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ACHIEVMENTS OF OUTREACH RESEARCH FOR AGRO-TECHNOLOGY GENERATION AND TRANSFER: AN EXPERIENCE OF NEPAL

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ABSTRACT

Outreach research (OR) *per se* is an interphase between research and extension to deliver agro-technology to the end users. In Nepal, OR was started since early 1960s. Formally, Outreach Research Division (ORD) was established in 1995 under Nepal Agricultural Research Council (NARC). Objectives, outputs, and chronology of OR have been explained in details and passed through a series of changes that led to improve its working modality. ORD in the centre has facilitated uptake and up-scaling of fine tuned technologies in different agro-ecological domains with respect to technology verification in a participatory process involving public, private, and partnership approaches. This paper compares top down and bottom up model of agro-technology transfer. OR supports regional/agricultural research stations (R/ARS), community based organizations (CBOs), and government/nongovernmental organizations (G/NGOs) for monitoring and evaluation of participatory technology development related activities. In NARC systems, OR has been initiating a bottom up process for solving grass root level problems with active involvement of R/ARS, and G/NGOs thereby providing agrotechnology to extension for dissemination. OR has been actively involved in planning for solving on-farm issues that were received as feedback from different stakeholders in local, regional, and national level in a way that research should address those issues by generating technologies. The process of OR project formulation systems have been revealed vividly in a new paradigm of working modality. There have been a number technologies developed by the NARC in Nepal and most of them have been popularized in farmers' field. These technologies have been up scaled by research and development (R&D) partners in general and OR in special. Some of the technologies, which helped reduce poverty in the country as a result of massive dissemination in farmers' field, have also been cited.

Key Words: Outreach research, model, agro-technology, generation, verification, dissemination

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INTRODUCTION

The literal meaning of outreach is the activity of an organization that provides a service or advice to people in the community, especially those who can not or are unlikely to come to an office for help. In accordance with this concept, outreach research (OR) in agrotechnology perspective refers to a combination of technology generation, verification, and service activities conducted by researchers in collaboration with extension personnel coupled with concerned stakeholders' active involvement with end users/farmers. Thus, OR activities assist extension personnel to disseminate technologies and provide feedback to researchers to identify researchable problems and potentiality of various sectors of agro- ecological domains. In Nepal, the National Agriculture Research and Service Center (NARSC, 1987) has given a pragmatic definition of outreach i.e. "research outreach program is referred to as a combination of adaptive research and service activities conducted by researchers that assist extension personnel to disseminate technology. The adaptive research component is conducted by research personnel in collaboration with extension personnel in farmers' field to verify technology, and adapt it with necessary relevant research agencies to make the technology more useful to farmers".

In NARC there is Outreach Research Division (ORD) in the centre which has been coordinating outreach research activities in more than 50 OR stations that are delineated under the command areas of regional/agricultural research stations (R/ARS) in various agro-ecological domains across the country.

Virtually OR is a practical process of bringing together the knowledge and research capacity of concerned stakeholders both from public and private sectors in an interactive way. Researchers involved in agriculture have helped pioneer some of these processes through farming systems research, action research, participatory plant breeding, and a wide range of other participatory technology development (PTD) approaches over years. The impacts of such activities have been reflected in wide scale up scaling of new technologies at farmers' level across the country (Vaidya, 1996). The overall effects of PTD have been centered to increase agriculture productivity as a whole. Emerging alternatives and new actors both in the public and private sectors are involved in agricultural research and technology development in the country. In the present scenario, changes have been taking place with regard to socio-economics, institutional context of R & D, and funding sources as well. Therefore, OR should take a lead role with respect to PTD, information technology management, research collaboration, and co-ordination encompassing a wide range of new partners to make technology development and diffusion more relevant and effective.

METHODOLOGY

A brief chronology of OR development has been cited here to reveal the history of OR (Table 1).

Table 1. Chronology of Outreach Research in Nepal

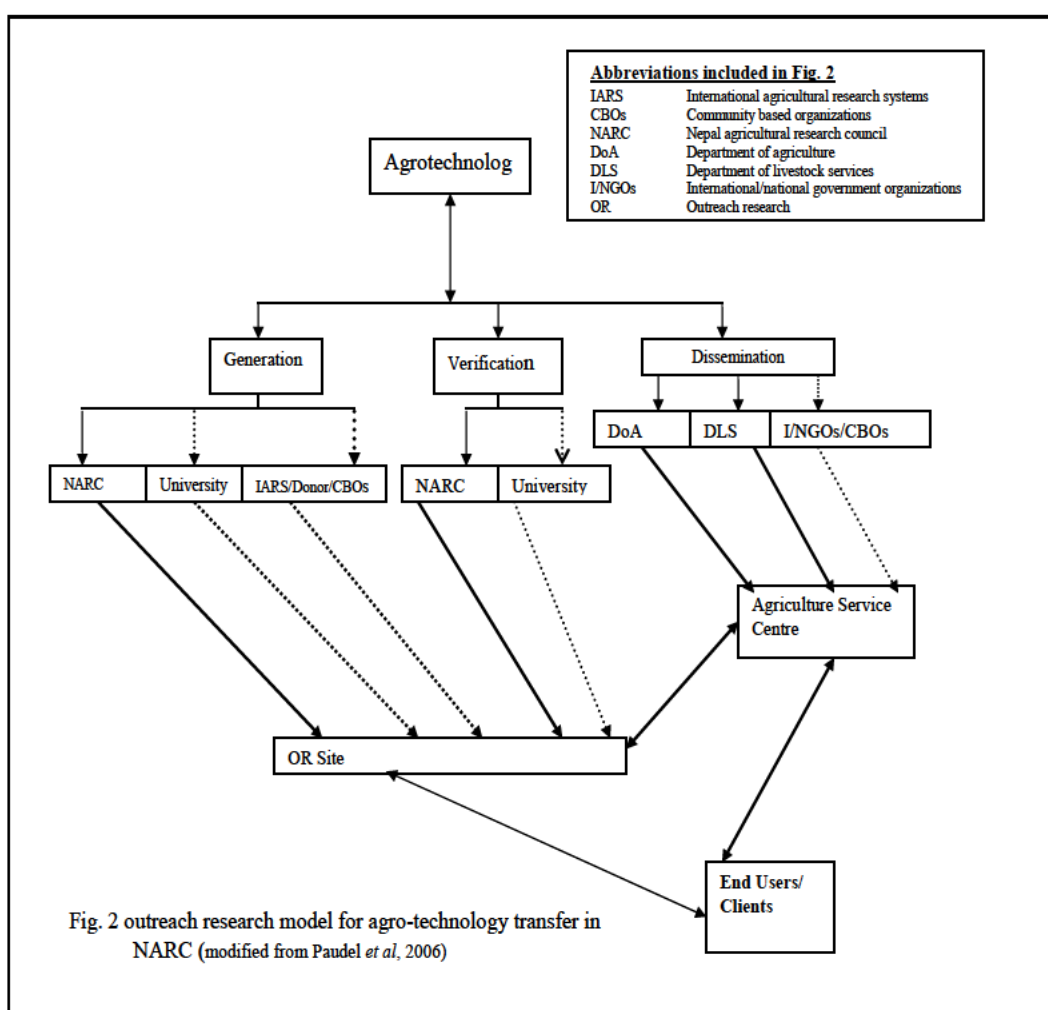
Year	Event
1960's	Initiation of Farmers' Field Trials (FFTs) from Parwanipur Agricultural Centre
1972	Beginning of minikits (seed kits) distribution by crop commodity programs
1977	Establishment of National Cropping Systems Program
1985	National Cropping Systems Program renamed into Farming Systems Research and Development Division
1985	Opening of OR sites under different Regional/Agricultural Research Stations (R/ARS) and commodity programs for establishing Farming Systems Research (FSR) sites
1985	Establishment of Socio-economic Research and Extension Division
1987	Issuance of policy guidelines for outreach research i.e. formal initiation of outreach research
1992	Formation of Co-ordination and Special Project Division
1995	Establishment of Outreach Research Division (ORD)
2004	Formation of Socio-economics and Agricultural Policy Research Division

Objectives

The mandate of OR is to plan, coordinate and strengthen outreach research programs at the national level. Outreach research initiates central level work plan, devices strategies, and various support activities related to PTD, supports R/ARS for monitoring and evaluation of PTD activities.

Technology verification is mainly done by NARC and university although there are institutions which are involved in this activity as well. These institutions engaged in technology verification include department of agriculture (DoA), department of livestock services (DLS) and some CBOs. The meeting point of technology verification is outreach research (OR) site of NARC where all the stakeholders gather together for verifying technology generated from research. Sometime work of technology verification is done by extension agencies. However, the task of technology verification by extension is not strong enough compared to that of NARC, because the prime mandate of extension is to disseminate fine tuned technology in a massive scale. In OR site there is a strong collaboration of farmers to test technology in their field where technology is verified with involvement of concerned stakeholders. If technologies are not

accepted by the farmers in the OR sites such technologies are either modified according to the demand of farmers or given feedback to researchers for further fine tuning. From technology verification point that is OR site of NARC, the disseminator should take technology to end users or the farmers. The OR site is the limitation of technology verification for NARC. Therefore, from OR site extension and related agencies are supposed to take technologies for dissemination in wider scale. In the proposed model, the role of NARC for technology generation and verification seems very strong compared to other institutions which have a weak role although it is anticipated that the role of extension in OR site should be more than that of research institutions.



Procedure for Implementing Outreach Research

Outreach researches are to be implemented in farmers' field. These procedures are the guiding principals of OR activities which are executed in the command area of R/ARSs. There are conditions when these procedures have been modified/changed according to the field conditions, availability of expertise, and socio-economic conditions where OR activities are implemented.

According to Pant (1990) site selection is a starting point from where OR is to be initiated in farmers' field thereby conducting surveys such as participatory rapid appraisal/rapid rural appraisal (PRA/RRA), house hold survey, transact walk, and other related tools which give information regarding farming systems research (FSR) sites. The priority for collecting information include crops, livestock, markets, support infrastructures, and so many objectively verifiable indicators that are necessary for selecting OR sites for agro-ecological domains in question. *Samuhik Bhraman* or group visit consisting of multidisciplinary team of experts, which take care of detail information in the sites, are conducted while implementing OR. *Samuhik Bhraman* is a regular phenomenon that keeps on describing site after a certain growing season so as to execute OR program effectively. The next step after *Samuhik Bhraman* is selection of participating farmers. Those farmers who are progressive and are willing to adopt new technologies for increasing productivity in their systems are selected as farmers cooperators or collaborating farmers for testing new technology in command areas of different R/ARS under various agro-ecological domains in OR sites of respective research stations. Collaborating farmers are identified through a number of interactions with extension personnel and researchers in the sites. Implantation of OR activities includes component technology trials such as varietal/breed, fertilizer application, and cropping system trials, insect, pest, and disease controlling super imposed trials, feed trials, and economic evaluation trials, so on and so forth. Farmers' field trials are monitored and evaluated by a multidisciplinary team of experts so that results obtained for addressing problems are ready to be tested in large scale in farming system sites for dissemination massively by extensionists.

In village level planning workshop (VLPW), the researchers sit together with farmers in the OR sites involving the important stakeholders such as extensionists, CBOs, and other related agencies that are concerned with the research in question. These stakeholders prepare need-based issues that should be addressed by research in the VLPW. In order to strengthen and pursue need based research works, the needs and problems of crops, animals, socio-economics, etc. are identified in a joint effort among researchers, extensionists, subject matter specialist, and farmers for a specified agro-ecological domain. After the identification of issues in VLPW, projects are prepared and discussed among the concerned stakeholders in outreach research planning and co-ordination workshop (ORPCW) where more fine tuning of research proposals than those of VLPW take place in respective R/ARS. Research proposals approved from ORPLCW are taken to regional technical working group (RTWG) where subject matter specialists make them more relevant to the research proposals to address regional issues. In the meantime, research proposals are given due consideration to avoid duplication and focus to address regional priorities by the experts in RTWG.

In NARC system, OR project proposals are screened through a series of bottom up planning process which give priority for project from village to national level according to the importance of the OR proposals in question. This assures the involvement of grassroots level workers and end users to assess the priority of the proposed research projects thereby checking redundancy and increasing efficiency of projects in a participatory involvement among farmers, researchers, and extensionists. The process of screening OR proposals channels to make solution related to problems aroused from farmers' field where feedback is collected from a grass root level stakeholders in R and D of agriculture. This process is actually a bottom up planning process having a joint ownership among public- private-partnerships program which could be a model for other R and D partners in agriculture.

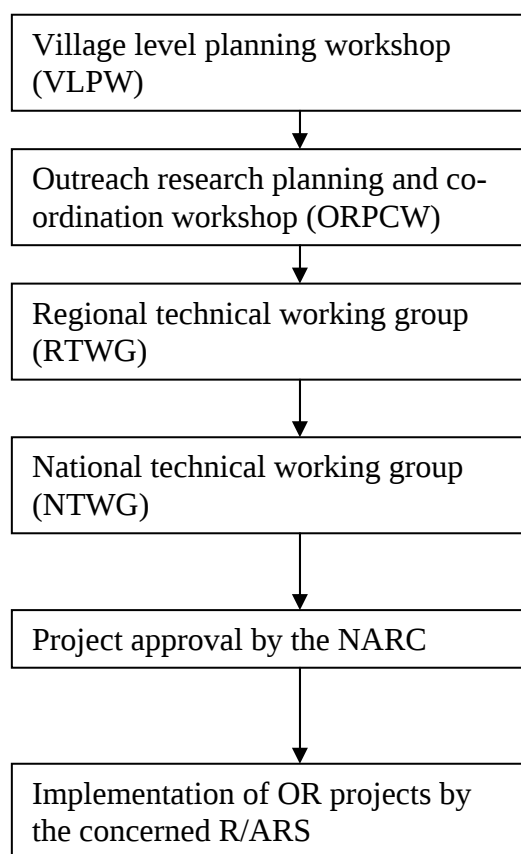


Fig. 3. A Bottom up approach of project planning processes in NARC

RESULT AND DISCUSSION

NARC has developed a number of technologies to be suited for different agro-ecological domains across Nepal.

- Resource conservation in rice and wheat is cost effective, environment friendly and time saving. Zero tilled seed drill technology seemed beneficial to farmers in *terai* condition. A farmer in Dallapur-4 Bardia district of mid western *terai*, had planted three *Bigha* (2/3 hectare) for wheat (var. Gautam) by using zero tilled seed drill machine versus tractor operated three times for wheat planting which costs Rs 1250 per operation. Now by using zero tilled seed drill he is doing one operation for planting wheat. According to his reporting the cost of land preparation in zero tilled practices can save up to 60% of the expenditure. Besides, the use of zero tilled seed drill can save at least 30% irrigation water. In terms of environment safety, it requires at least 10-liter diesel for one plowing of one *Bigha* land. Thus one can compute how much cost effective and environment safety, the resource conservation technology is? However it is highly imperative to develop understanding and strengthen coordination and linkage among all the partners involved in research, extension and development activities for the massive expansion of this technology among farmers in condition wherever feasible.
- Farmer in Bhaktipur, Sarlahi district in central *terai* planted *Boro* rice DR-11 put Common Carp fish in the month of Chaitra in the same field and got 4800kg ha⁻¹ rice yield and 200kg ha⁻¹ fish yield which they could sell at Rs 8/kg for rice and Rs 70/kg for fish, thus obtained Rs 52400.00 gross income per hectare (NARC Research Highlight, 2008)
- Experiments conducted in the farmers; field of Bara and Parsa central *terai* districts have shown that direct seeded rice by using power tiller drill has given Rs 25184.00 net profit as against Rs 13767 from traditional practices by planting rice variety Hardinath-1 (NARC Research Highlight, 2008) .
- Technology to minimize blast and foot-rot diseases of rice application of *Hinosan (Edifenphos)* @ 1.5 ml or *Kasugamycin* @ 2.0 ml per liter water at tillering and butting is recommended.
 - High value trout fish culture in cold water condition
 - The optimum sowing time for bean in Jumla (high hills >2000 m) condition was third week of June with spacing of 50 x 15 cm
- Open pollinated variety (OPV) Deuti and hybrid Gaurav variety of maize were comparable for grain yield and agronomic traits under Dukuchhap condition (1200-1500 m) of mid hills suggesting that there is no need of high input

demanding hybrid maize variety in mid hills condition of Nepal (Paudel *et al.*, 2007)

- Low cost technology of plastic house for off-season tomato production suitable both for rainy and winter season
- Optimum set planting time for off-season bulb onion production is from October to early November (mid *Asoj* to *Kartik*) in mid hills
- Pest management through locally available botanical pesticides such as Application of mustard oil @ 10 ml/kg grain is effective to manage bruchid (*Callosobruchus* sp.) in stored condition
- Shoot and fruit borer infestation in brinjal can be escaped if transplanting is done in early June in Katmandu valley
- Farmers in *terai* are utilizing swampy land by planting winter rice/*Boro* rice which otherwise would have remained fallow. Rice genotype BRRI Dhan 36 and Gautam have produced 5454 and 5400 kg/ha yield in winter season in farmers' field condition.
- As a result of massive dissemination of improved varieties of rice, maize, and wheat there has been tremendous impact of these varieties to increase productivity per unit area in Nepal. These are the three prime staple crops of Nepal and their contribution to reduce poverty in the country is very pivotal. Paudel *et al.* (2006) performed an impact assessment study of the improved varieties of these crops from 1994 to 2005 and found that the internal rate of return (IRR) of these varieties ranged from 84.04 to 105% (Table 2). This clearly indicates the importance of outreach research for disseminating and up scaling of improved technologies in the country. Revenue generated by the impact of dissemination of improved technologies in the farmers' field against expenditure incurred for R and D is very minimal. It again suggests the importance of research in general and outreach research in special in a country like Nepal where more than 65% of the rural population depends upon agriculture.

Table 2. A Comparison of expenditure, return, and internal rate of return (IRR) incurred in research for three cereal crops from 1995 to 2004 in Nepal

Crop	Expenditure in research (million NRs)*	Revenue obtained from improved variety (million NRs)	Proportion of research investment with respect to revenue obtained from improved variety (%)	Internal rate of return (IRR) %
Rice	167.12	151036.64	0.1106	105.00
Maize	182.89	38299.17	0.4775	84.04
Wheat	209.54	46337.73	0.4522	103.02
Total	559.55	235673.54	-	-

* Note: Exchange rate of 1 US\$ ~ 77.00 Nepalese Rupees (NRs) as of January 20, 2009

CONCLUSION

Outreach research is a bridge for linking research and extension to deliver agro-technology to farmers. There is a pattern of outreach research project formulation for solving on-farm related problems in a bottom up approach by consisting grass root level stakeholders. In Nepal, boundary of OR for validating generated technology by research is up to the outreach research site where technologies are tested in a joint collaboration involving researcher, farmer, and extensionist. Technology generation and verification is primarily done by NARC while technology dissemination is mainly taken by department of agriculture and department of livestock services. Oftentimes, I/NGOS and CBOs are involved for technology generation and dissemination in location specific domains where they are concentrated to R and D of agriculture as well. Internal rate of return (IRR) analysis for a decade during 1995-2004 on rice, maize, and wheat for expenditure incurred to the research of these crops against revenue generated by the impact of improved varieties of these crops indicated that there is an impressive IRR (84-105%) on research investments in Nepal.

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BIO-ECOLOGY AND MANAGEMENT OF FRUIT FLY AND EPILACHNA BEETLE IN BITTER GOURD

S. JHA

ABSTRACT

Bactrocera cucurbitae (Coq.) and *Henosepilachna septima* (Dieke) were found to be serious insect pests of bitter gourd. In case of *B. cucurbitae* (Coq.) egg incubation period varied from 2 to 9 days, larval period 5 to 20 days, pupal period 6 to 25 days and adult longevity 24 to 55 days. The rearing technique of fruit fly was standardized. For *H. septima* (Dieke) egg incubation period varied from 3 to 5 days, grub period 17 to 28 days and adult longevity 22 to 33 days. The predictive equation on maggot population of fruit fly on bitter gourd with minimum temperature during previous fortnight explained 82% variability. Such equation on previous week and week before previous week explained 68 to 78% variability. The equation on epilachna beetle population with minimum temperature could explain predictability up to 67% variability. Beyond 25°C temperature the population of epilachna beetle was found to be erratic. The population increment with increasing temperature was consistent when maximum temperature was below 25°C. In Kharif season bitter gourd fenvalerate 20EC, carbaryl 50 WP and triazophos 40EC were found to be most effective against fruit fly and epilachna beetle. An indigenous trap was also found to be effective for the control of *B. cucurbitae* (Coq.) and other species of fruit fly. Monitoring the pest population of fruit fly was also found important.

Key Words: Biology, pest surveillance and monitoring, population fluctuation, trap, management.

INTRODUCTION

Fruit fly, *Bactrocera cucurbitae* (Coq.) is a major pest of bitter gourd (Tan and Lee, 1982, Kapoor and Agarwal, 1983 and Mathew, Rekha and Gopalkrishnan, 1999). The female lays eggs in groups under the pericarp of young fruits and after hatching maggots bore into the tissues making lavities and feeding on it. Subsequently fruit rots and maggots jump out making big exit holes. epilachna beetle, *Henosepilachna septima* (Dieke) is also found to be destructive pest (Sreekala and Ushakumari, 1999). The adult and grub feed through out the growth stages skeletonizing the leaves and causing great debilitation to the crop. To suppress the insect pest population below economic injury level, management practices need to be developed through regular crop pest surveillance and monitoring. With a view to developing proper pest management strategy the present investigation was undertaken to study the biology, population fluctuation in relation to various abiotic factors, efficacy of different insecticides and trap designing for monitoring the insect pest of bitter gourd.

MATERIALS AND METHODS

The experiment- on biology of the fruit fly and epilachna beetle were conducted in who laboratory of Bidhan Chandra Krishi Biswabidyalaya (BCKV). The fruit flies were reared under wire net cylinder cages of 25cm diameter. The tops of the cages were covered with muslin cloth and all sides of the cages were covered with moist detachable cloth for maintaining humidity and partial darkness. The adult flies were fed on sugar solution (water, sugar, glucose and yeast in the ratio of 3: 1: 1: 1 respectively). For egg laying the fruits of bitter gourd were hollowed keeping 2mm thick pericarp. The cavity was filled with wet cotton covered with black cloth to make the eggs easily detectable. Food medium containing slurry of bitter gourd, brewer's yeast and glucose powder were used for rearing maggots.

The pairs of epilachna beetles were reared under series of glass chimneys placed on glass petri dishes. The chimney was covered with fine muslin cloth tied with rubber band. The adult beetles were fed with fresh tender bitter gourd leaves. The newly hatched grubs were reared individually for observation on each instar of the grub, prepupal and pupal stages.

The field experiments on seasonal incidence and efficacy of insecticides against insect-pests of bitter gourd were done for consecutive four seasons i.e. Kharif (June to October) and Summer (January to May) for two years i.e. 2002-03 and 2003-04 respectively, in the plot having an area of 2mx3m. All the recommended agronomic practices were followed to raise the crops.

The incidence of epilachna beetles was recorded as number of adult beetles and were correlated with meteorological parameters.

For fruit fly, the total harvesting season was divided into four plucks. The maggots per infested fruits were counted. These data were later converted to maggot population per fruit with the following formula (Gupta and Verma, 1992).

$$\text{Maggot population per fruit} = \frac{\text{No. of infested fruits} \times \text{No. of maggots per infested fruit}}{\text{Total numbers offruits sampled}}$$

The population of maggots obtained was correlated with meteorological factors for Previous Week (PW), Week before Previous Week (WPW) and Previous Fortnight (PF) on incidence of population.

Randomized Block Design used to test the efficacy of insecticides. There were eight treatments and four replications. The infestation of epilachna was recorded as number of adult beetles found 1, 3, 7 and 15 days after spraying. The infestation of fruit fly was recorded 7 and 15 days after spraying by counting the infested fruits from total harvested fruits and converting them into fruit infestation percentage.

