveness as well as pathogen population size, which determine the speed of blast development (Kamel and Sharkawy, 1989). Appropriate chemicals utilization can prevent blast disease from spreading and also reduce losses significantly because under favorable conditions blast fungal spores will not take more than 7-9 days to spread and break out in 10 to 14 days, while disease on leaves during the late seedling or tillering stage would break out within

3-5 days (Shen and Lin, 1994). They affirm that leaf blast is easy to control with chemicals, but once the disease reaches neck blast stage, then it requires more attention to the timing of application that needs accurate disease forecasting.

Development of highly effective systemic fungicides against blast has opened new possibilities for controlling the disease in more blast-conducive environment. The success of controlling rice blast by chemicals in Japan and China is accounted for the government support, comprehensive plant protection systems and well-organized communities that facilitate easy mobilization of farmers (Ou, 1985; Shen and Lin, 1994). Marchetti and Bonman (1989) have accredited that compounds, such as Tricyclazole and Pyroquilon are highly active that even seed treatment is effective against leaf blast; but farmers in developing countries rarely use fungicides, possibly because fungicides are purchased inputs. They went further in stating that if only small quantities are needed for seed treatment, then fungicide use might be economical, where blast is a significant constraint to production. However, fungicide usage is low in South Asia, South-East Asia, Africa, and Latin America due to higher chemical costs in relation to the crop value in the absence of epidemics and less technical support for the farmers to control rice blast (Froyd and Froeliger, 1994).

2.4.2 Cultural practices

The cultural control strategies of rice blast ought to be based on comprehensive understanding of the existing practices in relation to blast incidence and then explore the possibilities of manipulating these practices in such a way as to reduce the disease. However, the prime precondition should be to convince farmers that such manipulation is effective against disease management (Crill *et al.*, 1982). Manipulation of certain cultural practices known to reduce exposure to blast or suppress disease development is the time of planting, fertilization (especially with nitrogen), water management, and straw and stubble management. The increased availability of chemical fertilizers, changes in cultivation practices of improved varieties (shortened growing season) and expansion of irrigated area have made rice blast more likely to occur (Shen and Lin, 1994).

Planting time can have a marked effect on the development of blast within a rice crop. Date of sowing may influence the coincidence of weather favorable to rapid disease development and to the more blast-vulnerable growth stages of the rice crop: seedling/early tillering and flowering/milky stages. The main reason being that in early planting the air temperature is too low at tillering and too high at the heading stage for vigorous disease development (Hashioka, 1950; Kuribayashi and Ichikawa, 1952, cited in Ou, 1985). It was also reported by Chandramohan and Palaniswamy (1963) that the time of planting and severity of blast incidence was correlated with low temperatures, high humidity and heavy dews.

Availability of water affects the susceptibility of the host plants to blast. It has been suggested that the increased disease observed after water-deficient periods is due to longer dew periods resulting from rapid loss of radiant energy on clear nights during drought. In fact, experiments demonstrated that environmental conditions in drought-stressed plots were less favorable for infection during the stress period than those in fully watered plots (Bonman *et al.*, 1988). However, after the period of drought stress, greater disease development occurred in the previously stressed plants, probably because of increased susceptibility induced by water deficit (Gill and Bonman, 1988). In Japan, it was found that if the irrigation water is 20°C or below there is usually an increase in disease incidence (Ou, 1985). Water management practices that promote the maintenance of flood in lowland rice and the reduction of drought stress in upland rice; and regulation of irrigation water temperature could be a valuable component of integrated rice blast management and probably would increase production in the absence of disease.

Of the cultural practices known to encourage blast, excessive use of nitrogen is believed to increase susceptibility of rice to blast fungus. Many workers agree that excessive use of nitrogen induces severe outbreak of rice blast (Kozaka, 1965; Ou, 1985;

Huang and Miao, 1993; Ishiguro, 1994). The application of high dose of nitrogenous fertilizer in the absence of adequate resistance increases the severity of blast infection. The principle behind this concept is that the increasing application of nitrogen fertilizer makes the rice stems more succulent and the plant produces more leafy material making infection more probable. Ou (1985), Datnoff (1994) and Ishiguro (1994) state that split application of nitrogen is a better strategy for blast management than applying all at once as basal dose, but they warn that nitrogen topdressing at the early phase of leaf blast epidemic would cause more severe damage than at the late phase. In light of the foregoing facts, Datnoff (1994) stresses the importance of plant nutrition as one of the components of cultural method that can complement other strategies of biological and chemical management to reduce diseases in rice production.