An indigenous trap was also developed against fruit fly. Transparent plastic bottle was cut into two halves each with diameter of 7 cm. The two halves were used separately with a plastic plate of diameter 14 cm placed just above it to prevent entry of rain water. The mouth of the container was covered with a plastic funnel with a diameter of 7.5 cm and a tunnel of diameter 0.7 cm for smooth entry .of the flies. A minimum gap of 10-12 cm was maintained between the plastic cap and container. 200 ml of tari (fermented rice) a piece of red pumpkin and 5 drops of dichlorovos was poured into the container for attracting flies. The content used was removed weekly with fresh replacements. The set up was hanged to the frame of the creepers.

RESULTS AND DISCUSSION

i) Biology of the fruit fly, *B. cucurbitae* (Coq.)

The eggs of fruit fly, *B. cucurbitae* (Coq.) were slightly curved, elongated and tapering towards the ends. The colour was creamy white. Surface of egg was sculptured with numerous longitudinal ridges and grooves. Freshly laid eggs measured from 0.80 mm to 0.82 mm in length and 0.19 mm to 0.21 mm in width (Table 1) (Plate 1). The incubation period varied from 2 to 9 days (Table 2). The eggs were laid singly or in cluster. The first instar larvae were apodus, white translucent, a bit flattened dorsoventrally at both ends. The length varied 10m 1.51 to 1.54 mm and width varied from 0.28 to 0.30 mm (Table 1). The second instar larvae were broad tapering at both ends. The length varied from 4 to 6 mm and width varied from 0.80 to 0.82 mm (Table 1). The third instar larvae were yellowish in colour due to reserve food materials (Plate 2). The length varied from 8 to 10 mm and width 1.00 to 2.00 mm (Table 1). The total larval period was found to be 5 to 20 days (Table 2). The pupae were somewhat barrel shaped, anterior being narrower, freshly formed ones were yellowish and turned reddish brown later on. The length. varied from 4 to 5 mm and width from 1.50 to 2.50 mm (Table 1)(Plate 3). The pupal period varied from 6 to 25 days. Total duration from egg to adult stage was found to vary from 12 to 44 days (Table 2). The result was in conformity with Koul and Bhagat (1994) and Renjhen (1949), who reported the duration of larval and pupal period lengthened in winter and shortened in summer period.

Table-1. Measurement of different life stages of *Bactrocera cucurbitae* (Coquillett)

Life stage	Length (mm) Mean	Width (mm) Mean
Egg	0.81 (0.80 - 0.82)	0.20 (0.19 - 0.21)
Maggot		
Instar I	1.53 (1.51 - 1.54)	0.29 (0.28 - 0.30)
Instar II	5.00 (4 - 6)	0.81 (0.80 - 0.82)
Instar III	9.3 (8 - 10)	1.65 (1.00 - 2.00)
Pupae	4.35 (4.00 - 5.00)	1.90 (1.50 - 2.50)
Adult Male	14.60 (14.00 - 16.00)	7.10 (6.00 - 8.00)
Adult Female	16.80.(16.00 -18.00)	9.602 (9.00 - 10.00)

Data based on 10 observations, Figures in parenthesis are ranges.

Table-2. Duration of various stages in the life history of *Bactrocera cucurbitae* (Coquillett) during different period of the year

Period of study	Gene ration	Incubation period (days) Mean	Larval Period (days) Mean	Pupal period (days) Mean	Total duration from egg to adult (days) Mean	Days to start ovipositing after emergenic (days) Mean	Adult longevity (days)
15 July to 3 August, 2003	I	3.5 (2.5)	56.60 (5-7)	8.50 (6-11)	15.60	17	49.70
20 August 2003 to 2 October, 2003	II	7.3 (4-5)	16.30 (14.20)	18.50 (15-25)	42.10 (30-44)	37.80 (30-45)	28.40 (24.34)

Data based on 10 observations, Figures in parenthesis are ranges

ii) Biology of *H. septima* (Dieke)

The eggs of epilachna beetle, *H. septima* (Dieke) were cigar shaped and yellow in colour. The length varied from 1.50 to 1.75mm and width varied from 0.60 to 0.75 mm (Table 3). The incubation period varied from 3 to 5 days (Table 4). The grubs passed through four instars. They were brownish yellow in colour, campodeiform in shape and porcupine like general appearance. The length of 1st, 2nd and 4th instars varied to following ranges 1.50 to 1.75mm, 2.00 to 20.90mm, 3.15 to 4.20mm

and 5.00 to 7.00mm respectively. Similarly width varied from 0.50 to 0.66 mm, 0.95 to 1.25 mm, 1.20 to 1.55 mm and 2.00 to 3.00 mm respectively (Table 3). The total larval period was 17 to 28 days (Table 4). The newly formed pupae were shining yellow with brownish white markings on its dorsum. The colour of the pupae changed to dark red before adult emergence. The length varied from 4.00 to 5.00 mm and width varied from 1.50 to 2.50mm (Table 3). The pupal period varied from 6 to 25 days (Table 4). Total duration from egg to adult stage, was found to vary from 23 to 38 days (Table 4). The result was in conformity with Dhingra *et al.* (1983) and Jolly (1962). The lengthening of larval period in present experiment might be due to abundant food supply and the variation in period might be attributed to rearing technique, diet and environmental condition.

Table-3. Measurement of different life stages of *Henosepilachna septiva* (Dieke)

Life Stages	Length (mm) Mean	Width (mm) Mean
Egg	1.62 (1.50-1.75)	0.65 (0.75-0.60)
Grub		
Instar I	1.61 (1.50-1.75)	0.60 (0.50-0.66)
Instar II	2.45 (2.00-2.90)	1.12 (0.95-1.25)
Instar III	3.67 (3.15-4.20)	1.36 (1.20-1.55)
Instar IV	5.91 (5.00-7.00)	2.61 (2.00-3.00)
Pupal length	5.24 (5.00-5.60)	3.82 (3.50-4.25)
Male	5.38 (5.00-5.65)	4.898 (4.50-5.40)
Female	6.51 (6.20-6.80)	5.96 (5.75-6.20)

Data based on 10 observations Figures in parenthesis are ranges.

Table 4. Duration of various stages in the life history of *Henosepilachna septiva* (Dieke) during different period of the year

Period of study	Generation	Incubation period (days) Mean	Grub period (days) Mean	Pupal period (days) Mean	Total duration from egg to adult (days) Mean	Adult longevity (days) Mean
1st July, 2003 to 7th August, 2003	I	3.90 (3.00-5.00)	22.40 (17.00- 28.0)	4.10 (3.00-5.00)	30.40 (23.00- 37.00)	27.60 (25.00- 30.00)
25th August, 2003 to 1 st October, 2003	II	3.70 (3.00-4.00)	25.30 (20.00- 28.00)	5.0 (3.00-6.00)	34.00 (26.0-38.00)	27.50 (22.00-33.00)

Data based on 10 observations Figures in parenthesis are ranges.

iii) Seasonal incidence of insect pest of bitter gourd

The infestation of fruit fly *B. cucurbitae* (Coq.) on bitter gourd was found to be at peak during Kharif season with minimum or no infestation in summer season. In bitter gourd except maximum temperature all the weather parameters corresponding to different periodicities showed significant association with the population build up of fruit fly at harvest of bitter gourd. Minimum temperature during previous fortnight (PF), week before previous week (WPW) and previous week

(PW) showed 82%, 78% and 68% population variability. Here, rainfall corresponding to previous fortnight (PF) was good predictor of maggot population (Table 5 and Fig. 1, 2, 3). The results were in conformity with Fang and Chang (1984) and Su. (1986) who reported temperature and rainfall as important factors in population regulation. Paw, *et al.* (1991) reported more precisely that significant positive correlation lied with minimum temperature, rainfall and humidity which agreed with the present observation. The epilachna beetle, *H. septima* (Dieke) was active in Kharif season. However, less or no population was reported in summer season crop (Table 6). The observation was in conformity with Mondal (2001), who reported epilachna in bitter gourd during July to October. Similar report was made by Mote (1975), Kostha and Dhumdher (1980) and Rajagopal and Trivedi (1989) who observed peak population during August-September on bitter gourd. In the present study minimum temperature regime pertaining to previous 10 days can explain up to 67% variability in population build up (Fig 4). The change in epilachna beetle population was found to be erratic when the minimum temperature was beyond 25°C. The population increment with increasing temperature beyond 25°C was consistent as compared to below 25°C.

Table 5. Observation of fruit fly infestation as maggot population per fruit on bitter gourd at different seasons

Season	Date of Observation	Observation of four replications			Maggot population per fruit
		Total no. of fruits harvested	No. of affected fruits by fruit flies	No. of maggots/ affected fruit	
Kharif season	20.08.02	5	4	22.50	18.00
	28.08.02	10	7	20.50	14.35
	05.09.02	12	11	19.00	17.42
	13.09.02	6	4	19.75	13.17
Summer season	15.03.03	15	3	15.20	3.04
	23.03.03	20	5	13.50	3.37
	31.03.03	24	5	15.00	3.12
	08.04.03	25	7	14.25	3.99
Kharif season	24.08.03	7	5	20.50	14.64
	01.09.03	10	7	16.75	11.73
	09.09.03	5	3	17.00	10.20
	17.09.03	11	8	15.50	11.27
Summer season	13.03.04	18		16.00	2.67
	21.03.04	11	2	8.50	1.54
	29.04.04	20	5	15.00	3.75
	06.04.04	24	8	15.62	5.21

Table 6. Insect pests infesting bitter gourd at 10 days interval

Season	Date of Observation	Epilachna beetle/m ²
Kharif season	20.06.02	0.21
	30.06.02	0.29
	10.07.02	0.13
	20.07.02	0.71
	30.07.02	0.88
	09.08.02	0.46
	19.08.02	0.38
	29.08.02	0.63
	08.09.02	0.50
	18.09.02	0.29
	28.09.02	0.38
	08.10.02	0.50
Summer season	23.02.03	0.40
	05.03.03	0.08
	15.03.03	0.08
	25.03.03	0.21
	04.04.03	0.17
	14.04.03	0.29
	24.04.03	0.33
Kharif season	10.07.03	0.38
	20.07.03	0.25
	30.07.03	0.29
	09.08.03	0.21
	19.08.03	0.33
	29.08.03	0.42
	08.09.03	0.25
	18.09.03	0.46
	28. 09.03	0.58
	08.10.03	0.29

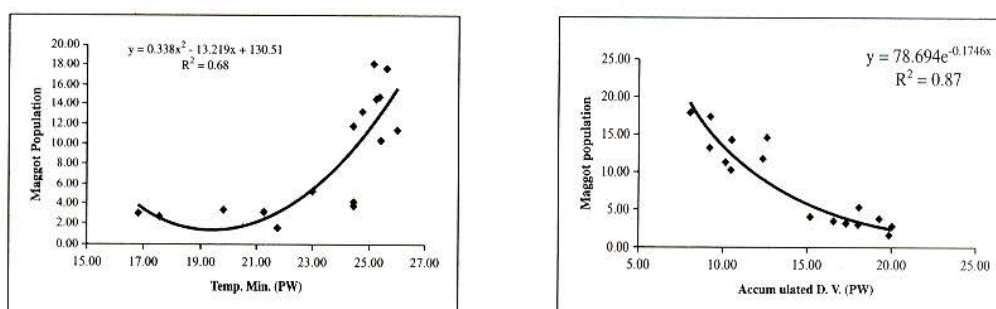


Figure 1 : Relationship between weather parameters corresponding to previous week (PW) of harvest and maggot population of bitter gourd.

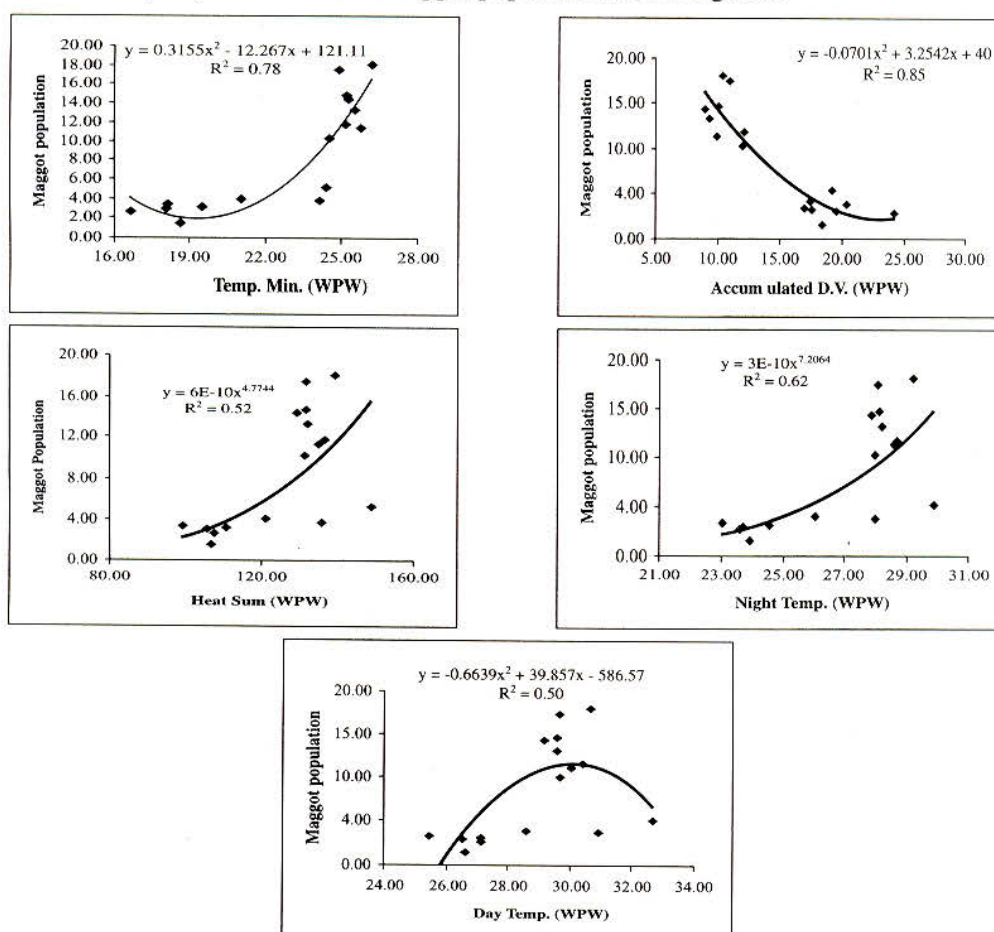


Figure 2 : Relationship between weather parameters corresponding to week before previous week (WPW) of harvest and maggot population of bitter gourd.

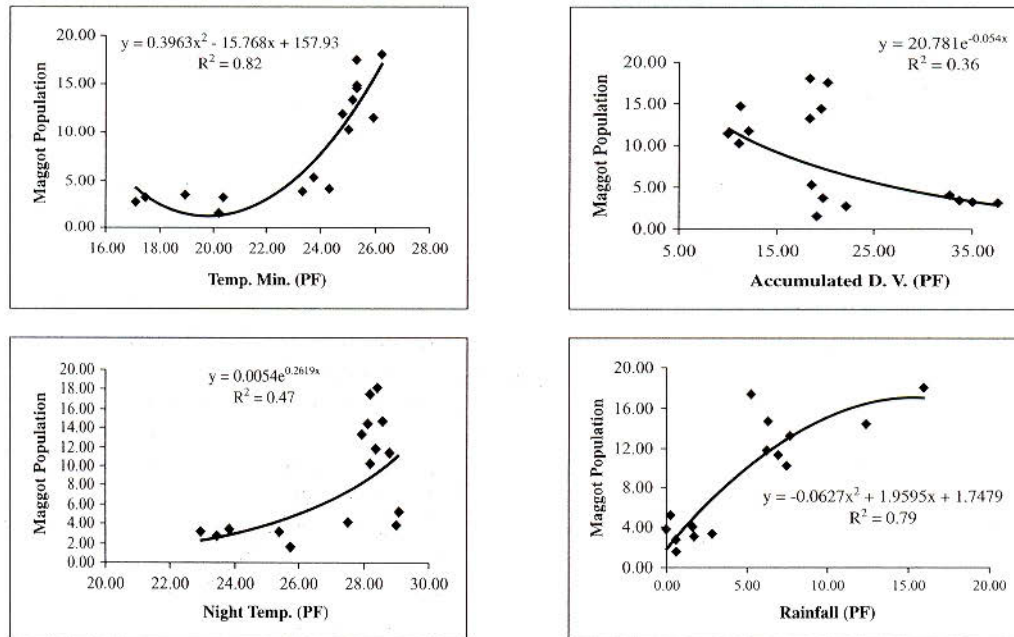
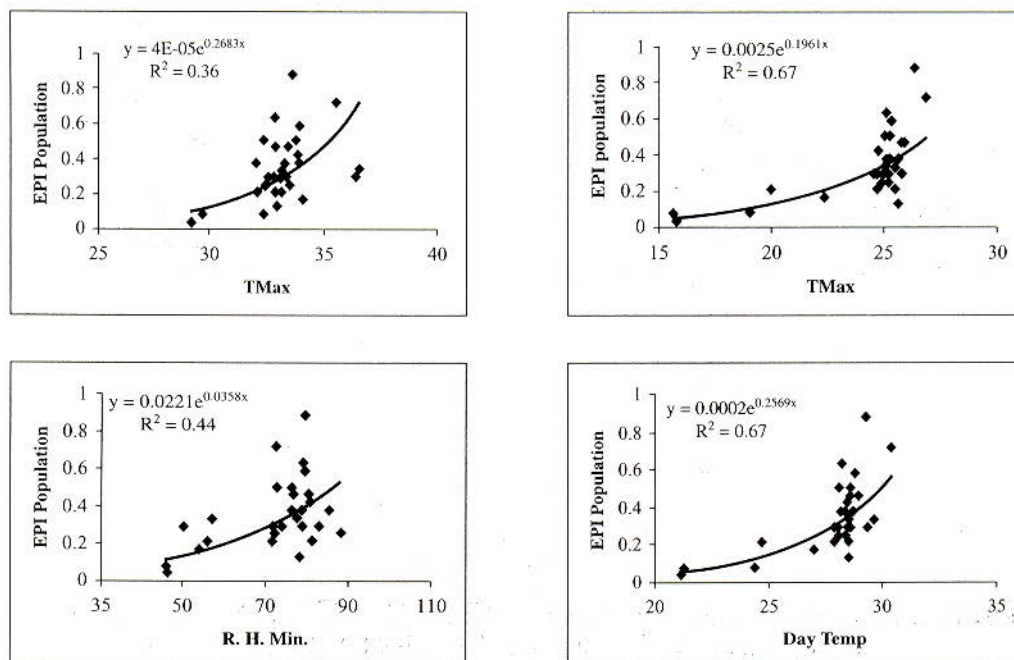


Figure 3 : Relationship between weather parameters corresponding to previous (PF) fortnight of harvest and maggot population on bitter gourd.



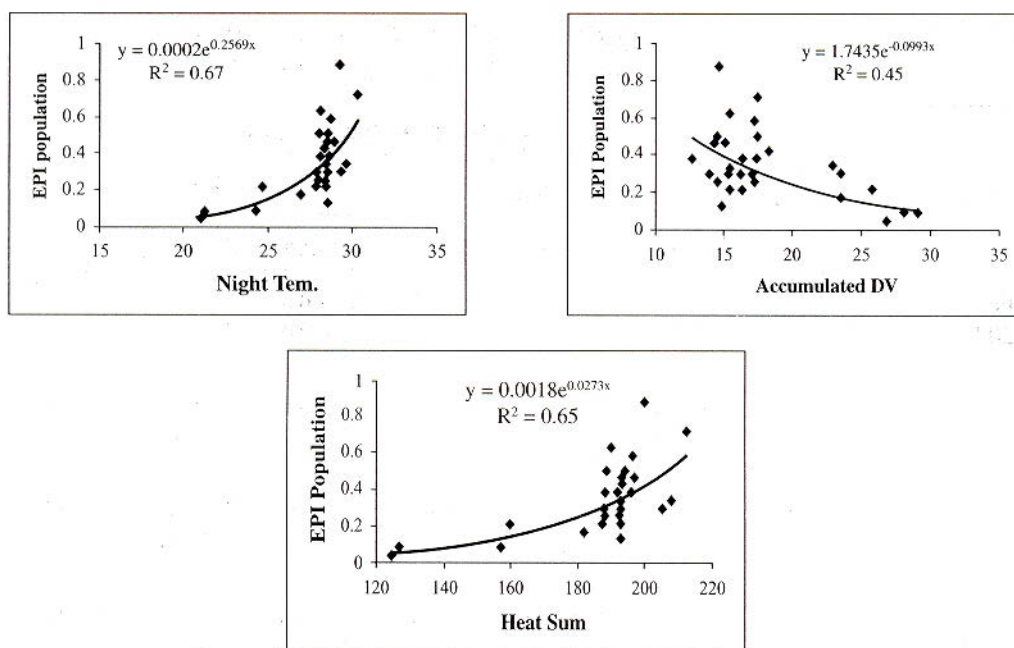


Figure 4 : Relationship between weather parameters corresponding to preceding 10 days and population build up of epilachna beetle on bitter gourd.

iv) Management of *B. cucurbitae* and *H. septima*

Efficacy of insecticide

Among the treatments, the overall best performance was found in case of triazophos 40EC and fenvalerate 20EC (Table 7) in controlling infestation of fruit fly. The result was in conformity with Reddy (1997) who confirmed the efficacy of triazophos among the most effective insecticide on bitter gourd. Carbaryl 50WP was also found to be effective against fruit fly. This result was in conformity with Bhatnagar and Yadav (1992). Carbaryl 50WP and fenvalerate 20EC were found to be effective against epilachna. The results were confirmed by Nagia *et al.* (1992) and Roa *et al.* (1989), who reported it as one of the best treatment (Table 8). The overall findings revealed that synthetic pyrethroids with quick knock down effect was followed by organophosphate insecticides in its effectiveness. Carbaryl was also found to be more or less effective. With the thrust in modern day agriculture for new, safer environment friendly pesticides, the use of botanicals is necessary approach. Present finding showed that performance of botanicals was not at all comparable with that of synthetic pyrethroid or organophosphate. The highest cost benefit ratio (1:36.19) was obtained in the plots treated with fenvalerate 20EC (Table 9).

Table 7. Pooled analysis (year 2002-03 & 2003-04) for effectiveness of different insecticides against fruit fly over two kharif season bitter gourd

Treatment	Dosage (a. i. %)	Mean, of fruit infestation (%) after 1st and 2nd spray					
		1st Spray			2nd Spray		
		7DAS	15 DAS	Mean	7DAS	15 DAS	Mean
Fenvalerate	0.5 ml / lit	23.75 a	18.90 ab	21.33	18.80 a	15.00 a	16.90
20 EC - T 1	(0.01 %)	(27.71)	(25.38)		(24.59)	(22.02)	
Carbaryl 50	2.5 gm/ lit	18.87 a	15.08 a	16.98	19.94 a	23.04 ab	21.49
WP - T2	(0.125%)	(24.28)	(22.34)		(26.27)	(26.28)	
Dichlorovos	0.75 ml /lit	32.04 a	21.90 ab	26.97	31.77 ab	27.97 ab	29.87
76EC-T3	(0.05%)	(33.48)	(27.33)		(33.87)	(31.21)	
Triazophos 40	1.5ml/lit	15.71 a	20.07 ab	17.89	23.38 a	18.65 ab	21.02
EC - T4	(0.06%)	(21.46)	(25.93)		(26.50)	(24.41)	
Endosulfan	2 ml / lit	30.73 a	29.34 ab	30.04	38.90 ab	35.93 b	37.42
35EC-Ts	(007%)	(33.25)	(32.65)		(35.65)	(36.64)	
Cartap	1 gm / lit	28.46 a	31.09b	29.78	28.84 ab	34.17 ab	31.52
hydrochloride	(0.05%)	(31.60)	(33.37)		(32.0 I)	(35.51)	
50 SP – T 6							
Azadirachtin	1 ml / lit	53.27 b	48.57 c	50.92	45.84 b	60.40 c	53.12
3000ppm-T7	(.0003%)	(48.91)	(45.54)		(42.47)	(54.83)	
Control- T8	-	83.27 c	62.08 c	72.68	78.56 c	74.99 c	76.78
		(73.54)	(54.12)		(70.21)	(65.23)	
CV%		10.02	8.19		9.67	9.75	
S.Em:t		5.22	3.86		4.98	5.1	
C.D. (P=0.05)		14.90	11.02		14.21	14.55	
C.D. (P=0.01)		19.92	14.73		19.00	19.46	

Figure in parenthesis are angular transformed (Arc sine -V percentage) values.

Table 8. Pooled analysis (year 2002-03 & 2003-04) for effectiveness of different insecticides against epilachna beetle over two kharif Season bitter gourd

Treatment	Dosage (a. i. %)	Mean of two seasons, eight replication					Mean	Mean of two seasons, eight replication				
		151 spray						2nd spray				
		Pre count	1 DAS	3DAS	7DAS	15 DAS		1 DAS	3DAS	7DAS	15 DAS	
Fenvalerate 20 EC - T1	0.5 ml / lit (0.01%)	1.75	0.00a (0.71)	0.00a (0.71)	0.50a (0.97)	1.25 ab (1.38)	0.43	0.00a (0.71)	0.00a (0.71)	0.63 ab (1.03)	1.13 (1.20)	
Carbaryl 50 WP - T 2	2.5 gm / lit (0.125%)	1.63	0.00a (0.71)	0.25a (0.84)	0.43a (0.97)	1.38 a (1.29)	0.51	0.00a (0.71)	0.00a (0.71)	0.38 a (0.89)	1.38 (1.33)	
Dichlorovos 76 EC - T3	0.75 ml / lit (0.05%)	2	0.38 a (0.89)	0.25a (0.84)	1.13a (1.20)	2.13 ab (1.61)	0.97	0.13a (0.78)	0.00a (0.71)	0.88 ab (1.13)	1.38 (1.32)	
Triazophos 40 EC - T4	1.5 ml / it (0.06%)	2.38	0.13a (0.82)	0.50b (0.97)	0.55 a (1.03)	1.75 ab (1.48)	0.73	0.38 ab (0.90)	0.25a (0.84)	0.88 ab (1.13)	1.00 (1.17)	
Endosulfan 35 EC - Ts	2 ml / lit (0.07%)	2.50	0.38a (0.91)	0.63bc (1.03)	0.88a (1.12)	2.63 b (1.74)	1.13	0.63b (1.02)	0.00a (0.71)	1.25b (1.31)	1.75 (1.46)	
Cartap hydrochloride 50 SP -T6	1 gm / lit (0.05%)	2	0.38a (0.90)	0.50b (0.97)	0.93a (1.18)	2.25b (1.63)	1.01	0.38 ab (0.91)	0.38a (0.90)	1.38b (1.32)	1.89 (1.39)	
Azadirachtin 3000ppm- T7	1 ml / lit (.0003%)	1.63	1.00b (1.20)	1.13c (1.22)	1.88b (1.54)	3.00 b (1.86)	1.75	1.00b (1.19)	1.38b (1.30)	2.25c (1.65)	2.13 (1.61)	
Control- T8	-	2.50	2.38c (1.58)	3.00d (1.86)	2.63b (1.74)	3.38b (1.94)	2.84	2.63c (1.70)	2.63c (1.72)	3.00c (1.86)	2.63 (1.75)	
CV%			6.36	5.04	6.69	5.27		7.12	5.88	6.16	NS	
S.Em:!			0.09	0.08	0.115	0.12		0.10	0.08	0.11	--	
C.D. (P=0.005)			0.26	0.23	0.39	0.34	"	0.28	0.23	0.31	--	
C. D. (P=0.001)			0.34	0.31	0.44	0.46		0.38	0.31	0.42	--	

Figures shown in the parenthesis are mean of square root transformed $[y = \sqrt{(x + 0.5)}]$ values of the four replications The numerical values represented are the mean population of eight replications.

Table 9. Cost-benefit ratios of different treatment over control against insect pest of kharif season bitter gourd

Treatment	Concentration (a/l%)	Quantity required (litres)	Mean crop yield (q/ha)	Crop yield increased over control (Q/ha)	Value of crop yield over control (Rs/ha)	Cost of insecticide (Rs/ha)	Labour costs for treatments (Rs/ha)	Total cost (Rs/ha)	Net profit over control	Cost benefit ratio
Fenvalerate 20EC T1	0.5 ml/lit (0.01%)	1.00 lit	94.54a	78.93	31,572.00	350.00	480.00	830.00	30,042.00	1 : 36.19
Carbaryl 50WP T2	2.5 gmlit (0.125%)	5.00 kg	84.17°	68.56	27,424.00	2250.00	480.00	3210.00	23,344.00	1 : 7.27
Dichlorov os 76EC T3	0.75 ml/lit (0.05%)	1.50 lit	52.50c	36.89	14,756.00	600.00	4810.00	1080.00	13,316.00	1 : 1.32
Tophos 40EC T4	1.5 ml/lit (0.06%)	3.00 lit	79.8b	63.77	25,508.00	2100.00	40.00	2580.00	22,788.00	1 : 8.38
Endosulfan 35EC Ts	2 ml/lit (0.05%)	4.00 lit	47 AOc	31.79	12,716.00	1400.00	480.00	1,880.00	10,836.00	1 : 8.83
Cartap hydrochloride 50SP T6	1 gm/lit	2.00 lit	47.82c	32.21	12,884.00	1700.00	40.00	2,180.00	10,704.00	1 : 4.91
Azadirachtin 3000 ppm T7	1 ml/lit (.0003%)	2.00 lit	30.00a	14.39	5,756.00	840.00	480.00	1320.00	4,268.00	1 : 3.23
Control T 8			15.61 c							
CV%			4.05							
S.E.m.:l:			3.23							
C.D. (P20.05)			9.22							
C.D. (P20.01)			12.32							

Value of bitter gourd @Rs. 400:00 per quintal, cost of labour @ Rs 60.00 per day, number of labour per spraying 2 men/ha.

Efficacy of indigenous trap

No appreciative results were found in case of traps with molasses and DDVP (Dichlorovos), tari, dry fish and pheromone capsule on sticky trap against fruit flies. The methyl eugenol trap was only effective to trap the male fruit of two species *B. zonatus* and *B. dorsalis* (Plate 5, 6) but they were not found to infest the bitter gourd. It led to development of indigenous trap which was effective against both male and female of *B. cucurbitae* (Plate 10, 11). The population of fruit fly was found to be positively correlated with significant values to average minimum temperature and rainfall (Table 10).

Table 10. Efficacy of indigenous trap in attracting fruit flies with emphasis on melon fruit fly *B. cucurbitae* and correlation with climatic parameters

Period of observation	T.max. (°C)	T. min. (°C)	Rainfall (mm)	Total population /3 trans	Average Popl.	<i>B. cucurbitae</i> / 3 traps	Average Popl.
15.05.03 to 21.05.03	37.07	24.44	-	22	7.33	7	2.33
22.05.03 to 28.05.03	36.17	25.27	6.92	23	7.67	4	1.33
29.05.03 to 04.06.03	38.25	27.08	-	19	6.33	5	1.67
05.06.03 to 11.06.03	35.90	23.82	4.11	18	6.00	7	2.33
12.06.03 to 18.06.03	36.85	25.84	4.68	22	7.33	10	3.33
19.06.03 to 25.06.03	31.54	24.25	36.71	20	6.67	8	2.67
26.06.03 to 02.07.03	33.44	24.61	11.12	19	6.33	5	1.67
03.07.03 to 9.07.03	33.92	25.50	1.40	18	6.00	7	2.33
10.07.03 to 16.07.03	33.51	24.95	7.94	19	6.33	4	1.33
17.07.03 to 23.07.03	33.62	25.17	4.61	18	6.00	8	2.67
24.07.03 to 30.07.00	33.21	24.82	21.77	28	9.33	11	3.67
31.07.03 to 06.08.03	32.21	24.62	3.38	30	10.00	9	3.00
07.08.03 to 13.08.03	33.68	25.32	7.70	31.00	10.33	9	3.00
14.08.03 to 20.08.03	33.47	25.55	1.65	26	8.67	10	3.33
21.08.03 to 27.08.03	33.97	24.64	7.48	29	9.67	12	4.00
28.08.03 to 03.09.03	32.48	24.68	6.11	30	10.00	11	3.67
04.09.03 to 10.09.03	33.12	25.80	8.45	27	9.00	9	3.00
11.09.03 to 17.09.03	33.32	26.04	0.94	16	5.33	6	2.00
18.09.03 to 24.09.03	33.95	25.67	2.14	25	8.33	8	2.67
(Contd...)							
25.09.03 to 01.10.03	33.88	24.81	11.62	20	6.67	5	1.67
16.02.03 to 22.02.04	31.17	15.75	-	5	1.67	2	0.67
23.02.04 to 29.02.04	32.74	16.85	-	6	2.00	1	0.33
01.03.04 to 07.03.4	34.12	15.65	-	4	1.33	2	0.67
0.8.03.04 to 14.03.04	31.78	18.84	1.28	10	3.33	4	1.33
15.03.04 to 21.03.04	36.74	22.15	-	12	4.00	2	0.67
22.03.04 to 28.03.04	38.30	24.48	0.05	15	5.00	3	1.00

Period of observation	T.max. (°C)	T. min. (°C)	Rainfall (mm)	Total population /3 trans	Average Popl.	<i>B. cucurbitae</i> / 3 traps	Average Popl.
29.03.04 to 4.04.04	36.10	24.11	-	20	6.67	5	1.67
05.04.04 to 11.04.04	34.50	22.37	7.67	23	7.67	8	2.67
12.04.04 to 18.04.04	39.18	26.44	-	18	6.00	4	1.33
19.04.04 to 25.04.04	36.08	23.72	8.15	21	7.00	9	3.00
26.04.04 to 02.05.04	34.80	24.20	-	19	6.33	7	2.33

Correlation

Name of the insect pest	T. max. (Avg.)	T. min. (Avg.)	Rainfall (Avg.)
Fruit fly (Total number)	r = -0.01	r = 0.75*	r = 0.34
<i>B. cucurbitae</i>	r = -0.18	r = 0.56*	r = 0.38*

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COMBINING ABILITY OF GRAIN CHARACTERS IN AN 8x8 DIALLEL CROSS OF RICE (*Oryza sativa* L.)

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ABSTRACT

An investigation was done to examine combining ability for grain characters in rice using an 8-parent diallel cross excluding reciprocals during Transplanted Aman season, 2002. Both additive and non-additive genetic components were important in the expression of grain characters. Except for embryo weight there was preponderance of additive genetic component. BRRI dhan28, Minikit, IR65610-38-2-4-2-6-3 and Amol3 were good general combiners for the development of rice varieties with long, slender and thin grain. ZhongYu7, IR8 and BR4828-54-4-1-4-9 showed good general combining ability for the development of bold grain rice varieties with high endosperm weight. Since small size of upper and lower empty glumes are preferred in rice, IR65610-38-2-4-2-6-3 and ZhongYu7 were good general combiners for empty glume length. IR8 was found good general combiner for high endosperm weight. Estimates of specific combining ability showed that the best specific cross combinations for long grains and long kernels were 'IR8 X IR65610' and IR8 X Minikit', respectively. 'BR4828 X ZhongYu7' for wide, thick grain and wide kernel, 'BR4828 X IR8' for thick kernel, 'BR4828 X Minikit' for slender grain and slender kernel, 'BR4828 X IR65610' for thin grain and thin kernel, 'IR8 X Minikit' for high endosperm weight displayed maximum specific combining ability. In case of endosperm weight, poor X poor, good X good and poor X good crosses produced both positive and negative effects reflecting the difficulties of increasing endosperm weight in rice. Development of long grains with thin breadth and thickness was found difficult due to complex gene action.

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Key Words: Combining ability, diallel, grain characters, rice, *Oryza sativa* L.

INTRODUCTION

In the past, modern rice variety development efforts have proceeded for high grain yield. The importance of grain parameters on the acceptability of modern variety is emphasized now. People differ largely in respect of size and shape of the grains. Bold grains are preferred by people in the southern districts while fine grains in the northern region of Bangladesh. Furthermore, export market favours long, slender grain rice. For the improvement of these grain characters, investigation on their genetic make up is important. Combining ability analysis is a powerful tool in identifying the nature of gene action. Information on combining ability for grain characters in rice is scanty. The present study was, therefore, undertaken to assess the nature and extent of gene action on different grain characters through diallel analysis.

MATERIALS AND METHODS

Eight genotypes of rice viz. BRRI dhan29 (BR29), BR4828-54-4-1-4-9 (BR4828), BRRI dhan28 (BR28), IR8, Amol3, IR65610-38-2-4-2-6-3 (IR65610), Minikit and ZhongYu7 with different grain characters were crossed in an 8 X 8 diallel design excluding reciprocals. Twenty-eight F_1 s and 8 parents were grown in a randomized complete block design with three replications at Bangladesh Rice Research Institute, Gazipur in Transplant Aman season, 2002. Twenty-five day old seedlings were transplanted @ single seedling/hill with a spacing of 25 X 20cm. The unit plot size was 2m X 2 rows. Data of 10 grains from 10 randomly selected panicles were recorded on grain length (mm), grain breadth (mm), grain thickness (mm), kernel length (mm), kernel breadth (mm), kernel thickness (mm), upper empty glume length (mm), lower empty glume length (mm) and endosperm weight (g) and embryo weight (mg). Grain and kernel length, breadth and thickness were measured by a digital slide caliper while micrometer was used for the measurement of upper and lower empty glume length. Endosperm and embryo weight were taken using sensitive electronic balance. Moisture content of endosperm was measured by moisture meter and adjusted at 14%. Griffing's (1956) method 2, Model 1 (Fixed effects model) was used for combining ability analysis of the grain characters.

RESULTS AND DISCUSSION

Preliminary analysis of variance (ANOVA)

Preliminary analysis of variance indicated highly significant mean squares for all the grain characters studied which indicated strong differences among all the genotypes validating further analysis (Table 1). Genotypes were partitioned into parents (P), crosses (F_1)

and parents vs. crosses items. Mean squares due to parents and crosses for all the characters implicated significant differences among the parents and crosses separately, which were also necessary for further Griffing's approach of diallel analysis. Highly significant mean squares due to P vs. F₁ item were obtained for kernel breadth and upper empty glume length only. The results indicated significant overall heterosis in the cross combinations for these two characters.

Table 1. Preliminary analysis of variance (MS) for different grain characters in an 8-parcent diallel cross of rice

Item	Df	Grain length (mm)	Grain breadth (mm)	Grain thickness (mm)	Kernel length (mm)	Kernel breadth (mm)	Kernel thickness (mm)	Upper empty glume length (mm)	Lower empty glume length (mm)	Endosperm weight (g)	Embryo weight (g)
Replication	2	0.026	0.0082	0.0056	0.0051	0.0004	0.0018	0.1276**	0.087*	4.69*	0.007
Genotype	35	0.797***	0.1860***	0.0227***	0.4730***	0.1484***	0.0219***	0.0907***	0.125***	17.61***	0.011***
P (Parent)	7	0.953***	0.3843***	0.0394***	0.4952***	0.3063***	0.0383***	0.1035***	0.107**	28.65***	0.006*
F ₁	27	0.785***	0.1408***	0.0191***	0.4825***	0.1120***	0.0183***	0.0822***	0.133***	15.38***	0.013***
P vs. F ₁	1	0.043	0.0196	0.0037	0.0606	0.0253**	0.0050	0.2286***	0.036	0.734	0.008
Error	70	0.032	0.005	0.0019	0.0214	0.0024	0.0017	0.0190	0.020	0.985	0.003

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

ANOVA for Combining Ability

The mean squares due to General combining ability (GCA) and Specific combining ability (SCA) were significant for all the grain characters indicating involvement of both additive and non-additive genetic components in the inheritance of these characters (Table 2). Additive and non-additive components in the inheritance of grain length and grain width were reported by Kuo and Liu (1986). Singh (1982) reported that both additive and non-additive gene effects were important for grain characters in a six-parental diallel analysis in rice. The estimates of components of GCA variances (σ^2_g) were larger than the corresponding SCA variances (σ^2_s) for all the characters except embryo weight indicating preponderance of additive genetic components in the inheritance of these grain characters except embryo weight. Singh and Singh (1985) and Panwar and Paroda (1983) reported predominance of additive effects for grain length and grain breadth in an 8 X 8 half diallel cross in rice. Pedigree method of breeding would be suitable for all of these characters showing preponderance of additive genetic components.

GCA effects

Table 3 presented the GCA effects of the parents for different grain characters. BRRI dhan28, Minikit, IR65610-38-2-4-2-6-3 and Amol3 showed significantly positive GCA effects for grain and kernel lengths but significantly negative GCA for grain and kernel breadths except IR65610-38-2-4-2-6-3 which showed nonsignificant kernel length but positive direction. For grain and kernel thickness, these four varieties also produced significantly negative GCA effects except Amol3. BRRI dhan28, Minikit, IR65610-38-2-4-2-6-3 and Amol3 were therefore good general combiners for the development of long, slender and thin grained rice varieties. On the other hand, ZhongYu7, IR8 and BR4828-54-4-1-4-9 exhibited either significantly negative or nonsignificant positive GCA for grain and kernel length along with significantly positive GCA for grain and kernel breadth and thickness. These genotypes thus showed good general combining ability for the development of bold grain rice varieties. BRRI dhan29 exhibited negatively significant length, breadth and thickness for both grain and kernel. Hence, BRRI dhan29 was a poor general combiner for the increase of grain length but good combiner for thin grains.

Minikit, IR8 and Amol3 exhibited significantly positive GCA effects for upper and lower empty glume lengths while IR65610-38-2-4-2-6-3 and ZhongYu7 showed significantly negative GCA effects for these characters. Since small size of upper and lower empty glumes are preferred in rice, IR65610-38-2-4-2-6-3 and ZhongYu7 would be the good general combiners for empty glume length. On the contrary, high endosperm weight is one of the important parameters as it may contribute to increase the husked grain yield in rice. BR4828-54-4-1-4-9, IR8, Amol3 and ZhongYu7 were good general combiners to increase the endosperm weight while BRRI dhan29, BRRI dhan28, IR65610-38-2-4-2-6-3 and Minikit were poor general combiners for high endosperm weight.

Table 2. Analysis of variances (MS) of combining ability for grain characters in an 8-parent diallel cross of rice

Item	Df	Grain length (mm)	Grain breadth (mm)	Grain thickness (mm)	Kernel length (mm)	Kernel breadth (mm)	Kernel thickness (mm)	Upper empty glume length (mm)	Lower empty glume length (mm)	Endosperm weight (g)	Embryo weight (g)
GCA	7	1.129***	0.287***	0.0335***	0.6718***	0.2259***	0.0308***	0.0942***	0.1568***	22.29***	0.0100***
SCA	28	0.050***	0.006***	0.0011*	0.0291***	0.0053***	0.0014**	0.0142**	0.0131*	1.77***	0.0022**
Error	70	0.011	0.002	0.0006	0.0071	0.0008	0.0006	0.0063	0.0067	0.328	0.0008
Components											
σ^2g		0.107	0.028	0.003	0.064	0.022	0.003	0.008	0.014	2.05	0.0008
σ^2s		0.039	0.004	0.000	0.022	0.005	0.001	0.008	0.006	1.44	0.0014
$\sigma^2g;\sigma^2s$		2.78	7.15	7.20	2.92	4.87	3.44	1.01	2.26	1.43	0.557

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 3. Estimates of general combining ability (GCA) effects for different grain characters in an 8-parcent diallel cross of rice

Parents	Grain length (mm)	Grain breadth (mm)	Grain thickness (mm)	Kernel length (mm)	Kernel breadth (mm)	Kernel thickness (mm)	Upper empty glume length (mm)	Lower empty glume length (mm)	Endosperm weight (g)	Embryo weight (g)
BRRI dhan29	-0.160**	-0.032*	-0.024*	-0.066*	-0.034**	-0.033**	-0.054	-0.053	-0.547*	-0.045**
BR4828-54-4-1-4-9	-0.014	0.191***	0.056***	-0.061*	0.177***	0.054***	-0.043	0.005	1.920***	0.002
BRRI dhan28	0.136**	-0.116***	-0.039**	0.118**	-0.115***	-0.041***	-0.023	-0.010	-1.287***	0.002
IR8	0.011	0.185***	0.068***	0.027	0.156***	0.063***	0.058*	0.105**	1.975***	0.061***
Amol3	0.483***	-0.111***	0.015	0.325***	-0.082***	0.027**	0.178***	0.151***	0.765**	0.003
IR65610-38-2-4-2-6-3	0.075*	-0.135***	-0.064***	0.056	-0.122***	-0.062***	-0.057*	-0.098**	-1.776***	0.009
Minikit	0.163**	-0.197***	-0.073***	0.160***	-0.172***	-0.065***	0.073*	0.122**	-1.465***	-0.033**
ZhongYu7	-0.693***	0.215***	0.062***	-0.560***	0.192***	0.055***	-0.131***	-0.221***	0.415*	0.001
SE(g)	0.031	0.013	0.0074	0.025	0.008	0.007	0.024	0.024	0.169	0.0086
SED(g-g)	0.046	0.019	0.0111	0.038	0.013	0.011	0.036	0.037	0.256	0.013

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

For development of long slender grains, IR65610-38-2-4-2-6-3 was the best general combiner followed by BRRI dhan28 and Minikit. On the other hand, ZhongYu7 was the best general combiner followed by BR4828-54-4-1-4-9 for development of bold grain rice variety.

SCA effects

The SCA effects of 28 cross combinations for different grain characters are presented in table 4. The cross combinations 'BR4828 X BR28', 'IR8 X IR65610' and 'IR8 X Minikit' (poor X good) produced significantly positive SCA effects for grain and kernel length due to additive-dominance interaction. 'BR28 X Amol3' cross combination showed additive-additive gene interaction in producing significantly positive SCA effects for grain and kernel length because both the parents were good general combiners for these traits. Four cross combinations composed of three poor X good and a good X good showed significantly good specific cross for thin grains. On the other hand, 'BR28 X Amol3' reflected strong positive SCA effect for increased grain breadth having both poor combiners for wider grain, which was due to overdominance effect. Two hybrids 'BR4828 X IR65610' (poor X good) and 'BR28 X IR8' (good X poor) showed good specific cross for thin grain while only one hybrid 'BR4828 X ZhongYu7' (good X good) showed good specific cross for thick grain. Again, seven hybrids produced significantly negative and five hybrids produced significantly positive SCA effects for kernel breadth. The combinations were of poor X poor, poor X good and good X good types. Similar results were obtained by Singh and Singh (1985) for kernel breadth in an 8-parent half diallel cross of rice. For kernel thickness, the SCA effects were significantly positive for four crosses, whereas three crosses had significantly negative effects.

'BR29 X Amol3', 'BR4828 X BR28' and 'Amol3 X IR65610' generated significantly negative SCA effect when as 'BR4828 X Amol3' was significantly positive specific combiner for upper empty glume length. For lower empty glume length four crosses showed significant SCA effects, half of which had positive and other half had negative effect.

For endosperm weight, 13 crosses showed significant SCA effects, seven of which had positive and the rest six crosses had negative effects. Here poor X good, good X good and poor X poor crosses produced both positive and negative effects, which reflected the difficulties of increasing endosperm weight in rice. 'IR8 X Minikit' displayed maximum SCA effect for high endosperm weight. Overdominance effect was prominent for high embryo weight. 'BR28 X Amol3' (poor X poor), 'Amol3 X Minikit' (poor X poor) and 'IR8 X IR65610' (good X poor) showed significantly positive SCA effects for embryo weight.