The other aspect of cultural management is the straw and stubble management. Straw is used as cattle feed and produces farmyard manure (FYM). Farmyard manure forms one of the major components of maintaining soil fertility in the small-integrated subsistence farming systems of Bhutan. This may have direct effect on removing the primary inoculum source from the field, since it is unlikely that the hyphae and conidia remain viable after passage through the ruminant digestive tract (Reed, 1994), but the amount of nitrogen that is supplied by the farmyard manure needs to be investigated. On the other hand, straw is believed to be the principle overwintering organ and primary source of inoculum especially in the temperate regions (Ou, 1985). Proper management by removal of infected straw and burning or ploughing of stubble may eliminate or reduce the primary source of inoculum.

Tables 3 and 4 show that cultural practices as a group needs to be considered in rice blast management, relative to their effects on other key pests in the rice ecosystems because farmers are unlikely to directly adopt a practice for rice blast management alone (Teng, 1994). Du *et al.* (2001) furnish the evidence of effectiveness of weed management together with water, residue and chemical management limiting the source of inoculum. It should be noted that a small amount of initial infection can cause severe disease and more specifically with neck blast, where a single infection can cause severe crop loss (Mundt, 1994). Thus, a call for advocating the integrated crop management for successful pest and disease management.

Table 3. Matrix of cultural management practices for some pests

Cultural practice	Pest					
	BL	ShB	RTD	BPH	SB	Rodents
Early planting	+	+	+	-	-	-
Synchronized planting (community)	-	-	+	+	+	+
Crop rotation	-	+	+	-	-	-
Intercropping	-	-	-	+	+	-
Sanitation						
Remove affected plants	-	+	+	-	-	-
Burn/plough stubble	-	-	+	+	+	-
Remove host weeds	-	-	+	-	-	+
No ratoons	-	-	+	+	+	-
Proper water management	+	-	-	+	-	-
Proper fertilizer management	+	+	-	+	+	+
Proper plant spacing	+	+	+	+	-	-

Source: Teng, 1994.

'+' = Practice has known effectiveness.

BL = blast, SB = sheath blight, RTD = rice tungro disease, BPH = brown plant hopper, SB = stem borer.

Table 4. Summary of potential blast management technologies and their effect on rice blast in the temperate ecosystems

Management technology	Effect on rice blast
Cultivation of resistant varieties	
(a) Vertical:	
Monogenic cvs.	Complete control
Gene (variety) rotation	Complete control
(b) Horizontal: (polygenic)	
Partial resistance cvs.	Partial control
(c) Transgenic plants	Complete control
Soil amendment and deep ploughing	Reduce incidence
Using low seed rate in seedbed	Reduce incidence and severity
Sowing healthy seed	Reduce incidence and severity
Delay in planting	Reduce incidence and severity
Using low N_2-rate and in split	Reduce severity
Using high K-rate basally or as topdress	Reduce severity
Using low P-rate in high N applied field	Reduce severity
Maintain wet condition or flooding of the land	Reduce severity
Applying SiO_2 in low Si-content soil	Reduce severity
Destroying weeds and alternate hosts	Reduce severity
Wide spacing and orientation of rows	Reduce severity
Fungicidal treatment (seed and foliar)	Complete or partial control
Infected stubble/residue burning	Reduce severity
Biological method (not yet transferable)	Reduce severity
Integrated management	Reduce incidence and severity

Modified from Shahjahan, 1994.

2.4.3 Varietal resistance

The extensive adoption of high-yielding varieties has led to major changes in the varietal composition of rice cultivation and to a reduction in genetic diversity and an increase in vulnerability to insects and diseases (Bennett, 1994). Breeding of disease-resistant varieties probably is the most cost-effective, reliable and ideal technology in rice blast management for resource-poor farmers (Ito, 1965; Rosero, 1979; Marchetti and Bonman, 1989; Kim, 1994; Nelson and Leung, 1994). In some instances, resistant varieties have provided effective and durable disease control, but not in the case of rice blast, where the success is short-lived or not easily achieved. Pathogens, like their hosts, are subject to the laws of nature and are capable of evolving under the selection pressures brought to bear by changes in their hosts. Breeders can manipulate complete resistance to blast (also known as vertical resistance, specific resistance and true resistance), but it has been known to break down, sometimes with serious economic consequences. Ezuka (1979) provides the names of a number of resistant varieties in Japan that broke-down their resistance. Marchetti and Bonman (1989) illustrate numerous incidences of varietal breakdown, of which, the variety Reiho best exemplified the fallacy of durable resistance. Reiho had complete resistance to Japanese races upon its release in 1969 until 1973, when it was damaged severely by blast. Similarly, Reiho was later released in Egypt as a blast resistant variety in 1984; resistance was overcome that first year, resulting in blast epidemic of some consequence. Given the break down of resistance of varieties within several years after their release because of the increase in new blast races virulent to the resistance, Koizumi (2001) is of the opinion that the use of multilines is effective against blast, although their composition has changed, but ends contemptuously that available genes with complete resistance are limited and expensive.