Table 4. Estimates of specific combining ability (SCA) effects for grain characters in an 8-parcent diallel cross of rice

Crosses	Grain length (mm)	Grain breadth (mm)	Grain thickness (mm)	Kernel length (mm)	Kernel breadth (mm)	Kernel thickness (mm)	Upper empty glume length (mm)	Lower empty glume length (mm)	Endosperm weight (g)	Embryo weight (g)
BR29xBR4828	0.020	-0.072	-0.040	-0.014	-0.070*	-0.041	-0.039	-0.101	-1.670**	0.002
BR29xBR28	-0.601***	0.027	-0.044	-0.301***	0.041	-0.049*	0.094	-0.0424	-1.213*	-0.054
BR29xIR8	-0.026	-0.013	-0.017	0.055	-0.031	-0.030	-0.143	-0.093	-0.419	-0.009
BR29xAmol3	-0.092	-0.033	0.007	-0.033	-0.022	0.011	-0.253**	-0.056	-0.226	-0.044
BR29xIR65610	0.128	0.054	-0.003	0.043	0.044	0.003	0.085	0.166*	0.869	0.010
BR29xMinikit	0.133	0.070	0.016	0.058	0.062*	0.035	0.055	0.049	0.919	-0.017
BR29xZhongYu7	0.112	-0.021	-0.002	-0.070	-0.012	0.015	0.049	0.022	0.524	0.034
BR4828xBR28	0.236*	-0.087*	-0.004	0.168*	-0.115***	-0.036	-0.171*	0.213**	-1.428*	0.013
BR4828xIR8	0.004	0.064	0.040	-0.019	0.072**	0.053*	-0.128	-0.008	1.614**	0.042
BR4828xAmol3	0.002	0.031	0.003	0.011	0.014	0.001	0.166*	0.109	0.180	-0.032
BR4828xIR65610	0.025	-0.102*	-0.069**	0.101	-0.086**	-0.072**	-0.023	-0.006	-1.682**	-0.054
BR4828xMinikit	0.160	-0.147***	-0.017	0.123	-0.157***	-0.024	-0.133	-0.152*	-0.718	-0.100***
BR4828xZhongYu7	0.019	0.148***	0.049*	0.012	0.131***	0.032	-0.079	-0.136	1.670**	0.031
BR28xIR8	-0.013	-0.056	-0.047*	-0.066	-0.055*	-0.057*	-0.004	-0.100	-0.664	-0.034
BR28xAmol3	0.245*	0.109**	0.042	0.204*	0.088**	0.062**	0.069	-0.009	1.374*	0.073*
BR28xIR65610	0.028	-0.119**	-0.017	-0.083	-0.122***	-0.022	-0.136	-0.104	-1.477**	-0.015
BR28xMinikit	-0.004	0.070	0.005	0.009	0.078**	0.003	0.004	0.066	1.098*	-0.024

Crosses	Grain length (mm)	Grain breadth (mm)	Grain thickness (mm)	Kernel length (mm)	Kernel breadth (mm)	Kernel thickness (mm)	Upper empty glume length (mm)	Lower empty glume length (mm)	Endosper m weight (g)	Embryo weight (g)
(Contd...)										
BR28xZhongYu7	-0.005	-0.022	-0.001	0.001	0.007	0.002	0.031	-0.058	0.347	-0.052
IR8xAmol3	-0.010	0.004	-0.009	0.027	0.006	-0.012	-0.038	0.009	1.111*	0.001
IR8xIR65610	0.352***	-0.055	0.038	0.262**	-0.044	0.045*	0.023	-0.035	1.183*	0.063*
IR8xMinikit	0.264**	-0.010	0.043	0.278**	-0.003	0.046*	0.017	0.115	2.479***	0.005
IR8x ZhongYu7	-0.443***	-0.068	-0.039	-0.382***	-0.063*	-0.030	-0.032	0.028	-2.514***	0.037
Amol3xIR65610	-0.037	-0.044	-0.030	-0.026	0.005	-0.03	-0.167*	-0.198*	0.616	0.008
Amol3xMinikit	0.125	0.056	0.026	0.129	0.000	0.020	0.123	0.149	0.490	0.054*
Amol3x ZhongYu7	-0.062	0.006	-0.006	-0.073	-0.030	-0.025	-0.039	-0.025	-0.756	0.006
IR65610xMinikit	-0.065	0.030	0.004	0.0003	0.040	0.004	0.095	0.141	-0.288	0.034
IR65610x ZhongYu7	0.117	0.010	0.009	0.117	-0.025	0.010	-0.094	-0.106	0.634	-0.088**
MinikitxZhongYu7	-0.301**	-0.030	-0.025	-0.174*	0.018	-0.012	-0.024	-0.109	-0.819	-0.019
SE(S _{ij})	0.090	0.039	0.023	0.077	0.026	0.022	0.072	0.074	0.519	0.0264
SED(S _{ij} -S _{ik})	0.133	0.057	0.033	0.113	0.038	0.032	0.107	0.110	0.769	0.0391
SED(S _{ij} -S _{kl})	0.125	0.054	0.032	0.107	0.036	0.030	0.101	0.104	0.725	0.0369

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Out of seven hybrids producing significant SCA effects, four hybrids produced significantly positive effects for kernel length while the combination 'IR8 X ZhongYu7' (poor X poor), 'BR29 X BR28' (poor X good) and 'Minikit X ZhongYu7' (good X poor) had significantly negative effects which suggested transgressive and epistatic gene action.

For kernel breadth a complex gene action was observed. Good X Good cross and Poor X Poor cross showed positive SCA effects which meant transgressive and overdominant effect. Poor X Good showed both positive and negative SCA effects indicating epistatic and additive mode. These results were true for kernel thickness. These results clearly showed the difficulty of developing long grains with thin breadth or thickness. However, it was noted that development of long slender varieties may be possible from the cross 'BR4828 X BR28', whereas development of long bold grain rice varieties could be obtained from 'BR28 X Amol3' cross combination.

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DIVERSITY BASED ON COEFFICIENT OF PARENTAGE AMONG RICE (*Oryza sativa* L.) CULTIVARS FOR MID AND HIGH HILLS OF NEPAL

BAL KRISHNA JOSHI¹

ABSTRACT

Genetic diversity between parents is necessary to derive transgenic segregants from a cross. The amount of genetic diversity presence depends on the number and diversity of the original ancestors involved in the creation of cultivars. The pedigrees of 20 rice cultivars recommended for mid and high hills of Nepal were traced back to ancestors and computed coefficient of parentage (COP) for all pair wise combinations. Cluster and principal components analyses were performed on the matrix of COP. Taiwan, IRRI, India and Nepal were the countries of origin of 20 cultivars. A total of 47 ancestors originated in 12 different countries were used to develop these cultivars. Most of the ancestors were *sativa* with indica group. The mean of COP for all cultivars was 0.035 ± 0.078 . The highest COP was between Machhapurchhre-3 and Chhomrong and between Taichung-176 and Tainan-1. Among 190 pairs, there were 122 completely unrelated pairs. The cultivar, Manjushir-2 was developed by using 19 different ancestors. Most commonly used ancestors were CP, Cina, Latisail, Sigadis, DGWG and SLO. Eight clusters were formed and six cultivars made a single individual cluster. Cultivars surveyed represent a wide range of variation for different areas of origin and adaptation. This genetic variation may be useful for further rice improvement.

Key Words: Ancestors, coefficient of parentage, genetic diversity,
Nepalese rice cultivars

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INTRODUCTION

Rice has been growing since time immemorial and it is a livelihood crop and most important in Nepal's economy. Different kinds of landraces and wild rice in Nepal are reported by Mallick (1981/82), Adhikari *et al.* (1995), NRRP (1997), Joshi *et al.* (1998), Shrestha and Upadhyay (1999), Upadhaya and Joshi (2003), Joshi (2004a, 2005). During mid 1960s the yield potential of semi dwarf high yielding varieties initiated a scope for raising rice production in the country. Several exotic varieties were obtained from IRRI (International Rice Research Institute) and Taiwan (NRRP, 1997). National Rice Improvement Program was established in 1972 at Parwanipur, Nepal to organize the research and development works on rice as a commodity crop. Since then, a great achievement has been made through a consolidated efforts of rice researchers, extension workers and farmers.

Selection of parents is the first step in any plant breeding programme. Genetic diversity between parents is necessary to derive transgenic segregants from a cross. One would like to detect genetic diversity among phenotypically superior breeding materials so that appropriate crosses could be designed. Both the potential for long term genetic gain and the reduction of genetic vulnerability may depend on the genetic diversity present in the genetic base. The amount of genetic diversity presents depends on the number and diversity of the original ancestors involved in the creation of cultivars. Coefficient of parentage (COP) estimates the diversity among cultivars. COP has also been used to predict breeding behavior of the progeny of crosses (Cowen & Frey, 1987), to summarize regional crop diversity (Souza *et al.*, 1994) and to identify parents that have contributed to yield improvements (Beer *et al.*, 1995). Diversity based on morphological traits and pedigree information was measured by Autrique *et al.* (1996) in durum wheat, Gerdes and Tracy (1994) in sweet corn, Schut *et al.* (1997) in barley. Morphological markers often do not reliably portray genetic relationships because of environmental interactions, epistatic interactions and the largely unknown genetic control of the traits (Smith & Smith, 1989). The objective of this research was to study the level of diversity present in the Nepalese rice cultivars recommended for mid and high hills.

MATERIALS AND METHODS

Altogether 20 cultivars had been released in Nepal from 1967 to 2002 for mid and high hills of Nepal. The pedigrees of 20 cultivars (Table 1) were examined. Most of the cultivars were introduced either from IRRI, Taiwan or India.

Table 1. Rice cultivars recommended for mid and high hills of Nepal

Variety	Abb	Pedigree	Parentage	Origin	Year released
Chianan-2	CHAN2	?	O-luamchu/Shiniri-Aikoku//Taichung 65	Taiwan	1967
Chianung-242	CHNUG242	?	Hsinchu 4/Taichung 150//Taipei7/T45	Taiwan	1967
Chandhanath-1	CHDNT1	Jinling 78-102	Selection from Jinling 78-102	IRRI	2002
Chandhanath-3	CHDNT3	Yunlen-1	Selection from Yunlen-1	IRRI	2002
Chhommrong	CHMM	Ghandruk local	Selection from Ghandruk local	Nepal	1991
Himali	HIM	IR 2298-PLPB-3-19-2-1-1B	Cica 4/Kulu	IRRI	1982
Kanchan	KAN	IR 3941-4 PL-P28	CR 126-42-5/IR 2061-213	IRRI	1982
Khumal –4	KH4	NR 10078-76-1-1	IR 28/Pokhreli Masino	Nepal	1987
Khumal –5	KH5	NR 10067-8-2-2-2	Pokhreli Masino/KN-1B-361-BLK-2-8	Nepal	1990
Khumal –7	KH7	IR 7167-33-2-3-3-1	China 1039-DWF-MUT/KN-1B-361-1-8-6-10	IRRI	1990
Khumal-11	KH11	NR 10375-14-2-1	Akiyudaka/Barkat	Nepal	2002
Khumal-2	KH2	NR 10068-60-3-2	Jarneli/KN-1B-361-BLK-2-8	Nepal	1987
Khumal-3	KH3	K 39	China 1039/IR 580	India	1983
Khumal-6	KH6	NR10172-2B-12-4-1-3-2	IR13146/IR17492	IRRI	1999
Khumal-9	KH9	IR 15579-135-2	K-28-76-B-1/KN-1B-214-1-4-3	IRRI	1990
Machhapuchhre-3	MCHPCH3	LR 88001-80-OL	Fuji 102/Chhommrong	Nepal	1990
Manjushri-2	MJS2	NR10291-6-1	Fuji 102/NR10157-2B-7-1-1	Nepal	2002
Palung-2	PLG2	NR 10073-167-3-1-3	BG 94-2/Pokhreli Masino	Nepal	1987
Taichung-176	TCG176	?	Tsai-Yuan Chung/DGWG	Taiwan	1967
Tainan-1	T1	?	Tsai-Yuan Chung/DGWG	Taiwan	1967

? Not known.

The pedigrees of 20 rice cultivars were traced back to 47 ancestors (Table 2) through constructing the pedigree tree of each cultivar (Figure 1). The source of pedigrees and release dates for cultivars were NRRP (1997), IRRI (1970, 1987, 1995, 2000a, 2000b, GEU), ABD (2003), Joshi (2004a, 2004b, 2005). The coefficient of parentage was computed for all pair wise combinations. The coefficient of parentage between two individuals is defined as the probability that a random allele at a locus in one individual is identical by descent to a random allele at the same locus in other individual. The following assumptions were made in computing coefficients of parentage: a) ancestors are unrelated, b) all cultivars, ancestors and parental lines are homozygous and homogenous, c) a cultivar derived from a cross obtains one-half of its genes from each parent, d) the COP between cultivar or ancestor and a direct selection from that cultivar or ancestor is 0.75, e) the COP between two selections from the same cultivar or ancestor is $(0.75)^2 = 0.56$ and f) the COP between a cultivar and itself is 1.0.

Table 2. Ancestors of 20 rice cultivars recommended for mid and high hills of Nepal (1965-2002)

Ancestor	ABB	Origin	Group	Species
AKIYUDAKA	AKDK	Korea	Japonica	Sativa
BPI-76	BPI76	Philippines	Indica	Sativa
CENTURY PATNA	CP	USA	Indica	Sativa
CHINA-1039	CH1039	India	Indica	Sativa
CHINA-971	CH971	China	?	Sativa
CHINA-1039-DWF-MUT	CH1039	China	Indica	Sativa
CINA	CINA	China	?	Sativa
CO-18	CO18	India	Indica	Sativa
DEE GEO WOO GEN	DGWW	Taiwan	Indica	Sativa
DUNGHAN SHALIL	DUG	?	Indica	Sativa
FUJI-102	F102	Japan	Japonica	Sativa
GEB-24	GEB24	India	Indica	Sativa
GHANDRUK LOCAL	GDKL	Nepal	Japonica	Sativa
GP-15	GP15	?	?	Sativa
HR-21	HR21	India	Indica	Sativa
HSINCHU-4	HSC4	Taiwan	Japonica	Sativa
JARNELI	JNL	Nepal	Indica	Sativa
JERAK	JRK	?	?	Sativa

(Contd...)

Ancestor	ABB	Origin	Group	Species
JINLILNG-78-102	JNLG78	China	Japonica	Sativa
JUMLI MARSHI	JUM	Nepal	Japonica	Sativa
K-28-76-B-1	K28	India	Japonica	Sativa
KN-1B-214-1-4-3	KN1B214	Indonesia	Indica	Sativa
KULU	KULU	Australia	Indica	Sativa
LATISAIL	LAS	Pakistan	Indica	Sativa
LD-66	LD66	?	?	Sativa
MCVA	MCVA	?	?	Sativa
MUDGO	MUDGO	India	Indica	Sativa
O. NIVARA	ON	?	?	Nivara
O-LUAMCHU	OLU	?	?	Sativa
POKHRELI MASINO	PKMS	Nepal	Indica	Sativa
PTB-18	PTB18	India	Indica	Sativa
PTB-21	PTB21	India	Indica	Sativa
R. HEENATI	RH	?	?	Sativa
REMADJA	REM	Indonesia	Indica	Sativa
SHINEI	SHN	Japan	?	Sativa
SHINIRI AIKOKU	SA	?	?	Sativa
SIGADIS	SGD	Indonesia	Indica	Sativa
SLO	SLO	India	Indica	Sativa
TADUKAN	TDKN	Taiwan	Indica	Sativa
TAICHUNG NATIVE-1	TN1	Taiwan	Indica	Sativa
TAICHUNG-150	T150	Taiwan	Japonica	Sativa
TAICHUNG-45	T45	Taiwan	Japonica	Sativa
TAICHUNG-65	T65	Taiwan	Japonica	Sativa
TAIPEI-7	TP7	Taiwan	?	Sativa
TETEP	TETEP	Vietnam	?	Sativa
TSAI YUAN CHUNG	TYC	Taiwan	Indica	Sativa
YUNLEN-1	YN1	China	Japonica	Sativa

? Not known.

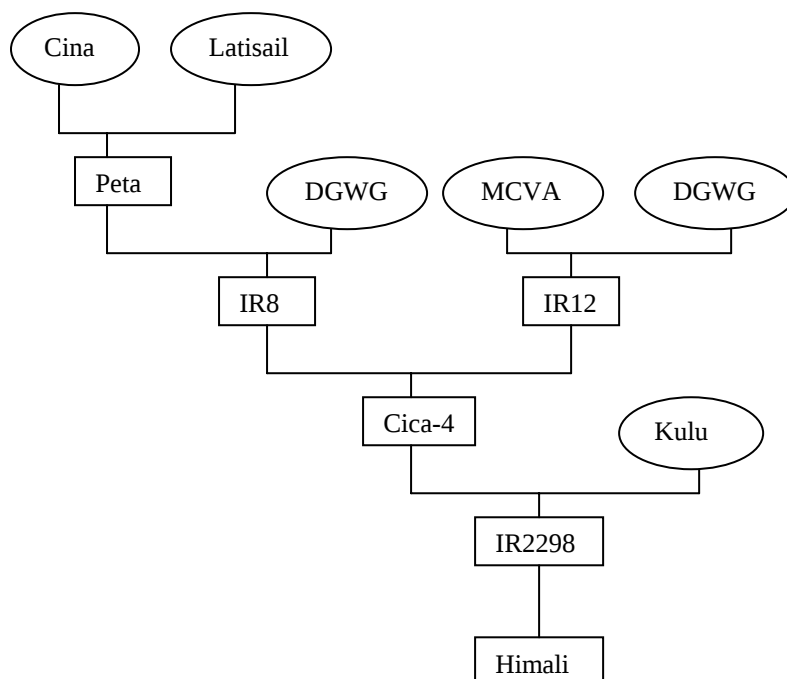


Figure 1. Pedigree tree of Himali that help to trace cultivar to their ancestors (Ancestors are kept in oval shape)

The computer programme, KIN was used to calculate the COP (Tinker & Mathur, 1993). Cluster analysis was performed on the matrix of COP using the computer programme NTSYS-pc (Rohlf, 1994), which employed the unweighted pair group method of clustering. A dendrograph which adds another dimension to the one-dimensional dendrogram by spacing units based on the relationships between units and clusters, in addition to portraying the hierarchical order among units or clusters was drawn based on the cluster analysis. Principal component (PC) analysis was performed upon the matrix of relationships among cultivars for reduction of dimensions for analysis of cultivar relationship. This procedure permits the representation of the cultivars as points in Euclidean space.

RESULTS AND DISCUSSION

Taiwan, IRRI, India and Nepal are the countries of origin for the 20 rice cultivars. In Nepal eight cultivars were originated. Four earliest released cultivars were Chianan-2, Chianung-242, Taichung-176 and Tainan-1. These are the Taiwanese cultivars. Shuttling of generations during the off-season can help develop more rice cultivars within a short period of time. Due to the varied agroecological diversity of the country, it is possible to plant the same cultivar in both winter and summer season. Some of these main season cultivars of mid and high hills can be planted in Tarai areas during winter season.

Most of the studied cultivars are adapted to hilly areas. Site-specific cultivars are necessary because of diverse climate in Nepal. The trend of releasing many cultivars in same year for same domain is not a strong strategy for a breeding programme. It would be better to release a cultivar per year for some specific domain at a time. Cultivars performance may be affected by the origin of ancestors, number of ancestors used and times of crossing considered for developing them. Thirteen parents with 42 times of crossing was used for developing Khumal-4 which is a popular cultivar among farmers (Joshi, 2004a). Therefore, study on origin of ancestors, number of ancestors and crossing frequency may be useful for crop improvement programme and conservation of gene pool.

The level of genetic variation present in gene pools of most important crops has been analyzed by studying the pedigree relationship between cultivars. Kinship coefficients estimation of cultivars of oat (Souza & Sorrells, 1989), soybean (Cox *et al.*, 1985a), winter wheat (Cox *et al.*, 1985b), rice (Dilday, 1990) and barley (Martin *et al.*, 1991) has shown that a restricted number of ancestral genotypes account for a large proportion of the variation present in released cultivars. Relatively more number of ancestors had been used in developing Nepalese wheat cultivars (Joshi *et al.*, 2004). Similarly ancestors of Nepalese rice cultivars were higher as found comparing by pedigree analysis of other crops. A total of 47 ancestors originated in 12 different countries were used to develop these 20 cultivars. The highest number of ancestors was from India (Table 2). Ancestors of both *sativa* and *nivara* species with *sativa* group of indica and japonica had been used indicating the accumulation of wide gene pool. Most of the ancestors were *sativa* and indica group. Only four landraces, Jarneli, Jumli Marshi, Pokhreli Masino and Ghankdruk Local from Nepal were used in developing these cultivars, though 2000 landraces have been reported to exist (Mallick, 1981/82). Cultivated landraces, wild rice and wild relatives of rice are found in Nepal (Upadhaya & Joshi, 2003; Joshi, 2004b, 2005). Gene pool from these landraces along with international gene pool contributed a lot in developing high yielding cultivars with wide adaptability.

It is assumed here that ancestors are not related and some of them may have other ancestors because breeding records of earliest work was not properly recorded. Therefore, if one could add ancestors' dissimilarity at molecular level on COP analysis, it may be better a way of diversity assessment of ancestors used in developing cultivar. If more number of ancestors is used it means more genes are conserved in a single cultivar. On an average, 2.35 ancestors were used to develop a cultivar. Diversity on ancestors with respect to origin of ancestors and group of ancestors was low which indicated that these 20 cultivars might have also low diversity on these aspects. However, there are possibility of mutation and transgressive segregation over the time, ultimately increasing the diversity. Similarly, the number of originating country may not be a good indicator of diversity, rather geographic differences among these countries should be considered in finding variations in released cultivars.

The COP for all cultivars is shown in Table 3. The mean of COP for all cultivars was 0.035 ± 0.078 and ranged from 0.00 to 0.50. The highest COP was between Machhapurchhre-3 and Chhommrong and between Taichung-176 and Tainan-1 i.e. these are most closely related. Other more closely related pairs based on COP are Khumal-4 and Kanchan, Palung-2 and

Khumal-4, Khumal-5 and Khumal-4, Khumal-5 and Palung-2. Among 190 pairs, there were 122 completely unrelated pairs. Most commonly used ancestors were CP, Cina, Latisail, Sigadis, DGWG and SLO. The COP mean across these cultivars was lower than those reported for oat and barley (Souza & Sorrells, 1989; Martin *et al.*, 1991), rice (Dilday, 1990) and durum wheat (Autrique *et al.*, 1996). In barley only five ancestors contributed more than 50% of the genetic make up of released cultivars (Martin *et al.*, 1991).

The COP, 0.50 between Macchapuchhre-3 and Chhommrong and Taichung-176 and Tainan-1 is due to the same ancestors used in developing them (Table 3). The highest the COP value the more closely they are related. Value of zero indicates that completely different ancestors were used for developing these cultivars. As the value increases, the ancestral similarity increases.

Eight clusters were formed based on COP (Figure 2). Six cultivars made a single individual cluster. Maximum number of cultivars in a cluster were 12. Plotting of these cultivars based on PC analysis could help locate cultivars responded with PC1 and PC2 (Figure 3). Highly scatter cultivars were Manjushri-2, Chhommrong and Macchapuchhre-3. Relatively cluster and scatter diagram drawn based on COP may be more reliable to pick most diverse genotypes. This is also supported by accounting much more variations by first two PCs in COP analysis. Among the four cells in PC graph, most of the cultivars have fallen within two cells.

Table 3. Coefficient of parentage among 20 rice cultivars recommended for mid and high hills of Nepal

Cultivar	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Himali	1																			
Tainan-1	0.13	1																		
Taichung-176	0.13	0.5	1																	
Kanchan	0.12	0.08	0.08	1																
Khumal-3	0.08	0.06	0.06	0.11	1															
Khumal-4	0.04	0.02	0.02	0.29	0.05	1														
Khumal-7	0.08	0.06	0.06	0.1	0.06	0.04	1													
Khumal-9	0	0	0	0	0	0	0	1												
Chhommrong	0	0	0	0	0	0	0	0	1											
Macchapuchhre-3	0	0	0	0	0	0	0	0	0.5	1										
Chianan-2	0	0	0	0	0	0	0	0	0	0	1									
Chianung-242	0	0	0	0	0	0	0	0	0	0	0	1								

(contd...)

Cultivar	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Khumal-2	0.08	0.06	0.06	0.1	0.06	0.04	0.13	0	0	0	0	0	1							
Palung-2	0.03	0	0	0.07	0.03	0.29	0.03	0	0	0	0	0	0.03	1						
Khumal-5	0.08	0.06	0.06	0.1	0.06	0.29	0.13	0	0	0	0	0	0.25	0.28	1					
Khumal-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1				
Khumal-6	0.07	0.04	0.04	0.21	0.06	0.15	0.06	0	0	0	0	0	0.06	0.07	0.06	0	1			
Chandhanath-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
Chandhanath-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
Manjushri-2	0.05	0.04	0.04	0.09	0.05	0.05	0.14	0	0	0.25	0	0	0.07	0.02	0.07	0	0.05	0	0	1

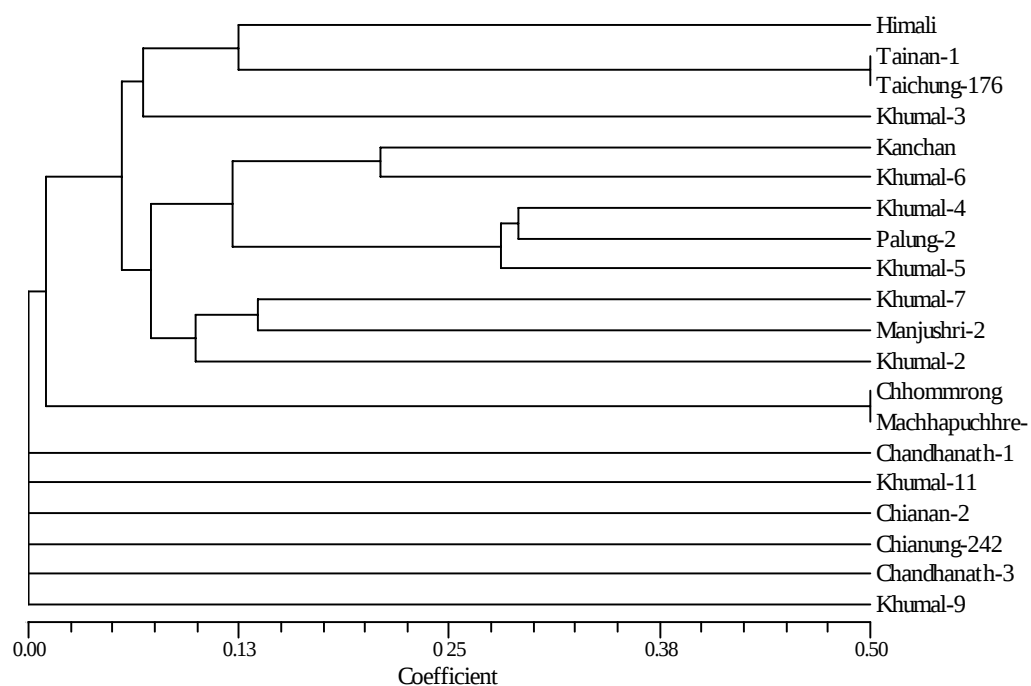


Figure 2. Clustering of 20 Nepalese rice cultivars based on coefficient of parentage

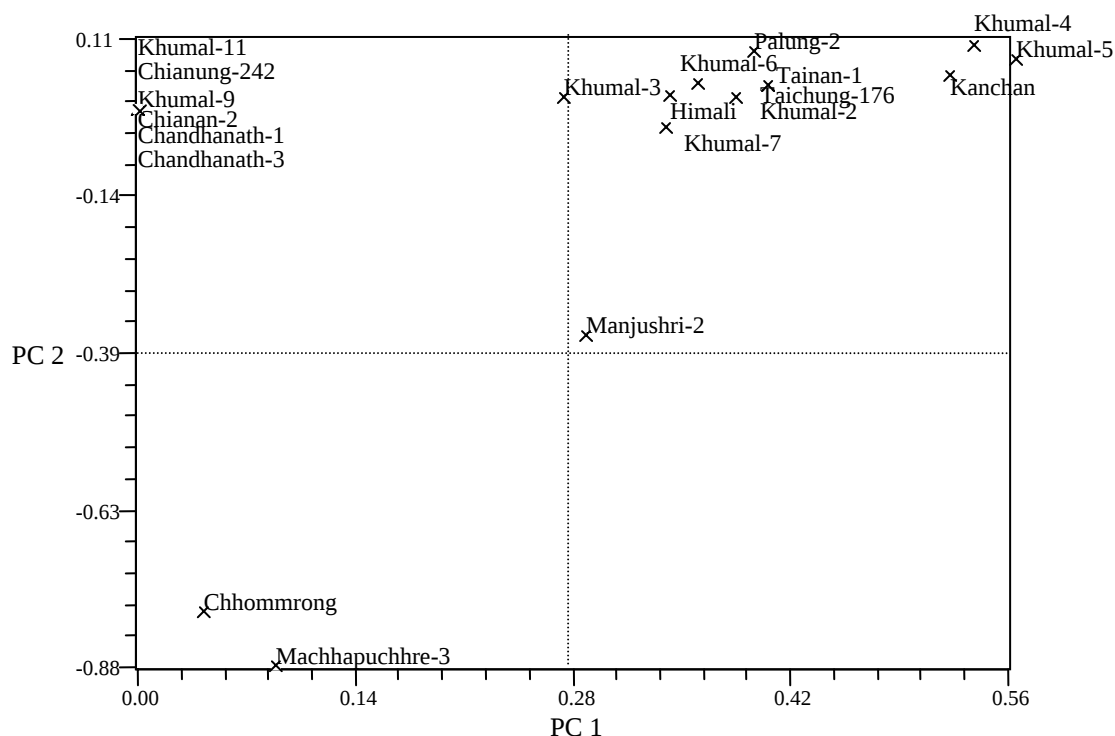


Figure 3. Plotting of 20 Nepalese rice cultivars based on coefficient of parentage along first and second

In this study, cultivars surveyed represent a wide range of variation for different areas of origin and adaptation. This genetic diversity may be useful for further rice improvement. The results of this study may help selection of the most diverse cultivars and greatly expand genetic variation for rice improvement. Measure of genetic diversity can be used to maximize the level of variation in segregating populations by intermating cultivars with greater genetic distance. Contributions of the different measures might be useful in the prediction of progeny performance, diversity or both. Prediction of progeny performance in winter wheat namely F_2 heterosis with morphological distance estimation was better predictors than COP (Cox & Murphy, 1990). However, COP was reported to be a better predictor than morphological traits of F_4 family performance in oats and a combined measure was a better estimator of specific combining ability in F_1 (Souza & Sorrells, 1991).

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EFFECT OF PODS CHARACTERISTICS ON POD BORER, *Helicoverpa armigera* (Hubner), INVESTIGATION IN CHICKPEA

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ABSTRACT

An experiment was conducted at Regional Agricultural Research Station, Ishurdi, Pabna, Bangladesh during rabi 2003-04 to find out the influence of pod morphological traits (like pods trichome length and density, pod wall thickness, pod length, breadth, area and number of pods per plant) on pod borer resistance in chickpea. All the traits showed significant influence on pod borer resistance. Pod trichomes length and density showed negative correlation to pod borer damage in chickpea i.e., genotypes having longer pod trichomes and or more pubescent pods received lower pod borer damage. Relationship study between pod wall thickness and pod borer damage indicated negative correlation which suggested the chickpea genotypes having thicker pod wall received lower pod borer damage. Pod length, breadth and area of respective genotypes showed significant effect in resistance mechanism against pod borer damage. Correlation study showed a negative correlation between the pod length, breadth and area to pod borer damage. The pods having higher length, breadth and area were less preferred by the pod borer. Number of pods per plant also affected pod borer incidence. Correlation study determined a positive correlation between the number of pods per plant and pod borer damage. The genotype having higher pod bearing potentiality received higher pod borer damage.

Key Words: Chickpea, pod borer, pod morphological traits,
Helicoverpa armigera.

INTRODUCTION

Chickpea, *Cicer arietinum* L., is one of the important pulse crops in Bangladesh which is attacked by eleven species of insect pests (Rahman *et al.*, 1982). Of them, the pod borer, *Helicoverpa armigera* (Hubner), is the major one in most of the chickpea growing areas in the country (Begum *et al.*, 1992). On an average 30 to 40 per cent pods were damaged by it resulting into 400 kg of grains per hectare (Rahman 1990). In a favourable condition the pod damage goes as high as 90-95 per cent (Shengal and Ujagir, 1990; Sachan and Katti, 1994). For reducing such losses of chickpea from the pod borer, use of resistant varieties is an important strategy.

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During the course of evolution, plants required several defense mechanisms against insect pests to reduce their damage. Multiple types of resistance (tolerance, antixenosis, antibiosis and escape) are reported in chickpea (Clement *et al.*, 1994). Many morphological characteristics which contribute to antixenosis have been used to breed varieties resistant to *Helicoverpa*. Several morphological traits such as pod trichomes length and density, pod wall thickness, pod length and breadth, pod shape and pods/plant seem to influence *Helicoverpa* infestation in chickpea (Ujagir and Khare, 1987). Trichomes and trichome exudates on plant surfaces play an important role in host selection process of insect herbivores. The types of trichomes and their orientation, density and length have been correlated with reduced insect damage in several crops (Jeffree, 1986, David and Easwaramoorthy, 1988; Peter *et al.*, 1995). Keeping this in view, the present study was conducted to find out pod morphological traits as sources of resistance to *Helicoverpa* pod borer and their relations to pod damage in chickpea.

MATERIALS AND METHODS

The experiment was conducted at Regional Agricultural Research Station Ishurdi, Pabna, Bangladesh during the rabi season of 2003-04. The following 14 lines and 6 varieties of chickpea were screen against *Helicoverpa* infestation in relation to pod morphological traits: ICCL 87315, ICCL 87220, ICCL 87322, ICCV 98936, ICCV 98939, ICCV 95138, ICCV 96020, ICCV 97004, ICC 4918, BCX 91040-1, BCX 91042-3, BCX 91044-3, BCX 91043-1, BCX 91040-3, BINA-chola 2, BINA-chola 3, BARI-chola 3, BARI-chola 4, BARI-chola 5 and BARI-chola 6. The experiments were laid out in a randomized complete block design with three replications. The treatments were randomly allotted to each block. The seeds of respective varieties/lines were sown on November 22, 2003 in rows with a spacing of 50 cm. The populations of the plants were maintained constant by keeping plant to plant distance of 10 cm. Individual plot size was 2m x 4m. Each plot contained 4 rows of 4 m length. NPK fertilizers @ 20-40-20 kg/ha were applied at final land preparation. Normal intercultural operations were done.

At podding stage of chickpea plants, pod trichomes length was measured by a transparent millimeter scale. Trichomes touch over the surface of the scale was seen by a magnifying glass and measured. Mean pod trichomes length was obtained from each genotype. Density of the trichomes was determined by placing unit pod area of 2 mm² under a light microscope. Number of trichomes per unit area was converted into per sq. cm pod area. Mean pod trichomes density per sq.cm was obtained from each genotype. Trichomes length and density were measured from 10 randomly collected pods from each plot of the genotypes (three observations per pod). To determine the length and breadth of pods in each genotype, 10 pods of each plot of the genotypes was randomly collected and measured by using slide calipers. Mean length and breadth of the pods were obtained and sizes of the pods of each genotype were measured. Pod wall thickness was measured in three parts of each pod with the help of a digital slide calipers from 10 randomly collected pods of each plot. Finally, mean pod wall thickness was obtained from each genotype.

At maturity, all the pods were collected from 10 randomly selected plants from middle rows of each plot and examined. The damaged (bored) and total numbers of pods were counted and per cent pod damage was determined using the following formula:

$$\text{Percent pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

Number of pods/plant was also computed from each genotype. The experimental data were analyzed by MSTAT-C software. The percent data were transformed by square root transformation for statistical analysis. Mean comparisons for treatment parameters were compared using Duncan's Multiple Range Test (Steel & Torrie, 1960) at 5% level of significance.

RESULTS AND DISCUSSION

Influence of pod trichomes length on pod borer damage

The trichome length of pods in different chickpea genotypes varied significantly (Table 1). The highest pod trichome length (1.10 mm) was observed in the line ICCV-97004 and BARI-chola 3 which were statistically identical to ICCL-87315 and ICCV-96020. The second highest pod trichome length (0.77 mm) was observed in ICCV-98936 which was identical to ICCV-95138, BINA-chola 2, BARI-chola 4 and BARI-chola 6. The lowest trichome length (0.50 mm) was found in BCX-91042-3.

Analysis of relationship between pod trichomes length and pod borer damage (From Table 1 & 2) in different chickpea genotypes (Fig. 1) manifested a negative insignificant correlation ($y = -14.274x + 25.861$; $R^2 = 0.175$). These results indicated that with the increase of pod trichomes length the pod borer damage decreased in chickpea.

Influence of pod trichomes density on pod borer damage

The pod trichomes density of different chickpea genotypes differed significantly (Table 1). The highest pod trichomes density (482.7/sq.cm) was found in the line ICCL-87315 which differed significantly among all other genotypes. The second highest (408.7/sq.cm) and the lowest (202/sq.cm) pod trichomes density were found in BCX-91040-1 and BARI-chola 3 respectively.

A relationship study between pod trichomes density and pod borer damage in different chickpea genotypes showed a negative insignificant correlation ($y = -0.0333x + 25.966$; $R^2 = 0.1028$) (Fig. 2). From the results it was noted that the genotypes having higher pod trichomes density received lower pod borer damage in chickpea.

Pod trichomes provided potential resistance mechanisms against pod borer. Pod trichomes length and density varied significantly among the genotypes and showed important

resistance mechanism against *H. armigera*. Trichomes length and density provided negative correlation to pod borer damage in chickpea. The chickpea pods having longer trichomes and or more pubescent pods received lower pod borer damage. Longer trichomed pods and or more pubescent pods might provide physical barrier to feeding by pod borer, resulted lower pod damage. Peter *et al.* (1995) and Romies *et al.* (1999) reported that the length and density of pod trichomes in pigeonpea provided potential host plant resistance mechanism to *H. armigera*. Shanower *et al.* (1997) found trichomes on pods of *Cajanus* spp. to be an important resistance mechanism against *H. armigera*. These authors suggested that increasing the density of nonglandular trichomes in pigeonpea pods could reduce damage and losses due to pod feeding insect pests.

Table 1. Morphological features of pods of different chickpea genotypes during rabi 2003-04 at Ishurdi, Pabna, Bangladesh

Genotypes	Pod trichome length (mm)	Pod trichome density (no./sq.cm)	Pod wall thickness (mm)	Pod length (cm)	Pod breadth (cm)	Pod area (sq.cm)	No. of pods/plant
ICCL-87315	1.03 a	482.7 a	0.127 c	1.77 cd	0.83 cd	1.46 cd	32.17 hi
ICCL-87220	0.63 c-e	348.7 c	0.113 g	1.46 i	0.72 f	1.05 i	38.97 d-h
ICCL-87322	0.60 c-e	294.0 f-h	0.110 h	1.92 b	0.84 bc	1.62 b	39.90 c-i
ICCV-98936	0.77 b	333.3 c-e	0.110 h	1.56 h	0.74 ef	1.15 hi	38.47 d-h
ICCV-98939	0.53 de	322.7 c-f	0.107 i	1.67 ef	0.78 d-f	1.29 f-h	46.20 a-c
ICCV-95138	0.70 bc	282.0 g-i	0.143 a	2.03 a	1.03 a	2.09 a	36.80 e-h
ICCV-96020	1.03 a	248.7 jk	0.143 a	1.95 b	1.00 a	1.96 a	33.27 g-i
ICCV-97004	1.10 a	340.0 cd	0.143 a	1.95 b	1.00 a	1.97 a	42.10 b-e
ICC-4918	0.63 c-e	218.0 lm	0.093 k	1.63 e-h	0.81 cd	1.32 d-g	38.60 d-h
BCX-91040-1	0.53 de	408.7 b	0.117 f	1.65 e-g	0.73 ef	1.22 gh	38.93 d-h
BCX-91042-3	0.50 e	258.0 i-k	0.113 g	1.70 de	0.79 c-e	1.34 d-g	42.73 b-e
BCX-91044-3	0.63 c-e	342.0 cd	0.103 j	1.70 de	0.74 ef	1.27 gh	41.37 b-e
BCX-91043-1	0.60 c-e	315.3 d-f	0.123 d	1.77 cd	0.81 cd	1.44 c-e	47.67 ab
BCX-91040-3	0.57 c-e	275.3 h-j	0.107 i	1.65 e-g	0.79 c-e	1.30 e-g	44.47 b-d
BINAchola 2	0.67 b-d	300.0 f-h	0.107 i	1.81 c	0.83 cd	1.50 bc	40.20 c-f
BINAchola 3	0.57 c-e	298.0 f-h	0.133 b	1.59 f-h	0.77 d-f	1.22 gh	41.90 b-e
BARIchola 3	1.10 a	202.0 m	0.120 e	1.83 c	0.89 b	1.63 b	27.37 i
BARIchola 4	0.67 b-d	306.7 e-g	0.103 j	1.58 gh	0.77 d-f	1.22 gh	34.00 f-h
BARIchola 5	0.60 c-e	309.3 e-g	0.113 g	1.78 cd	0.80 cd	1.43 c-f	51.70 a
BARIchola 6	0.70 bc	240.0 kl	0.103 j	1.64 e-h	0.81 cd	1.32 d-g	39.13 d-h

In a column, treatment means having the same letter(s) are not significantly different by DMRT at 5% level.

Values are the means of three replications

Table 2. Intensity of *Helicoverpa armigera* damage in different genotypes of chickpea during rabi 2003-04 at Ishurdi, Pabna, Bangladesh

Varieties/lines	Pod damage (%)
ICCL-87315	8.43 (2.89) i
ICCL-87220	15.41 (3.92) d-g
ICCL-87322	23.53 (4.85) bc
ICCV-98936	9.34 (3.05) hi
ICCV-98939	7.94 (2.80) i
ICCV-95138	8.96 (2.98) i
ICCV-96020	8.63 (2.93) i
ICCV-97004	11.71 (4.08) g-i
ICC-4918	33.60 (5.79) a
BCX-91040-1	14.69 (3.82) e-g
BCX-91042-3	18.21 (4.25) c-f
BCX-91044-3	16.39 (4.05) d-g
BCX-91043-1	20.52 (4.53) cd
BCX-91040-3	13.11 (3.60) f-h
BINAchola 2	14.21 (3.76) e-g
BINAchola 3	15.50 (3.92) d-g
BARIchola 3	11.53 (3.39) g-i
BARIchola 4	26.55 (5.14) b
BARIchola 5	19.15 (4.37) c-e
BARIchola 6	17.69 (4.19) d-f

In a column, treatment means having the same letter(s) are not significantly different by DMRT at 5% level.

Values are the means of three replications.

Figures in the parentheses are the square root transformed mean values.

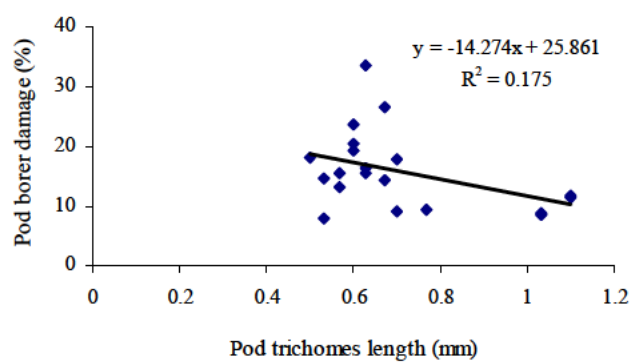


Fig. 1 Relationship between pod trichomes length and pod borer damage in different chickpea genotypes

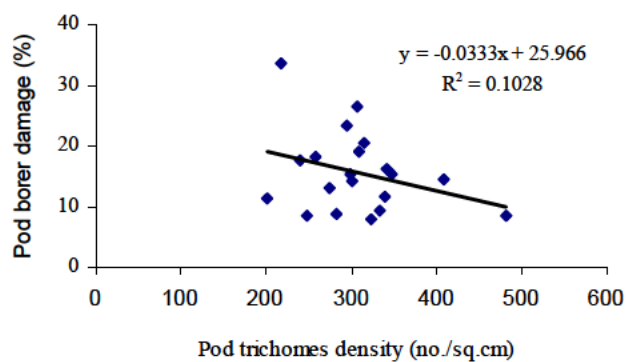


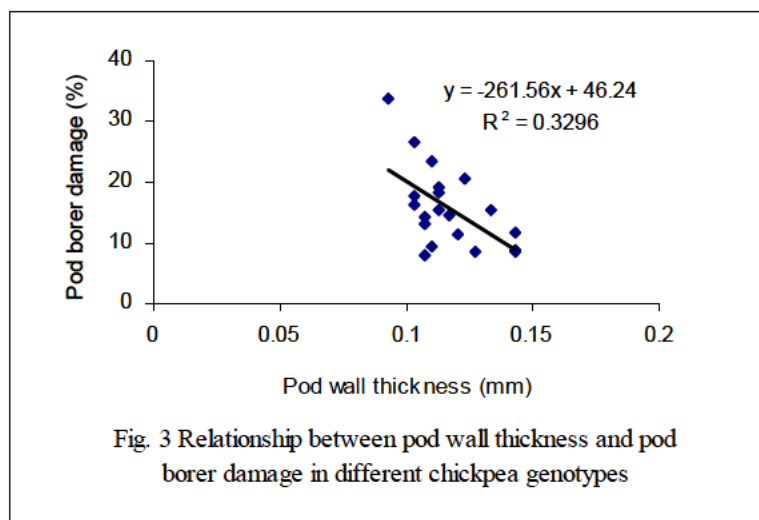
Fig. 2 Relationship between pod trichomes density and pod borer damage in different chickpea genotypes

Influence of pod wall thickness on pod borer damage

Pod wall thickness of different chickpea genotypes also varied significantly (Table 1). The highest (0.143 mm) and statistically identical pod wall thickness was obtained from the lines ICCV-95138, ICCV-97004 and ICCV-96020, followed by BINA-chola 3. The lowest pod wall thickness (0.093 mm) was found in line ICC-4918. It was seen from the data on pod wall thickness (Table 1) and pod borer damage (Table 2) that the line ICC-4918 having the lowest pod wall thickness accordingly received the highest pod borer damage among the genotypes.

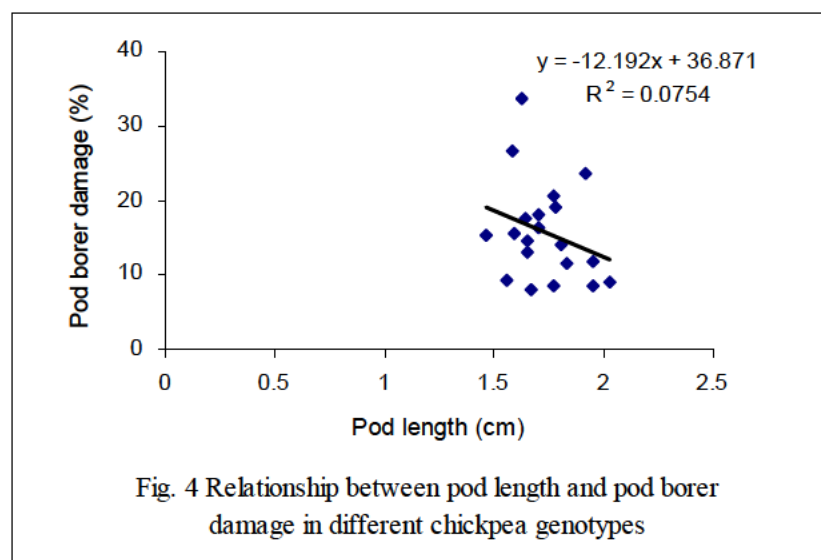
The relationship study between pod wall thickness and pod borer damage in different chickpea genotypes showed a negative significant correlation ($y = -261.56x + 46.24$; $R^2 = 0.3296$) (Fig. 3). It indicated that the genotypes of chickpea having the higher pod wall thickness received lower pod borer damage. For every 1 mm increase in pod wall thickness, there was a decrease of pod borer damage by 261.56%. The correlation coefficient (r) was 0.574 and the contribution of regression indicated that 32.96% pod borer damage might be decreased by pod wall thickness.