In spite of many limitations to develop durable resistance to disease, plant-breeding process has to go on for the benefit of mankind. Shen and Lin (1994) put the burden of controlling rice blast in future on the rice breeders, since rice blast races are continually changing, where one kind of resistant variety may lose its resistance within few years and breeding a new variety requires at least 5-7 years. It is the variability and diversity in the pathogen that are responsible for overcoming previously effective disease resistant varieties and some fungicides (Ou, 1979; Disthaporn, 1994; Zeigler, 1998).

Kim (1994) believes that the use of disease resistant variety is a painless and inexpensive method for the farmer to control disease, except that he has to pay for the care and harvest. This is in tune to developing rice varieties with highly effective and durable resistance to rice blast, which is economically feasible and environmentally sound management approach in most blast-prone ecosystems. However, a dynamic change in race composition of the blast pathogen has often resulted in short-lived efficiency of host resistance in improved varieties. Thus, breeding for resistance to rice blast is directed toward enhancement of durability of host resistance, with genetically diverse blast resistance sources. Then, Kim (1994) concludes that one or two methods alone cannot provide satisfactory blast management. The introduction of resistant varieties and proper cultural practices, followed by timely application of fungicide will result in an ideal management of blast disease.

The knowledge of interaction between agricultural practices and blast would be useful in integrating blast management systems within the overall crop management practices (Kranz 1986; Shahjahan, 1994). For that reason, to achieve maximum benefit, a strong linkage between research, extension and farmers is inexorable to close the technology gap. However, the adoption of integrated crop management depends on farmers' understanding of ecology of crop and human systems, and the familiarity with the techniques, experiences and resources (Ho *et al.*, 1994).

2.5. Extension methods

Technologies made available to farmers need to be mobilized for diffusion across the target communities, through efficient extension service (Collinson and Tollens, 1994). The shift in new paradigm of extension approach from traditional one-way technology transfer to facilitation of technology development or adaptation, calls for the dialogue between various actors and agencies involved in supporting farmers to become more actively embedded in the agricultural knowledge and information systems (Christoplos and Kidd, 2000). However, in many countries, the "transfer of technology" model is still the customary practice for developing and spreading innovations (Deutsche Gesellschaft für Technische Zusammenarbeit, 1997) and Bhutan is no exception, where a variety of extension approaches from the conventional top-down approach to participatory approach are followed in varying degrees. Notwithstanding, the spate of new and emerging extension approaches, the literature review in this section covers the extension approaches within the scope of the study area, while every effort is made to relate the emerging concepts and approaches to the present context.

2.5.1 Individual farmer visit

As documented by Baxter *et al.* (1989), the staple method of agricultural extension in most developing countries, remains the individual farmer visit undertaken by the field staff and still one of the approaches used in public extension systems for basic information transfer and advisory functions, though financially unstable (Farrington *et al.*, 2002a). Farrington *et al.* (2002b) suggest the need to identify 'para-extensionists', who will travel out to villages to articulate local requirements to bring back advice on one hand, and on the other, to create appropriate team of adaptive researchers and extensionists, who will visit villages periodically for purposes of diagnosis, training, on-farm trials, and demonstrations that respond to local demand. However, in the absence of private extension systems in Bhutan, individual farmer visits by extension agents have been meeting that end to deliver agricultural extension to the farming communities. Extension agents during their farm visits, generally concentrate their efforts on informing and educating farmers about best farming practices, from crop husbandry to plant protection. The individual farmer visit facilitates monitoring and evaluation processes as well and provides feedback to the farmers and researchers. But, in some cases, extension agents are more interested in meeting their targets for extension visits, than having the extra effort of reporting back the problems and ideas reported by farmers and then following up to find a lasting acceptable solution. Nonetheless, individual farmer visit provides extension agents the better understanding of the lives of their clients and the prevailing situation of the environment they work.

2.5.2 On-farm trial

On-farm trial is born out of the failure of conventional top-down approach of technology transfer that yielded poor adoption rates by farmers. It was initially established to verify ready-made techniques in farmers fields, however, it did not lead to increase in adoption rate owing to its failure to address the diversity of farmers' socio-economic and institutional environment (Deutsche Gesellschaft für Technische Zusammenarbeit, 1997). Nevertheless, the overall effect on the knowledge and understanding gained through simulation of experimentation in farmers' fields, strengthens farmers' confidence in their own solutions and increases their ability to choose options and to develop solutions appropriate for their specific ecological, economical and socio-cultural conditions and circumstances (Hagmann *et al.*, 1996).