Pod wall thickness showed important resistance mechanism against *H. armigera*. Relationship study between pod wall thickness and pod borer damage indicated negative correlation which suggested that the chickpea genotypes having thicker pod wall received lower pod borer damage. Ujagir and Khare (1987) have established resistance mechanism of pod wall thickness against pod borer damage.



Influence of pod length on pod borer damage

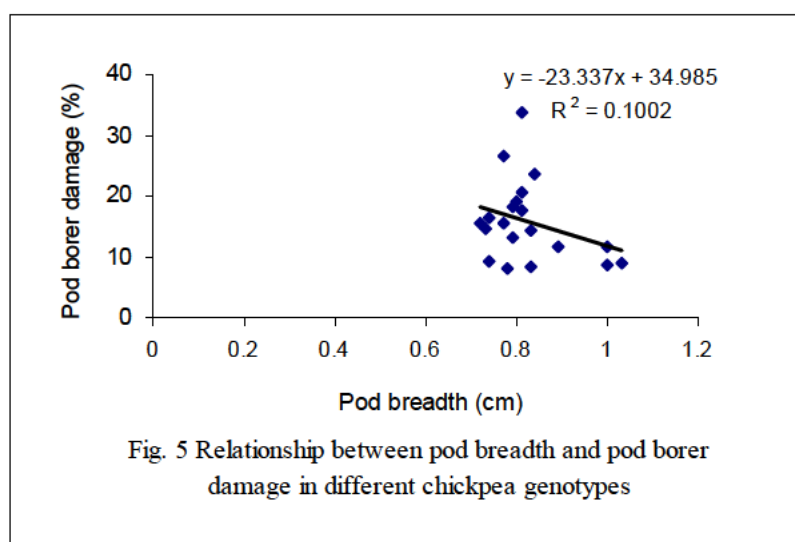
Significant difference of pod length in different chickpea genotypes were found (Table 1). The highest pod length (2.03 cm) was recorded in the line ICCV-95138 followed by ICCV-97004, ICCV-96020 and ICCL-87322. The lowest pod length (1.46 cm) was recorded from the line ICCL-87220. Relationship between pod length and pod borer damage gave negative insignificant correlation ($y = -12.192x + 36.871$; $R^2 = 0.0754$) (Fig. 4). These findings indicated that the genotypes of chickpea having higher pod length suffered lower pod borer damage.



Influence of pod breadth on pod borer damage

Pod breadth of different chickpea genotypes also varied significantly (Table 1). The highest pod breadth (1.03 cm) was recorded in ICCV-95138 which was statistically identical to ICCV-97004 and ICCV-96020. The lowest pod breadth (0.72 cm) was recorded from ICCL-87220.

Correlation study also showed negative insignificant correlation ($y = -23.337x + 34.985$; $R^2 = 0.1002$) between pod breadth and pod borer damage (Fig. 5). These findings indicated that the genotypes of chickpea having higher pod breadth received lower pod borer damage.



Influence of pod area on pod borer damage

The pod area of different chickpea genotypes also varied significantly (Table 1). The highest pod area (2.09 sq.cm) was obtained from the pods of ICCV-95138 which was statistically identical to ICCV-97004 and ICCV-96020 followed by BARI-chola 3. The lowest pod area (1.05 sq.cm) was obtained from ICCL-87220.

A relationship study between pod area and pod borer damage was made (Fig. 6) in different chickpea genotypes (Fig. 6). It showed negative insignificant correlation ($y = -7.2945x + 26.259$; $R^2 = 0.0977$). These results indicated that the genotypes of chickpea having the higher pod area received lower pod borer damage.

Therefore, pod length, breadth and area of respective genotypes showed significant effect in resistance mechanism against pod borer damage. Correlation study showed a negative correlation between pod length, breadth and area to pod borer damage. The pods having higher length, breadth and area are less preferred by the pod borer.

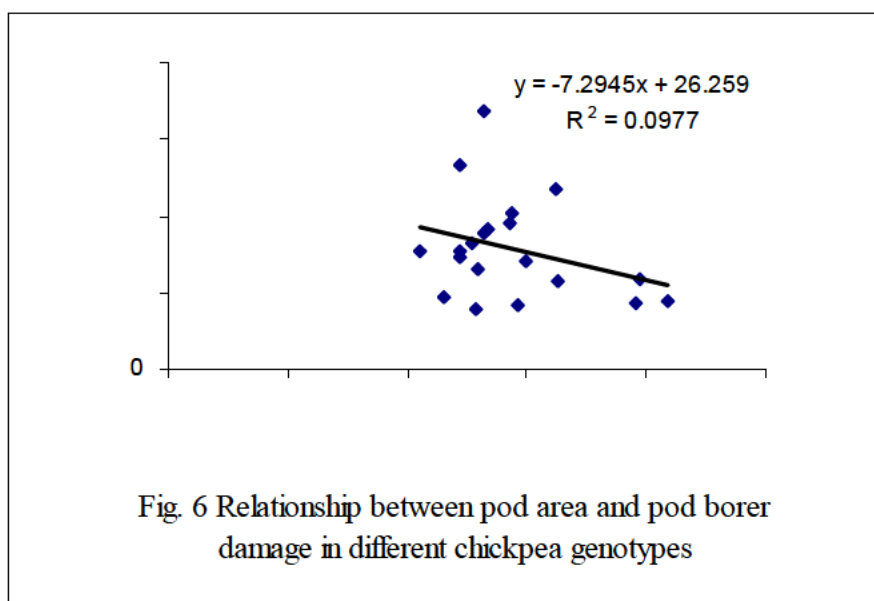


Fig. 6 Relationship between pod area and pod borer damage in different chickpea genotypes

Influence of pods/plant on pod borer damage

Pod per plant in different chickpea genotypes varied significantly (Table 1). The highest number of pods per plant (51.70) was recorded from the variety BARI-chola 5 which was statistically identical to BCX-91043-1 and ICCV-98939. The lowest number of pods per plant (27.37) was obtained from the variety BARI-chola 3. A positive but insignificant correlation ($y = 0.1927x + 8.0843$; $R^2 = 0.0262$) was found between pods per plant and pod borer damage (Fig. 7). This suggested that number of pods per plant positively influenced pod borer damage i.e. the chickpea genotypes having higher pod bearing potentiality suffered higher pod borer damage.

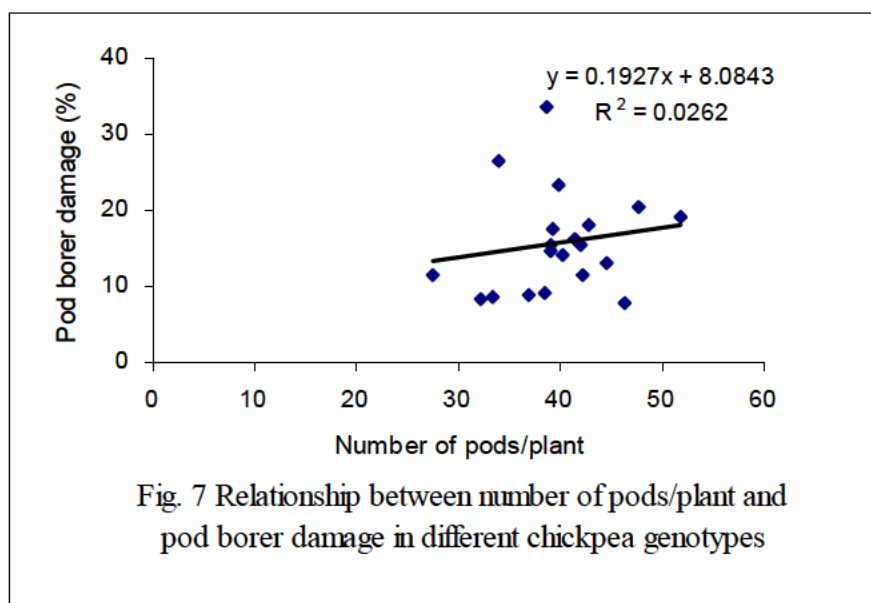


Fig. 7 Relationship between number of pods/plant and pod borer damage in different chickpea genotypes

Different chickpea genotypes showed significant variation in podding potentiality. Number of pods per plant also affected pod borer incidence. Correlation study determined a positive correlation between the numbers of pod per plant and pod borer damage. Greater pod borer damage was observed in the genotypes producing higher number of pods per plant. This might be due to more availability of pods to feeding by pod borer with less movement. Gumber *et al.* (2000) documented positive correlation between the number of pods per plant and pod borer damage.

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EFFECT OF TILLAGE AND WEED MANAGEMENT PRACTICES IN MAIZE (*Zea mays* L) – SUNFLOWER (*Helianthus annus*) CROPPING SYSTEM

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ABSTRACT

Field experiment was conducted during *kharif* and *rabi* seasons of 2005-2006 to study the effect of different tillage and weed management practices on weed population and productivity dynamics in maize-sunflower cropping system. Continuous zero tillage resulted in increased perennial and some annual grass weed species. Treatment those received zero tillage after conventional tillage recorded higher density of grasses. Density of *Cyperus rotundus* was higher in treatment that received conventional tillage. *Amaranthus viridis* and *Amaranthus polygamus* density were higher in zero tillage plot. At the end of study period, their density became nil. Hand weeded plot significantly reduced all grass and broad –leaved weeds. Herbicide treated plot failed to reduce grassy weeds effectively. Conventional tillage produced higher grain yield and zero tillage also produced higher grain yield during first year, then the yield was reduced in second year.

Key Words: Productivity, Relative Density, Weed Change, Maize and Sunflower cropping system.

INTRODUCTION

Changes in agricultural practices and techniques, which alter conditions at the level of microhabitat, have the influence on the composition of weed flora. Species, which are better adapted to the new conditions, will survive whereas those, which are less fitted, tend to be

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eliminated. According to Frick and Thomas (1992), in summer crops, broad-leaved populations were higher under conventional tillage than in no tillage. They also observed that annual weeds were more at higher densities and perennial weeds at lower densities in conventional than in reduced tillage systems. Bud dormancy induced by deep burial would explain the lower quack grass population with reduced tillage (Lemieux *et al.*, 1993). In Wheat, annual broad-leaved species showed higher populations in conventional tillage, and annual and perennial grass species showed an erratic response with tillage system (Tuesca *et al.*, 2001). However, in some cases, tillage had no selective influence on weed flora (Swanton *et al.*, 1993).

Manual weeding generally removes all types of weeds irrespective of grass sedges and broad leaved weeds. On the other hand, herbicidal methods are found to be effective in controlling only one group of weeds in cropped fields. Because of selective nature of herbicides (Guar *et al.*, 1991) reported that pre-emergence application of atrazine 0.5 kg ha⁻¹ completely controlled the broad-leaved weeds, but all grass weeds were not controlled. Atrazine was more effective against *Ageratum conyzoides* and less effective against *Echinochloa colonum* and *Brachiaria romosa* than pendimethalin or alachlor (Pandey *et al.*, 2001). Good control of *Trianthema portulacastrum*, *Amaranthus spp.*, *Dactyloctenium aegyptium* and *Echinochloa colonum* was observed by using fluchloridone 0.5 kg/ ha⁻¹ as pre-emergence application followed by hand weeding 30 DAS or pendimethalin 1.0 kg ha⁻¹ followed by hand weeding 40 DAS in sunflower (Nalayini, 1990). Number of studies were done on the effect of tillage on weed growth but very limited number of studies were found on the effect of tillage and weed management practices on weed flora shift under maize –sunflower cropping system in the clay loam soil. Hence, the present study was conducted to know the effect of tillage and weed management practices on weed flora shift under clay loam soil of Tamil Nadu.

MATERIALS AND METHODS

Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during *Kharif* and *Rabi* seasons of 2005 and 2006 to study the effect of tillage and weed management methods on weed flora shift in maize – sunflower cropping system. The soil was clay loam in texture with available N, P and K respectively @ 325.5, 12.5 and 365.4 kg ha⁻¹. The experiments were laid out in split plot design with four replications. Main plot treatment consisted of four tillage methods viz., zero tillage (ZT) - zero tillage (ZT) [T₁], zero tillage (ZT)-conventional tillage (CT) [T₂], and conventional tillage (CT) - zero tillage (ZT) [T₃] and conventional tillage (CT) - conventional tillage(CT) [T₄] for maize- sunflower cropping system. Three weed management methods viz., hand weeding 20 and 40 DAS [W₁], pre-emergence herbicide (atrazine 0.5 kg ha⁻¹ for maize and pendimethalin 1.0 kg ha⁻¹ for sunflower) application followed by hand weeding 40 DAS [W₂], along with an unweeded check [W₃] for both the crops consisted the sub plot treatments.

The first crop of maize was raised during *Kharif* (June-Sep) 2005 and 2006 and the second crop of sunflower during *Rabi* (Oct-Dec) 2005 and 2006. In zero tillage the seeds were dibbled in the stubbles of the previous crop without any tillage or soil disturbance, except that which was necessary to place the seeds at the desired depth (Weed characters were studied 20 DAS of both the crops. Predominant weed species in unweeded control were grouped as grasses, sedge and broadleaved weeds). Weed density in each plot was recorded by using quadrat (0.5 X 0.5m) in four places at random and expressed as number m⁻² (Burnside and Wicks, 1965). Relative density (RD) of individual predominant weed species was worked out as detailed below and expressed as percentage. The observed data on weeds and test crops were statistically analysed based on the procedure given by Gomez and Gomez (1984) to find out the treatment difference. The data on weed count and weed dry weight which showed higher variation were subjected to log (X+2) transformation before analysis. Wherever the results were found significant, critical differences were worked out at five per cent probability level.

The non-significant results were indicated as NS.

$$\text{Relative Density} = \frac{\text{Absolute density of a given species (No m}^{-2}\text{)}}{\text{Total absolute density of all species (No m}^{-2}\text{)}} \times 100$$

RESULT AND DISCUSSION

Effect of treatment on dynamics of weed population

The predominant among broad – leaved weeds were *Trianthema portulacastrum*, *Parthenium hysterophorus*, *Digera arvensis* and *Datura metal* . Among the grass weeds, *Panicum repens*, *Cynodon dactylon*, *Dactyloctenium aegyptium*, *Chloris barbata* and *Dinebra retroflexa* were the dominant ones. *Cyperus rotundus* was the only sedge present. The change in weed species, dominance of one weed species and relative density of weed species due to treatment effect during the course of study were studied and presented in table 1.

Change in weed flora occurs due to the selection pressure imposed by innovations and modifications in the existing agricultural practices. *Cynodon dactylon* density was maximum in first year maize, and then it was reduced during 1st year sunflower. At the end of

cropping period (second year sunflower) its density was increased from 9.4 to 33.1 No. m⁻² due to continuous zero tillage (T₁) as it could not cause much disturbance to the vegetative propagules of the grass weeds. Grime (1979) reported that vegetative expansion is most successful in relatively undisturbed habitats. Buhler et al. (1994) recorded higher density of perennial grass weeds in reduced tillage systems as the rooting depth of the soil was not disturbed. The density of *Chloris barbata* was higher in treatments which received zero tillage in both the crops irrespective of crop rotation due to the higher densities of aboveground weeds and germinable weed seeds in the surface soil layer. Weed dry weight was also increased with the reduction in tillage intensity. Treatments of zero tillage after conventional tillage recorded higher density of other grasses. Density of *Cyperus rotundus* was higher in treatment that received conventional tillage due to smothering effect of grasses.

**Table 1. Effect of tillage and weed management practices on relative density of important grasses, sedge and broad leaved weeds
20 DAS in corn-sunflower-corn-sunflower cropping system (Per cent)***

Treat ments	DR				CD				DE				CB				PR				CR			
	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF
T ₁	20.1	5.7	3.0	4.2	9.4	10.2	17.6	33.1	6.5	20.5	9.8	6.5	10.8	0.0	9.8	10.6	0.2	5.6	0.8	6.7	4.2	18.4	33.4	3.9
T ₂	14.8	4.9	1.8	1.1	6.1	1.4	10.6	13.2	1.8	4.3	14.0	4.7	3.4	0.3	13.3	4.1	0.2	16.7	0.8	4.2	7.4	16.8	29.3	19.6
T ₃	4.2	2.2	0.0	1.1	7.6	3.4	17.3	17.4	6.1	6.6	4.0	5.8	11.0	2.6	0.0	8.3	0.5	10.4	0.5	3.3	19.8	19.5	62.1	8.9
T ₄	13.1	2.2	2.8	0.9	13.2	6.3	13.4	17.8	2.4	1.9	4.0	4.6	4.6	2.5	0.0	0.9	0.6	27.1	0.9	0.3	25.8	16.9	63.4	23.9
W ₁	10.4	2.8	5.7	1.5	7.9	4.8	7.5	11.8	2.9	14.1	6.7	6.1	4.6	0.0	2.6	2.4	0.1	24.3	0.8	4.3	7.5	13.9	53.4	9.5
W ₂	10.1	5.1	0.0	0.9	13.9	8.3	14.7	34.7	2.2	1.4	5.4	5.2	3.7	0.0	4.2	4.2	0.4	2.6	0.7	3.1	26.5	32.7	63.3	27.6
W ₃	18.7	3.3	0.0	3.1	5.4	2.9	21.9	14.7	7.5	9.6	11.7	4.8	14.0	4.1	10.6	11.3	0.6	17.9	0.9	3.5	8.9	7.0	24.5	5.1
Mean	13.1	3.8	1.9	1.8	9.1	5.3	14.7	20.4	4.2	8.4	8.0	5.4	7.4	1.4	5.8	6.0	0.4	15.0	0.8	3.6	14.3	17.9	47.1	14.1

Cont..

Treat ments	TP				PH				DA				DM				AV				AP			
	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF	CN	SF
T ₁	17.6	6.1	5.5	7.3	1.3	25.1	6.6	10.4	16.2	1.2	3.8	3.7	5	2	1.4	1.2	5.4	1.8	0.0	0.0	1.8	3.3	0.0	0.0
T ₂	33.6	10.1	6.7	16.1	2.1	21.2	7.1	16.1	16.8	1.7	3.3	5.1	5.3	4.1	1.7	2.5	5.6	1.2	0.0	0.0	1.9	2.4	0.0	0.0
T ₃	36.9	8.1	5.6	15.5	1.2	24.8	2	13.7	5.7	0.4	11.5	4.2	4.1	2.6	2	4.2	1.9	2.1	0.0	0.0	0.6	0.7	1.3	0.0
T ₄	28.7	5.8	5.5	15.5	1.4	25.4	0.9	17.6	6.0	0.0	4.6	5.9	0.8	2.5	1.8	2.9	2.0	3.0	0.0	0.6	0.7	0.5	1.0	0.0
W ₁	44.6	8.1	7.4	18.4	1.2	18.4	5.2	20.2	7.5	0.9	8.8	6.1	9.1	3.3	3.1	3.4	2.5	2.1	0.2	0.2	0.8	0.6	0.4	0.0
W ₂	22	4.8	3.1	2.9	0.3	28.9	1.9	6.7	13.4	0.0	3.9	3.3	0.8	3	0.3	1.2	3.9	1.3	0.0	0.0	1.3	1.2	0.9	0.0
W ₃	21.1	9.6	7	19.4	3	25	5.5	16.5	12.6	1.5	4.7	4.9	1.6	2.2	1.7	3.4	4.7	2.6	0.4	0.0	1.6	3.3	0.4	0.0
Mean	29.2	7.5	5.8	13.6	1.5	24.1	4.2	14.5	11.2	0.8	5.8	4.8	3.8	2.8	1.7	2.7	3.7	2.0	0.2	0.1	1.2	1.7	0.6	0.0

*Data statistically not analysed

T₁-T₄- Tillage practices, W₁-W₃- Weed management methods; DR- *Dinebra retroflexa*; CD- *Cynodon dactylon*; DE- *Dactyloctenium aegyptium*; CB- *Chloris barbata*; PR-*Panicum repens*; CR- *Cyperus rotundus*; TP-*Trianthema portulacastrum*; PH- *Parthenium hysterophorus*; DA- *Digera arvensis*; DM-*Datura metal* ; AV- *Amaranthus viridis*, and AP- *Amaranthus polygamus*, CN – Corn, SF- Sunflower

Trianthema portulacastrum density was higher during first year maize, afterwards its density was reduced which may be due to rotation with sunflower. Under continuous zero tillage (T_1), there was marked reduction in the density of *Trianthema portulacastrum*. It shows the change of weeds from broad-leaved weeds to grasses. *Amaranthus viridis* density was higher in zero tillage treated plot. At the end of study period, the density became nil. Similarly the density of *Amaranthus polygamus* was higher in zero tillage plot during 1st year maize but due to shifting of weeds from broad-leaved weeds to grasses, the density of *Amaranthus polygamus* became nil. The same trend was followed in other broad-leaved weeds.

In general, there was a marked shift in the weed flora from broad –leaved weeds to grasses and sedge due to tillage and weed management practices and stages of crop growth. Continuous zero tillage resulted in increased perennial and some annual grass weed species. Adoption of zero tillage practices led to shift in weed types, sometimes at the benefit of more difficult to control species (Derksen *et al.*, 1993). Buhler and Mester (1991) found that giant foxtail density under no tillage condition was 5 to 10 times higher than in conventional tillage plots.

Pre-emergence herbicide application (atrazine 0.5 kg ha⁻¹ for maize and pendimethalin 1.0 kg ha⁻¹ for sunflower) followed by hand weeding 40 DAS (W_2) controlled broad-leaved weeds effectively at initial stage (20 DAS) but other group of weeds particularly *Cynodon dactylon* and *Cyperus rotundus* increased at this stage. Herbicide treated plot recorded lower density of *Trianthema portulacastrum*. Its density was decreased from 22 to 2.9 m⁻²; this showed the efficiency of herbicide against *Trianthema portulacastrum*. However, hand weeding 20 and 40 DAS (W_1) effectively controlled all types of weeds except the sedge. This was due to effective control and subsequent reduction of broad-leaved weeds and grasses incidentally resulted in higher density of sedge weed. However, there was shift in weed flora from broad-leaved weeds to grasses as the age of crops advanced irrespective of tillage and weed management practices because broad-leaved weeds matured earlier than grasses and sedges as their life cycle was shorter than grasses and sedges (Anju, 2005).

Effect of treatment on weed density and weed dry weight

The lower weed density and weed dry weight were observed with conventional tillage –CT (T_4) and CT-ZT (T_3) in first year maize due to the inversion of surface soil and burial of weed seeds by disc ploughing (Table 2). Zero tillage (T_1 and T_2) was found to record higher total weed density and weed dry weight mainly due to the higher densities of both grasses and broad- leaved weeds. Higher weed seed densities in no tillage systems may be the result of reduced herbicide availability because of adsorption to near-surface organic matter (Sadeghi and Isensee, 1996).

Table 2 (Wide)

Table 2. Effect of tillage and weed management practices on Weed density (Nos. m⁻²), weed dry weight (kg ha⁻¹) 20 DAS and yield of maize-sunflower cropping system (kg ha⁻¹)

Treatments	1 st year Cropping system				2 nd year Cropping system				1 st year Cropping system			2 nd year Cropping system		
	Maize		Sunflower		Maize		Sunflower		Maize		Sunflower	Maize		Sunflower
	Weed density	Weed dry weight	Weed density	Weed dry weight	Weed density	Weed dry weight	Weed density	Weed dry weight	Grain yield	Stover yield	Seed yield	Grain yield	Stover yield	Seed yield
T₁	4.91 (142.4)	5.86 (357)	3.97 (54.7)	5.55 (277)	4.00 (53.9)	5.38 (227)	4.25 (76.2)	5.63 (293)	4293	7494	1383	4642	7558	948
T₂	5.41 (225.4)	5.78 (328)	4.25 (72.5)	5.78 (327)	4.05 (58.8)	2.29 (217)	3.89 (51.2)	5.33 (212)	4258	7454	1608	3067	6479	1518
T₃	4.71 (111.5)	5.63 (280)	4.45 (91.8)	6.00 (410)	3.53 (32.5)	4.82 (130)	4.26 (73.7)	5.43 (233)	4482	7862	1272	5133	8850	1234
T₄	4.31 (78.3)	5.61 (278)	3.88 (52.2)	5.58 (280)	3.44 (29.8)	4.64 (108)	3.76 (42.8)	5.25 (200)	4519	7901	1710	5362	9533	1551
SEd	0.02	0.03	0.03	0.03	0.01	0.03	0.019	0.05	118.4	219.7	52.3	204.1	309.9	57.5
CD (P=0.05)	0.04	0.07	0.06	0.07	0.04	0.06	0.043	0.12	NS	NS	118.3	461.8	701.1	130.0

W₁	4.97 (151.5)	5.80 (336)	4.28 (73.0)	5.75 (3.29)	3.80 (45.5)	5.09 (173)	4.08 (59.0)	5.40 (226)	4796	8931	1785	5613	9800	1586
W₂	4.49 (99.0)	5.58 (266)	3.64 (38.0)	5.51 (265)	3.55 (33.8)	4.60 (104)	3.60 (36.0)	5.28 (201)	4641	8032	1715	5434	9043	1509
W₃	5.05 (167.8)	5.78 (330)	4.49 (92.4)	5.92 (376)	3.91 (51.9)	5.41 (235)	4.44 (87.9)	5.55 (276)	3727	6070	981	2606	5471	844
SEd	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.04	105.9	200.1	42.6	169.6	271.6	37.5
CD (P=0.05)	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.09	218.5	412.9	88.1	350.2	560.6	77.5
T at W - S.Ed	0.03	0.04	0.04	0.04	0.03	0.04	0.03	0.09	209.5	393.8	87.1	344.1	541.1	84.0
T at W - CD	0.007	0.09	0.08	0.09	0.07	0.09	0.07	0.19	NS	NS	186.1	NS	NS	NS
W at T- S.Ed	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.09	211.7	400.2	85.3	339.3	543.2	75.1
W at T-	0.01	0.06	0.06	0.06	0.07	0.09	0.07	0.19	NS	NS	176.2	NS	NS	NS

CD														
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Figures in parenthesis are original values

T₁. T₄- Tillage practices,

W₁-W₃- Weed management methods

Lower weed density and weed dry weight were recorded by continuous conventional tillage (T_4) and continuous zero tillage (T_1) followed by conventional tillage (T_2) during first year sunflower. In second year maize, lower weed density and weed dry weight were observed with continuous conventional tillage (T_4) and conventional tillage (T_3). Higher weed density, weed dry weight and lower weed control efficiency were recorded by CT-ZT (T_3) and continuous zero tillage (T_1). In general, the weed density became higher with minimum than with moderate and intensive tillage systems (Dorado *et al.*, 1999). Donovan and McAndrew, (2000) also observed that weed seedlings density in the field increased from 31 plants m^{-2} in the intensive tillage system to 315 plants m^{-2} in the zero tillage system. Lower weed density and weed dry weight were recorded by continuous conventional tillage (T_4) and conventional tillage (T_2) during second year sunflower. Higher weed density, weed dry weight and lower weed control efficiency were recorded by continuous zero tillage (T_1) due to increase in perennial and annual grass weed species. Density of several annual grasses increased faster in reduced than in conventional tillage system over years (Buhler and Mester, 1991).

Lower weed density and weed dry weight were observed with pre-emergence herbicide application (atrazine 0.5 kg ha^{-1} for maize and pendimethalin 1.0 kg ha^{-1} for sunflower) followed by hand weeding 40 DAS (W_2) during initial period of crop growth (20 DAS). Application of herbicides at pre-germinated as well as at early establishment of weeds in both the crops was found to control graminaceous weeds and broad-leaved weeds effectively (Arti Khare and Jain, 1995). Pre-emergence herbicides gave effective control of weeds by inhibiting the germination of the weed seeds and also killing the emerging weeds at the early stages (Vyas *et al.*, 2000).

Efficiency of different tillage practices on weed control could be further increased by integration of weed management practices. Conventional tillage with herbicide application (T_4W_2 and T_3W_2 or T_2W_2) and hand weeding (T_4W_1 and T_3W_1 or T_2W_1) recorded lower weed density. It was due to better exposure of weeds and their seeds to herbicides and manual removal in well distributed soil layers created by deep tillage (Chinnusamy *et al.*, 2002).

Effect of treatment on yield of crops

Tillage treatments failed to influence the yield of maize significantly during first year because all tillage practices produced similar and comparable yields (Table 2). According to Wilhelm and Wortmann, (2004), the soybean yield obtained under no-tillage was similar to yields with other tillage practices. During second year, treatments those received conventional tillage (T_4 and T_3) produced higher and comparable grain and stover yield which was an indication for higher efficiency of deep tillage over a longer cropping period. Zero tillage (T_2) resulted in minimum grain and stover yields of maize due to higher weed infestation. Higher grain and stover yields of maize obtained

with hand weeding 20 and 40 DAS (W_1) during first and second year respectively was due to efficient control of weeds and increased root growth.

Higher seed yield of sunflower obtained with continuous conventional tillage (T_4) during both the years could be attributed to better growth of plants and good weed control. Comparable yields of sunflower were obtained with conventional tillage (T_2) to that of continuous conventional tillage due to better weed control and favourable soil environment. The lowest seed yield obtained with zero tillage (T_3 and T_1) was due to higher weed competition during cropping period. Higher seed yield of sunflower obtained with hand weeding 20 and 40 DAS (W_1) during both the years was due to better growth and yield parameters as a result of efficient grass weed control by hand weeding at critical crop weed competition. Comparable seed yields of sunflower were obtained with pre-emergence application of pendimethalin 1.0 kg ha^{-1} followed by hand weeding 40 DAS (W_2) was due to early application of broad spectrum selective herbicide which controlled and increased the seed yield of sunflower (Basavarajappan, 1992).

CONCLUSION

Continuous zero tillage increased the grass weed population. Conventional tillage resulted with a mixture of all types of weed species at lower density. Conventional tillage-conventional tillage with hand weeding 20 and 40 DAS or conventional tillage-conventional tillage with pre-emergence herbicide (atrazine 0.5 kg ha^{-1} for maize and pendimethalin 1.0 kg ha^{-1} for sunflower) followed by hand weeding 40 DAS may keep the weed density and weed dry weight below the economic threshold level and increase the productivity of crops.

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PHYTOPHTHORA DISEASES OF BETEL VINE (*PIPER BETLE* L.) – A MENACE TO BETEL VINE CROP

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ABSTRACT

Cultivation of betel vine is highly risky and returns are uncertain because of its proneness to several diseases, aggravated by the moist and humid weather conditions. The major constraint to cultivation of betelvine is its diseases that severely damage foot, stem, root and foliage. The serious diseases reported include a foot rot syndrome produced by a number of pathogens including *Phytophthora parasitica* var. *piperina*, *Phytophthora nicotianae* var. *parasitica* species of *Rhizoctonia*, *Pythium* and *Sclerotium rolfsii* Sacc, and foliage diseases like leaf rot by *Phytophthora parasitica*, *Phytophthora palmivora*, leaf spot and stem anthracnose caused by *Colletorichum capsici* and bacterial leaf spot and stem rot caused by *Xanthomonas campestris* pv. *betlicola*. Among the pathogens, *Phytophthora* sp. perhaps ranks first in its destructiveness under both field and storage conditions. In this paper scientific works of different researchers regarding nomenclature, symptoms of diseases, cultural characteristics of sporangiospores, protein content and protein file of the pathogen and serological studies were noted. Epidemiological studies and management of diseases were also included. Different management studies as varietal resistance, *in-vitro* and *in vivo* effect of chemicals against *Phytophthora* sp., biological control of *Phytophthora* rots of betelvine and integrated disease management were reviewed.

Key Words: Betelvine diseases, Phytophthora, protein profile, serology, epidemiology, integrated disease management

INTRODUCTION

Betelvine is cultivated mainly under an artificially erected structure, known as Boroj, Bareja or Bheet, which is a kind of hut whose sides and roof are made of jute slaths or straw on a

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light framework of bamboo. In spite of the tremendous potentiality of the crop, cultivation of betelvine is highly risky and returns are uncertain because of its proneness to several diseases, aggravated by the moist and humid weather conditions. Obviously the major constraint to cultivation of betelvine is its diseases that severely damage foot, stem, root and foliage. The serious diseases reported include a foot rot syndrome produced by a number of pathogens including *Phytophthora parasitica* var. *piperina*, *Phytophthora nicotianae* var. *parasitica* species of *Rhizoctonia*, *Pythium* and *Sclerotium rolfsii* Sacc, and foliage diseases like leaf rot by *Phytophthora parasitica*, *Phytophthora palmivora*, leaf spot and stem anthracnose caused by *Colletotrichum capsici* and, bacterial leaf spot and stem rot caused by *Xanthomonas campestris* pv. *betlicola*. Among the pathogens, *Phytophthora* sp. perhaps ranks first in its destructiveness under both field and storage conditions.

History and geographical distribution of *Phytophthora* in betelvine

The disease in focus has been reported from almost all betelvine growing countries in the world including Indonesia, Myanmar (Su, 1937), Sri Lanka (Paul, 1939) and Bangladesh (Roy, 1948; Turner, 1969) etc. Dastur (1926) first reported this disease of Pan (*P. betle* L.) from Durg, caused by *P. parasitica*. Stem portion of *P. betle* in Ceylon was reported to be attacked by *Phytophthora* sp. (Anonymous, 1928). In India, the disease has been reported from all the betelvine gardens of the country. Some of the more important subsequent reports are noted in Table 1.

In West Bengal, the highest intensity of foot and leaf rot has been recorded in Midnapore and Nadia district (Dasgupta and Sen, 1997, 1999). The extent of losses may vary from 30 – 100% in case of foot rot and 20 – 40% in case of leaf rot, leading to almost total crop failure (Maiti and Sen, 1982; Dasgupta *et al.*, 2000).

Nomenclature:

Species identification of foot rot and leaf rot pathogen is still in a state of flux. There is considerable confusion regarding the nomenclature of the species of *Phytophthora* causing disease(s) under consideration. Mc-Rae (1928) established the parasitism of *Phytophthora* species. Later Mc Rae (1934) by morphological study identified *P. nicotianae* var. *parasitica*. The *Phytophthora* species reported to attack betelvine includes *P. nicotianae* var. *parasitica* (Mc Rae, 1934), *P. nicotianae* var. *piperina* (Dastur, 1927) *P. parasitica*, *P. palmivora* (Maiti and Sen, 1977). Turner (1969) referred all isolates of *Phytophthora* from Southeast Asia as ‘*palmivora*’ type and this was stated to be true for the Indian isolates as reported by Maiti and Sen (1977). Based on existing keys to *Phytophthora* spp. all the isolates from Assam were identified as *Phytophthora palmivora* (Butl.) Butl. Mohanty (2000) isolated 16 isolates *Phytophthora* from different betelvine gardens of West Bengal (Table 2) and identified the isolates as *parasitica*. A new species of *Phytophthora* (*P. capsici*) isolated and identified as pathogenic to betelvine was reported from Tamilnadu centre of AICRP.

Table 1: Sources of isolates of *Phytophthora* sp.

Isolates	Place of collection	Source	Variety
P ₁	Betelvine Laboratory, BCKV, Kalyani, Nadia	-	-
P ₂	Betelvine Laboratory, BCKV, Kalyani, Nadia	-	-
P ₃	Betelvine Laboratory, BCKV, Kalyani, Nadia	-	-
P ₅	Virus Research Farm (Bareja II), BCKV, Kalyani, Nadia	Leaf	Simurali deshi
P ₆	Simurali, Nadia	Stem	Simurali bhabna
P ₇	Betelvine Laboratory, BCKV, Kalyani, Nadia	-	-
P ₈	Virus Research Farm (Bareja II), BCKV, Kalyani, Nadia	Leaf	Simurali bhabna
P ₉	Betelvine Laboratory, BCKV, Kalyani, Nadia	-	-
P ₁₀	Mahisadal, Midnapore (East)	Stem	Mitha
P ₁₁	Betelvine Laboratory, BCKV, Kalyani, Nadia	-	-
P ₁₂	Kakdwip, South 24 Parganas	Stem	Kali bangla
P ₁₃	Betelvine Laboratory, BCKV, Kalyani, Nadia	-	-
P ₂₁	Bira, North 24 Parganas	Leaf	Bagerhat
P ₂₂	Kakdwip, South 24 Parganas	Stem	Mitha
P ₂₃	Kakdwip, South 24 Parganas	Leaf	Mitha
P ₂₄	Betelvine Laboratory, BCKV, Kalyani, Nadia	-	-

Symptomatology

Dastur (1935) gave an accurate description of the symptoms of the disease. In *Phytophthora* induced foot rot, wet rot associated with wilting of vines is common. In leaf rot, circular brown to black water soaked spots develop on the leaves that enlarge fast extending to petiole and stem. Leaves subsequently are shed. Under intermittent wet and dry conditions (Maiti and Sen, 1977) clear zonations were seen on leaves giving a wavy appearance due to shrinkage or collapse of cells. The detailed symptoms of foot rot and leaf rot are as follows:

Foot rot of betelvine

The leaves and shoots turn yellow, wither and finally dry out to a pale brown colour. In the diseased plants fine young roots are infected first. Gradually the rotting spreads through older roots and ultimately reaches the foot or collar region of the plant. In a diseased plant, the whole underground portion gets more or less completely rotten. The soft tissues of old roots and the

inter-nodal portion of the cuttings are completely decomposed by the pathogen, leaving only the fibrous portion.

Leaf rot of betelvine

The initial symptoms appear in the form of water soaked spots, enlarging rapidly in size, on mature leaves near the soil. The spots are of two types, one type is circular, necrotic, deep brown in colour with distinct grey-brown zonation and the other is expanding, circular, dark-brown necrotic spot without any zonation. The central rotten portion of the spot drops out, leaving a hole with irregular edges. In both of these types, the symptoms develop on any part of the leaves, including tips and margins. The two types of spots are an expression of fluctuating (Type-I) and continuous high humidity (Type-II), respectively.

Cultural characteristics

The characteristics of different isolates showed considerable variation. The general cultural features of the test isolates grown on Czapek Dox agar medium are presented in table 3 (Mohanty, 2000).

Table 2. Cultural characteristics of colonies of isolates

Isolates	Characteristics
P ₁	Colony white in colour, compact growth, no aerial mycelium, growth of mycelium is quick, regular margin.
P ₂	Colony white in colour, compact growth; mycelia comparatively less smooth; growth of mycelia is very quick, regular margin.
P ₃	Colony white in colour, moderately compact growth, no aerial mycelium, growth of mycelium is slow.
P ₅	Colony dull white in colour, compact growth, no aerial mycelium, growth of mycelium is quick.
P ₆	Colony white in colour, compact growth, no aerial mycelium, growth of mycelium is quick.
P ₇	Colony white in colour, not so compact growth, no aerial mycelium, growth of mycelium is fast.
P ₈	Colony milky white in colour, compact growth, no aerial mycelium, growth of mycelium is fast.
P ₉	Colony dull white in colour, compact growth, no aerial mycelium, growth of mycelium is quick, regular margin.

P ₁₀	Colony white in colour, not so compact, aerial mycelium absent, growth of mycelium is moderately fast.
P ₁₁	Colony milky white in colour, not so compact, aerial mycelium absent, growth is moderately fast.
P ₁₂	Colony white in colour, compact growth, no aerial mycelium, growth of mycelium is quick.
P ₁₃	Colony white in colour, compact growth, no aerial mycelial growth of mycelium is slow, regular margin.
P ₂₁	Colony white in colour, compact growth, no aerial mycelium, growth of mycelium is very fast, regular margin.
P ₂₂	Colony white in colour, moderately compact growth, textures roughly granular with undulating centre; growth of mycelium is slow.
P ₂₃	Colony dirty white in colour, moderately compact growth, textures roughly granular with undulating centre; growth of mycelium is slow.
P ₂₄	Colony white in colour, compact growth, no aerial mycelium, regular margin, growth of mycelium is very quick.

Morphometric characteristics of different isolates of *Phytophthora*

Mycelium of the fungus was abundant. Hyphae were large, often with irregular swellings, coenocytic, hyaline, measuring 3 – 7 µm in diameter with an average of 5 µm; aerial hyphae long, sparingly branched. While submerged hyphae develop with irregular swellings, shorter and branched.

Sporangiophores were monochasial sympodium or unbranched, length varied from 15.5 – 36.0 µm. Sporangia were *Phytophthora* like, ovoid to obpyriform to elongate ovoid, always terminal, caduceus, markedly papillate, exit pore narrow, measuring 43.6 – 50.14 x 20.71 – 24.00 with an average of 47.18 x 22.44 µm and length-breadth ratio (L : B) 1.86 – 2.42 (average 2.10). Germination of sporangia was found by developing germ tubes, frequently through the apex, or indirectly by the development of zoospores. Chlamydospores were terminal or intercalary, hyaline, spherical, measuring 23.30 – 29.19 µm in diameter with an average of 26.20 µm. The relative reproductive structures of *Phytophthora* species reported by different workers are shown in table 4.

Table 3. Relative dimensions of reproductive structure of *Phytophthora* sp. reported by different workers

Structure	Dimension (µm)		
	<i>P. parasitica</i> (McRae, 1934)	<i>P. parasitica</i> var. <i>piperina</i> (Dastur, 1935)	<i>P. palmivora</i> (Maiti and Sen, 1977)
Sporangium			
Range	19 – 58 × 15 - 35	30 – 65 × 20 – 41	23 – 66 × 15 – 41
Mean	35 × 15	41 × 20	40 × 26
Ratio	1.58	-	1.53
Chlamydospore			
Range	20 – 35	-	20 × 40
Mean	33	-	29
Oospore			
Range	14 – 40	18 – 30	17 – 41
Mean	30	26	26
Colour	Brown	Hyaline to yellow	Light brown

Sporangial characteristics of different isolates of *Phytophthora parasitica*

The sporangial measurements of different isolates collected from different agro climatic zones of West Bengal grown on CAM are shown in table 5 (Mohanty, 2000).

Table 4. Dimensional characteristics of sporangia of isolates of *Phytophthora parasitica* collected from different agro-climate zones of West Bengal

Isolates	Sporangial measurement (in μ) ¹		Average length breadth ratio	Shapes
	Length	Breadth		
P ₁	20.1 – 26.4 (23.8)	15.9 – 18.1 (16.8)	1.42	Pear
P ₂	23.2 – 31.4 (28.0)	16.1 – 19.0 (18.2)	1.54	Lemon
P ₃	21.0 – 28.5 (26.6)	16.3 – 19.1 (18.2)	1.46	Lemon
P ₅	35.0 – 42.4 (39.2)	29.5 – 34.1 (32.1)	1.22	Spherical
P ₆	18.7 – 23.2 (21.0)	15.1 – 15.9 (15.4)	1.36	Pear
P ₇	31.4 – 39.2 (35.0)	26.0 – 31.2 (29.4)	1.19	Spherical
P ₈	27.4 – 33.1 (30.8)	19.1 – 24.0 (22.4)	1.37	Pear
P ₉	25.2 – 30.0 (28.0)	18.3 – 23.6 (21.0)	1.33	Pear
P ₁₀	35.0 – 40.5 (37.8)	20.1 – 28.4 (25.2)	1.50	Lemon
P ₁₁	37.5 – 43.2 (40.6)	25.0 – 30.4 (25.0)	1.62	Lemon
P ₁₂	31.2 – 37.2 (35.0)	21.4 – 28.0 (25.2)	1.39	Pear
P ₁₃	27.12 – 35.0 (30.8)	20.0 – 28.9 (25.2)	1.22	Spherical
P ₂₁	34.2 – 40.1 (37.8)	25.6 – 31.7 (30.8)	1.23	Spherical
P ₂₂	36.0 – 43.3 (40.6)	22.1 – 29.0 (26.6)	1.52	Lemon
P ₂₃	26.2 – 32.0 (29.4)	15.0 – 22.4 (18.2)	1.61	Lemon
P ₂₄	30.7 – 35.1 (33.6)	20.1 – 27.4 (23.8)	1.41	Pear

¹The figures are an average of 10 replications

Figures in parentheses are average values

Relative Dimensions of *Chlamydospores* of Different Isolates of *P. parasitica*

The range, average diameter and attachment of Chlamydospore of above different isolates reported by Mohanty, 2000 are presented in table 6.

Table 5. Dimensional characteristics of *Chlamydospores* of isolates of *Phytophthora parasitica*

Isolates	Chlamydospores		Attachment
	Diameter range (in μ) ¹	Average diameter (in μ)	
P ₁	25.4 – 31.3	29.4	Terminal/Intercalary
P ₂	21.1 – 25.6	23.8	Terminal/Intercalary
P ₃	30.1 – 37.3	33.6	Terminal
P ₅	27.7 – 34.4	30.8	Intercalary
P ₆	25.0 – 30.0	28.0	Terminal
P ₇	35.4 – 43.2	39.2	Intercalary
P ₈	27.1 – 32.6	29.4	Intercalary
P ₉	29.0 – 34.2	30.8	Intercalary
P ₁₀	32.2 – 39.5	35.0	Intercalary
P ₁₁	23.0 – 29.3	26.6	Intercalary
P ₁₂	35.7 – 40.2	37.8	Intercalary
P ₁₃	26.0 – 31.1	28.0	Intercalary
P ₂₁	34.1 – 42.0	39.2	Terminal
P ₂₂	27.5 – 33.5	30.6	Terminal
P ₂₃	30.1 – 36.2	33.6	Terminal
P ₂₄	28.0 – 33.7	30.8	Intercalary

¹The figures are an average of 10 replications

It was found from the microscopic observations that all the Chlamydospores were double layered, thick walled and spherical in shape.

Protein Content of *P. parasitica*

Mohanty, 2000 tested the soluble protein content of 6 different isolates of *Phytophthora parasitica* using Lowry's Method. The protein content of six test isolates are given in table 7.

Table 6. Protein content of different isolates of *P. parasitica*

Isolates	Protein (mg/g of mycelium)
P ₁	71.24
P ₅	83.69
P ₆	70.78
P ₈	70.17
P ₁₃	57.67
P ₂₁	88.46

Protein Profile of Isolates of *P. Parasitica* by SDS-PAGE Method

The protein profile of test isolates was studied by SDS-PAGE method. It was revealed that there were two distinct groups i.e., P₁₃, P₈ and P₆ in one group and P₁, P₅ and P₂₁ in another (Mohanty, 2000).

Serological Identification of *P. parasitica*

For serological identification of isolates of *P. parasitica*, agar gel double diffusion method was used. A sum total of fourteen isolates of *P. parasitica* were tested against antiserum of 4 isolates. The results are given in table 8.