Though, on-farm research was the first effort to improve transfer of technology approach, whereby trials were established to verify ready-made techniques on farmers' fields and to demonstrate technologies to farmers, it did not fare well because the technologies were still being developed by researchers (Hagmann *et al.*, 1999). Unless the farmers are involved in all the processes of technology development and implementation, success is less likely. When farmers are involved in on-farm research based on their own need, decision and situation, Leeuwis (2000) agrees that small changes in the design of farmers' experiments can sometimes lead to a considerable increase in the accuracy of the conclusion drawn. Hagmann *et al.* (1999), Bellon (2001), and International Fund for Agriculture and Development (2003) emphasize the importance of joint evaluation of new technologies and practices by farmers and researchers to generate appropriate technologies that are often context-specific and require validation by farmers through experimentation. In view of many advantages, the

Ministry of Agriculture with the aim of getting closer to the farmers' socio-economics and bio-physical aspects, has initiated on-farm trials for developing disease resistant rice varieties and improved nutrient management in the farmers' fields (Renewable Natural Resources Research Centre-Yusipang, 2000).

2.5.3 Field day

Roberts (2000) asserts that the mass or group methods have been used as the part of extension programs over a long period. The group methods such as field days, demonstrations, seminars, workshops, farmer discussion groups and farm walks are aimed at providing a multiple audience for delivering research results or expert recommendations for farming activities.

Field days allow farmers to see what they have been hearing, thus, providing the opportunity for building the desired attitude towards the innovation (Swanson *et al.*, 1997). Once farmers become interested in a new technology, then field days offer discussion platform for establishing multilateral communication platform, exchanging experiences and gaining more specific and in-depth information about the technology. Field days coupled with group meetings promote the exchange of observations and the judgments on each experiment and its outcome (Deutsche Gesellschaft für Technische Zusammenarbeit, 1997) and reinforce their interest by viewing tangible results (Swanson *et al.*, 1997). Dorward *et al.* (2003) acknowledge the importance of evaluating technologies together with farmers prior to on-farm experimentation/ trial to speed up the process of technological development and its adoption. Since, evaluation is the critical stage in the adoption process (Swanson *et al.*, 1997), field day could be employed as one of the tools for participatory assessment of technology. Field day will facilitate farmers to analyze the impact of interventions on their systems and resources as a whole; and also together with researchers, suggest adaptations to the technology, which would ensure a better fit into the farming systems, prior to experimentation.

2.5.4 Farmers' training

International Fund for Agriculture and Development (1999) pronounces, "access to knowledge and capacity-building are variables that can transform rural life, by strengthening the ability of the rural poor to gain and retain their access to productive assets and the tools to manage them, and enabling them to act as protagonists in policy-making processes". Though, the statement implies to peoples' participation in the project cycle in rural development, the adoption of participatory approach as one of the facets of extension approach will bring about far reaching impact on the delivery of extension services.

Agricultural extension assists farmers through educational procedures in improving farming methods and techniques, thereby increasing production efficiency and income (Food and Agriculture Organization, 1996). Zaffaroni (1998) states that the main challenge of small farmers is the lack of training, which often lead to application of low technology systems that do not make full use of their resources, resulting into low yields per animal or unit land and high production cost per unit of product. Rice farming with respect to integrated crop management is knowledge intensive and complex. Van de Fliert *et al.* (1999) also agree that intensive farmers' training is needed to achieve the overall objectives of enhanced problem-solving and decision-making capacity under smallholder conditions to next impact at a larger scale, especially, in case of integrated pest management and integrated crop management, which are complex requiring location-specific, informed decision making and collective actions. Education and training enhance farmers' ability and willingness to make successful changes to their management practice (Kilpatrick, 2000). In the similar tone, Marcotte *et al.* (2002) have stressed the need of farmers' training as one of the key mechanisms in disseminating knowledge and technology to a broad audience and development of human resource capacity essential in enabling individuals in acquiring knowledge, skills/tools and abilities that will ultimately enhance productivity, income and livelihood.

On the other hand, Rogers (1996) is of the opinion that the conventional "transfer of knowledge" is inappropriate for many reasons, some of which are ideological, relating to cultural hegemony, while others are more practical, relating to motivating farmers to learn and to change, and still others have to do with the need to provide farmers with appropriate advice. Most of the training of extension agents is based on knowledge-transfer systems, which is hierarchical and authoritative and consequently will transfer such approaches to their own work in the field. However, he states that it can be improved or conducted in a participatory manner by encouraging farmers to choose subjects or contents that address their problems rather than the problems identified by the researchers and/ or the extension agents. Further, Taylor (1998) complements the importance of farmers' role in the development of education and training programs that affect them directly.