Table 7. Presence of common antigens among different isolates of *P. parasitica* on agar gel double diffusion test

Antigen	Antisera			
	P ₃	P ₁₃	P ₅	P ₁₁
P ₂	-	-	-	-
P ₃	+	-	-	-
P ₅	-	-	+	-
P ₈	-	-	-	-
P ₉	+	-	-	-
P ₁₀	-	-	+	-
P ₁₁	-	+	-	+
P ₁₃	-	+	-	+
P ₁₅	-	-	-	-

(Contd...)

Antigen	Antisera			
	P ₃	P ₁₃	P ₅	P ₁₁
P ₁₆	-	+	-	-
P ₂₁	+	-	-	-
P ₂₂	+	-	-	-
P ₂₃	-	-	-	-
P ₂₄	-	-	-	-

+ = common precipitation band(s) detected

- = common precipitation band(s) not detected

In the present investigation, these isolates were grouped into 3 serogroups, e.g. P₃ (P₃, P₉, P₂₁ and P₂₂), P₁₃ (P₁₁, P₁₃ and P₁₆) and P₅ (P₅ and P₁₀).

Epidemiological studies

Maximum temperature, maximum relative humidity and rainfall played an important role in the development of both the diseases (Anonymous, 2000-2006; Maiti and Sen, 1982).

Management of *Phytophthora* diseases of Betelvine

Varietal resistance to *Phytophthora* leaf and stem rot

Available varieties at different centres of AICRP on betelvine were rigorously screened under artificially created epiphytotic condition for resistance to *Phytophthora* leaf and stem rot. Halisahar sanchi was found to possess resistance at Kalyani centre and Pachaikodi and Karappu at Jabalpur centre.

In-vitro effect of chemicals against *Phytophthora* sp.

Under *in-vitro* conditions, Bordeaux Mixture showed high requirement for checking *Phytophthora* isolates of betelvine (Chaurasia, 1976). Chaurasia *et al.* (1973) reported the effectiveness of antibiotics like streptomycin and streptocycline under *in-vitro* conditions against *Phytophthora* isolates of betelvine, while the same was reported ineffective by Deshpande (1981). Volatile oils, like those from *L. scandans* and *Mentha arvensis* were sown to inhibit growth of *Phytophthora* sp. (Chaurasia and Vyas, 1977). They (Chaurasia and Vyas, 1975) also reported the inhibition of growth of *Phytophthora* sp. by vitamins like Pyridoxin, Biotin, Thiamin and Riboflavin.

Laboratory evaluation indicated that the growth and sporulation of *P. parasitica* var. *nicotianae* were totally suppressed by Rhidomyl @ 0.1, 0.2, 0.3 and 0.4 per cent concentration

and there was no growth of the fungus after 21 days in the treated petriplates (Reddy and Nagarajan, 1980). In *in-vitro* screening of fungicides against *P. palmivora* and *P. meadii* using poison food technique, Bordeaux Mixture (1%), Blitox, Bayer – 5072, Terrazole and Metalaxyl were found effective to inhibit the growth and sporangial formation (Sastry, 1982).

The experiments conducted in an ICAR sponsored ad-hoc project revealed that Fosetyl-Al showed a great promise under *in-vitro* conditions for inhibition of *P. parasitica* followed by Chlorothalonil, Dithane M-45 and Bordeaux Mixture (Table 9). Different isolates showed minor variation in their germinability of sporangia but the pattern of response in general, was similar. The trend of ED₅₀ value for six isolates against one fungicide varied within a short range. Fosetyl-Al (Aliette), a fungicide recommended specially for Oomycetes, proved its high efficacy in checking both sporangial germination and mycelial growth. The high requirement of copper for inhibition could be due to ignoring the synergy involved in the preparation of Bordeaux Mixture in these tests.

Table 8. ED₅₀ value of different fungicides towards germination of spores and mycelial growth inhibition of *P. parasitica*

Fungicides	ED ₅₀ value (range) in ppm	
	Sporangial germination inhibition	Mycelial growth inhibition
Chlorothalonil	92.6 - 128.8	125.6 – 170.4
Fosetyl-Al	59.7 – 93.7	105.8 – 161.4
Mancozeb	100.0 – 158.5	180.4 – 230.6
Bordeaux Mixture	180.6 – 229.9	290.5 – 325.4

***In-vivo* effect of Chemicals Against *Phytophthora* sp.**

There is a much greater volume of literature on field trials starting from the early works of pioneers like Dastur, McRae, Hector, Chowdhury to present day. These have been recorded from time to time (Saxena, 1977; Mehrotra, 1981, 1984; Sen *et al.*, 1981; Khare *et al.*, 1988; Chattopadhyay and Maiti, 1990) and the consensus that emerges is that no efficient method of controlling the *Phytophthora* diseases of betelvine is available yet. The age old Bordeaux Mixture still has the highest promise. However, the salient literatures on field trials for the control of *Phytophthora* rots of betelvine are listed in table 10.

Table 9. Field trials for controlling Phytophthora rots of betelvine during last eight decades

Chemical	Dosage/Mode	Reference
Bordeaux Mixture	2 : 2 : 50 @ 125 lit per 150 ft. line before planting or premonsoon and 4 drenches up to September.	Dastur, 1931, '35, Hector, '30; Uppal, '31, '38, Mc Rae, '34; Chowdhury, 1944 C; Mahmud, '52; Subramanian and Venkata Rao, '70; Venkata Rao <i>et al.</i> , '73; Narasimhan <i>et al.</i> '76; Patil, <i>et al.</i> '86; Rabindran and Marimuthu, '92; Dasgupta '93; Dasgupta and Sen, '96
	4 drenching @ 1% BM at an interval of 30 days starting of the onset of monsoon	Maiti and Shivshankar, 1998; Dasgupta and Sen, 1999; Dasgupta <i>et al.</i> , 2000; Mohanty <i>et al.</i> , 2000.
	8-9 spraying @ 0.5% BM at an interval of 15 days starting of the onset of monsoon	Anonymous, 1995, 96, 97; Dasgupta <i>et al.</i> , 1988
Burgandy mixture	Soil fungicide	Thompson, 1933;
Cuprous oxide	Soil drench	Chattopadhyay, 1967, Ayavavoo <i>et al.</i> , '81
Chloroneb	100 µg/ml	Bambawala, 1973
Streptomycine	Soil drench	Chaurasia and Thind, 1975
CuOCl ₂	Soil drench	Narasimhan <i>et al.</i> 1976; Patil <i>et al.</i> '86
Cuman L., Blitox, Dexon, DM-45	Soil drench	Maiti <i>et al.</i> 1978
Ridomyl and Daconil	and Soil drench	Ramraj and Vidyasekharan, 1983
Streptomycin		Dhara <i>et al.</i> 1989
Fosetyl-Al	Soil drench and spraying	Dasgupta <i>et al.</i> 1988; Dasgupta & Sen, 1998 and 1999; Dasgupta <i>et al.</i> 2000; Dasgupta <i>et al.</i> 2005.

Dasgupta *et al.*, 2005 reported that the best control of foot rot was recorded in the plots treated with Fosetyl-Al (3g/l) at monthly intervals at Jorhat and Trichy whereas at Kalyani centre the best control was recorded with Bordeaux mixture (1%). The highest leaf yield was recorded with Fosetyl-Al at Jorhat, Trichy and Kalyani. The highest fresh weight of 100 leaves was recorded with phosphorus acid (4g/l). The highest cost: benefit ratio was recorded with Fosetyl-Al at Jorhat and at Kalyani with Bordeaux mixture (1%) at monthly interval (Table 11).

Table 10. Control of *Phytophthora foot rot* with fungicides

Treatment	Disease incidence (%)				Yield in lakh leaves/ha				Fresh weight of 100 leaves			
	Jorhat	Bapatla	Trichy	Kalyani	Jorhat	Bapatla	Trichy	Kalyani	Jorhat	Bapatla	Trichy	Kalyani
Phosphorus acid (Akomin) 4g/l, 4drenches at monthly interval	11	37	15	26	27	32	23	45	290	198	208	212
Phosphobis acid (Akomin) 4g/l, 2drenches at bi- monthly interval	14	34	20	29	24	31	22	45	293	193	209	205
Fosetyl-Al 3g/l, 4 drenches at monthly interval	5	25	9	12	41	32	25	58	292	196	208	199
Fosetyl-Al 3g/l, 2 drenches at bi-monthly interval	8	25	13	15	34	32	23	53	288	200	208	197
Chlorothalonil 2.5g/l, 4 drenches at monthly interval	9	33	26	15	34	27	22	55	291	195	207	201
Chlorothalonil 2.5g/l, 2 drenches at bi-monthly interval	14	41	32	19	29	27	22	52	287	193	207	184
Bordeaux mixture 1%, 4 drenches at monthly interval	6	22	11	11	40	30	24	56	290	191	210	205
Control (no drenching)	23	46	44	34	22	29	21	39	290	191	207	176
CD (P=0.05)	3.4	NS	3.2	2.2	3.9	NS	1.5	4.5	NS	NS	NS	20
CV%	12	22.6	6.8	9.1	7.2	10	3.8	9.5	0.7	2.1	0.6	11

Biological control of *Phytophthora* rots of betelvine

Earlier works (Tiwari and Mehrotra, 1968; Mehrotra and Tiwari, 1976) showed that dipping of cuttings in a *T. viride* cell suspension effectively reduced the disease. Similarly use of corn straw and til oil cake also reduced disease (Mehrotra and Tiwari, 1976).

Of the 2 approaches of biological control viz., indirect through manipulation of associated microbiota by amendments and direct use of antagonist (Baker and Cook, 1974), the first, that is the use of oil cake in betelvine plantation is an age old practice.

Four applications of a *Trichoderma harzianum* inoculated oil cake in soil at quarterly interval significantly reduced the disease incidence as well as increase in leaf yield and fresh weight of 100 leaves but was less effective than Bordeaux mixture (1%) application at monthly intervals for four times starting at the onset of monsoon in all the AICRP centres of betelvine (Anonymous, 1997-98, 1998-99 and 1999-2000).

Pseudomonas fluroscence inoculated oil cake applications for four times in soil at quarterly intervals significantly reduced the disease incidence as well as increase in leaf yield and fresh weight of 100 leaves and it was statistically at par with the four applications of *Trichoderma harzianum* inoculated oil cake applications in soil at quarterly intervals, but was less effective than Bordeaux mixture (1%) application at monthly intervals for four times starting at the onset of monsoon in all the AICRP centres of betelvine (Anonymous, 1999-2000, 2000-01, 2001-02, 2002-03 2004-05).

Integrated Disease Management

Till the year 1999 little information has been published on Integrated Diseases Management (IDM) of Betelvine. Maiti (1999) has meticulously identified the component of IDM that are now available for the *Phytophthora* diseases of betelvine, including disease resistance, plant nutrition, sanitation, chemical and biological control. The constraints to IPM and IDM development are identified as lack of forecasting system, non availability of tools for breeding either conventionally or biotechnologically, and a sketchy understanding of the biological control system.

Efforts on IDM of betelvine were initiated under the AICRP Betelvine project at several centers during 1997-98. The results of different AICRP on betelvine revealed that integrated disease management with sanitation + one soil drench of Bordeaux mixture (1%) + *Trichoderma* application after one month of application of Bordeaux mixture + one more application of Bordeaux mixture (1%) after one month of application of *Trichoderma* starting at the onset of monsoon significantly reduced the disease incidence in addition to the increase in leaf yield and fresh weight of 100 leaves. These were recorded in Jabalpur, Bihar, Tamilnadu, Assam and Kalyani centres (Anon., 1997-1998, 1998-99, 1999-2000).

CONCLUSION

Different workers have given some information regarding management strategies of *Phytophthora* diseases of betelvine. These results are not yet enough to accurately recommend to the betelvine growers.

There are wide scopes of research in the field of bio-control. Although *Trichoderma* was found to be an effective antagonist under *in-vitro* conditions which is probably due to poor rhizosphere competence and less secretion of antifungal enzymes. These problems may be overcome by the use of genetically engineered strains of *Trichoderma* sp. For bio-control of these diseases application of bio-protectant may be used on the foliage and also near the collar region which is very much sensitive to foot rot pathogens.

To get better results in IDM programme, the sources of initial disease inoculum need to be identified along with possibilities of their elimination. There are several reports that some co-lateral hosts harbour the pathogens. The irrigation water from the adjoining ponds may be the source of inoculum. The growers usually wash the infected material in nearby reservoirs and irrigate their crops with the same water, thus enabling the recurrence of the disease. So, the actual means of survival within and in the immediate vicinity of betelvine conservatory should be identified first and then factors affecting inoculum build-up and their dispersal need to be searched. Evolved strategy thus obtained should be confirmed following *in situ* farmer's plot demonstrations.

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RESPONSE OF NITROGEN LEVELS ON YIELD OF SESAME (*Sesamum indicum* L.)

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ABSTRACT

A field experiment was conducted under rainfall condition at the Bangabundhu Sheikh Mujibur Rahman Agricultural University, Gazipur during Kharif-I (March to June, 2002) season to study the effect of nitrogen fertilizers on growth character, nitrogen content and yield of sesame varieties viz. T-6, BARI Til-2 and BARI Til-3. The nitrogen levels were N₀, N₅₀, N₁₀₀ and N₁₅₀ kg ha⁻¹. Application of nitrogen fertilizer significantly enhanced the growth, nitrogen uptake and yield attributes over control. Plant height, number of branches/ plant, nitrogen content in plant tissues and N uptake increased with the increase in nitrogen application in all varieties. The tallest plant (121.70 cm) was recorded under N₁₅₀ kg ha⁻¹ for BARI Til-3. The highest number of branches/ plant 4.37, 4.26 and 4.67 were obtained in varieties T-6, BARI Til-3 and BARI Til-3 respectively at N₁₅₀ kg ha⁻¹. The number of capsules plant⁻¹, seeds capsule⁻¹, 1000-seed weight and seed yield increased significantly up to N₁₀₀ kg ha⁻¹ in T-6 and BARI Til-3 but BARI Til-2 up to N₁₅₀ kg ha⁻¹. The highest seed yield 1.54 t ha⁻¹ and 1.29 t ha⁻¹ were obtained from the sesame varieties BARI Til-3 and T-6 respectively at N₁₀₀ kg ha⁻¹ while the variety BARI Til-2 produced highest seed yield 1.31 t ha⁻¹ with N₁₅₀ kg ha⁻¹. Among the three varieties tested BARI Til-3 performed best in terms of nitrogen uptake and seed yield.

Key words: Sesame varieties, nitrogen levels, growth and yield.

INTRODUCTION

Oil seeds are important in the national economy of Bangladesh. They constitute the second most important group of the crop next to cereals (Anon., 2000). Out of the total cropped area of 13.53 million ha, oil crops occupy only 0.561 million ha (Wahhab *et al.*, 2002). Recent data indicated 0.16 million tons of oilseeds are produced for a population of 143.8 million in Bangladesh (Mondal *et al.*, 2001). Out of total production mustard contributes 52.2%, sesame 10.4%, groundnut 8.5%, linseed 9.3%, coconut 18.8% and other oil crops 0.2%. The national average production of oilseed crop is 739 kg ha⁻¹ (Anon., 2000). The shortage of edible oil has

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become a chronic problem for the nation. To fulfil the requirement, the country has to import edible oils at the cost of huge foreign exchange. Therefore, the country has to increase its production to satisfy its internal demand. The low yield of the crop is due to the low yielding cultivars and lack of appropriate agronomic practices.

Sesame (*Sesamum indicum* L.) is an important oil seed crop belonging to the family Pedaliaceae. It is generally a photosensitive crop. In Bangladesh it is mainly grown during kharif-1 season (Anon, 1997). Despite its versatile use, the crop is still neglected both in the research and farmers level. The present average seed yield of sesame in Bangladesh is 900 kg ha⁻¹ in demonstration trials but the national average yield is 628 kg ha⁻¹ (Wahhab *et al.*, 2002). Among the agronomic manipulation, proper nutrient management plays a vital role in getting higher yield. Therefore, the present investigation was carried out to find out the response of nitrogen fertilizers on growth, nitrogen content and yield of sesame varieties.

MATERIALS AND METHODS

The experiment was conducted in the field of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur during Kharif-1 (March-June) season. The land was medium high and the soil was shallow red brown containing 33% clay, 31% silt and 36% sand with pH 6.7 under Agro Ecological Zone (AEZ 28), of Madhupur tract (Anon., 1988). The treatments were three varieties (T-6, BARI Til-2 and BARI Til-3) of sesame and four levels of nitrogen (0, 50, 100 and 150 kg ha⁻¹). Seed yield, yield attributes, N-uptake and content (%) at 30, 50, and 70 DAE was recorded.

The seeds were collected from the Oilseed Research Center, Bangladesh Agricultural Research Institute (BARI), Gazipur and treated with vitavax-200 at the rate of 2.5 g kg⁻¹ of seeds. The experiment was laid out in a Randomized Complete Block Design (RCBD) with twelve treatment combinations and three replications. The size of unit plot was 4m x 4m. Row and plant spacing was 30 cm x 5 cm. The adjacent blocks and the adjacent plots were separated from one another by 1.5 m and 1 m respectively. The land was fertilized with 60 kg P₂O₅, 30- kg K₂O, 14 kg S, 1.8 kg Zn and 1.05 kg B ha⁻¹ in the form of urea, triple super phosphate (TSP), muriate of potash (MP), gypsum, zinc sulphate and boric acid, respectively (Anon., 1997). During final land preparation cowdung was incorporated into the soil at the rate of 10 tons ha⁻¹. One-third of the total urea and all other fertilizers were applied during final land preparation. The remaining amount of urea was applied as top dressing in two equal installments at the vegetative stage (20 DAE) and flower initiation stage (35 DAE). Seeds were sown in lines on March 06.

The relevant data were statistically analyzed with the help of 'MSTAT' Program. The difference between the treatment means was compared by least significant difference (LSD) test at 5% level of significance.

RESULTS AND DISCUSSION

The plant height increased significantly with the increasing doses of nitrogen fertilizer irrespective of varieties. The tallest plants were recorded at N₁₅₀ kg ha⁻¹ in BARI Til-3 (Table 1).

The highest number of branches (4.67) per plant was produced at N₁₅₀ kg ha⁻¹ in BARI Til-3 and the lowest number of branches (2.67) per plant was obtained from N₀ kg ha⁻¹ in BARI Til-2 variety (Table 1). Similar result was recorded by Mondal and Gaffer (1983). Srivastava and Tripathi (1992), Prakasha and Thimmegowda (1992) also reported that nitrogen fertilizer application had significant effect on number of primary branches per plant in sesame.

Table 1. Plant height, yield & yield attributes of different varieties of sesame at different levels of Nitrogen

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Table 2. Nitrogen content (%) and Nitrogen uptake in total plant by three sesame varieties at different stages as influenced by nitrogen fertilizer application

Variety	Nitrogen levels (kg ha ⁻¹)	Nitrogen content (%)			Nitrogen uptake (Kg ha ⁻¹)		
		Vegetative stage	Flowering stage	Maturity stage	Vegetative stage	Flowering stage	Maturity stage
		(30 DAE)	(50 DAE)	(70 DAE)	(30 DAE)	(50 DAE)	(70 DAE)
T-6	N ₀	0.61	0.96	0.78	2.89	16.75	16.19
	N ₅₀	0.91	1.22	1.00	5.66	26.10	26.30
	N ₁₀₀	1.15	1.47	1.15	1039	4659	43.37
	N ₁₅₀	1.25	1.69	1.42	11.44	47.53	48.27
BARI Til -2	N ₀	0.76	1.08	0.78	2.85	16.54	14.47
	N ₅₀	0.83	1.24	0.89	3.96	21.53	19.79
	N ₁₀₀	0.97	1.54	1.13	7.18	38.0	34.04
	N ₁₅₀	1.50	2.01	1.59	12.83	65.19	46.05
BARI Til -3	N ₀	1.13	1.41	1.09	6.72	24.09	23.68
	N ₅₀	1.32	1.81	1.19	9.89	38.81	34.42
	N ₁₀₀	1.54	1.93	1.42	16.87	53.11	46.59
	N ₁₅₀	1.76	2.27	1.67	17.62	66.92	58.19
LSD (0.05)		0.31	0.27	0.26	0.39	0.44	0.41
CV(%)		15-81	10.02	12.77	1.66	5.74	5.17

T-6, BARI Til-2 and BARI Til-3 were three varieties of sesame; N₀, N₅₀, N₁₀₀ and N₁₅₀ were different levels of urea. DAE = Days After Emergence.

Uptake of N also increased due to the application of higher level of N. However, response of N uptake to the applied N fertilizer was parallel to the response of plant N content (%). Total uptake of N varied due to variation of nitrogen treatment. Plants treated with N₁₅₀ kg ha⁻¹ had the highest N uptake in all varieties irrespective of all growth stages i.e. vegetative (30 DAE), flowering (50 DAE) and maturity stages (70 DAE). Among three stages N uptake was highest at flowering stage. Nitrogen uptake was lowest at N₀ kg ha⁻¹ in all growth stages in all varieties tested. Almost similar result was obtained by Tiwari *et al.*, (1996) in sesame.

The number of capsules per plant significantly increased with the increasing levels of nitrogen (table). Plants treated with N₁₀₀ kg ha⁻¹ produced the highest number of capsules per plant in T-6 and BARI Til-3 respectively. BARI Til-2 produced the highest number of capsules per plant (63.67) with N₁₅₀ kg ha⁻¹. The lowest number of capsules per plant was recorded with N₀ kg ha⁻¹ in BARI Til-2.

Irrespective of varieties and nitrogen levels seeds per capsule increased with the increasing N levels. The maximum number of seeds per capsule (75.33) was obtained with N_{100} kg ha⁻¹ treatment in BARI Til-3 variety.

Variety T-6 and BARI Til-2 produced the highest number of seeds per capsule with N_{150} kg ha⁻¹. The minimum (59.33) was obtained without N in BARI Til-2. The varieties did not differ significantly in terms of number of seeds per capsule. This indicates that the number of seeds per capsule in sesame is mainly due to its genetic character. Beyond N_{100} kg ha⁻¹ number of seeds per capsule was reduced in T-6 and BARI Til-2. Roy *et al.*, (1995) Shrivastava and Tripathi (1992) and Singh (1990) recorded the highest number of seeds per capsule at moderate level of nitrogen and beyond it the number of seeds per capsule was reduced in sesame and pea respectively.

Among the different N levels significant variation in 1000 seed weight was observed. The highest 1000-seed weight was observed at N_{100} kg ha⁻¹ in T-6 (3.41) and BARI Til-3 (3.46) which was statistically identical with the treatment of N_{150} kg ha⁻¹. BARI Til-2 produced the heavier seeds with N_{150} kg ha⁻¹.

The yield per hectare was significantly increased due to increasing level of N fertilizer in sesame varieties. It was clear that seed yield per hectare increased up to N_{100} kg ha⁻¹ and thereafter it decreased in T-6 and BARI Til-3, while the variety BARI Til-2 gave the highest seed yield (1.30 t ha⁻¹) with N_{150} kg ha⁻¹. The highest seed yield in BARI Til-2 at N_{150} kg ha⁻¹ was supported by the number of capsules per plant. The highest seed yield (1.53 t ha⁻¹) was obtained at N_{100} kg ha⁻¹ in BARI Til-3 and the lowest (0.80 t ha⁻¹) with N_0 kg ha⁻¹ in BARI Til-2. The highest seed yield at N_{100} kg ha⁻¹ was due to favorable growth, nitrogen nutrient uptake, higher number of seeds per capsule and heavier seeds. Among the three varieties BARI Til-3 always produced highest seed yield. This is due to the larger production of dry matter which was ultimately translocated to the developing grain.

CONCLUSION

From the study, it may be concluded that the growth of sesame varieties was significantly increased with the increase in nitrogen fertilizer level up to 100 kg N ha⁻¹ in T-6 and BARI Til-3 and up to 150 kg N ha⁻¹ in BARI Til-2. Both total nitrogen content and N uptake increased with the increment of N fertilizer up to 150 kg N ha⁻¹ in all the three sesame varieties. Yield was significantly increased up to 100- kg N ha⁻¹ in T-6 and BARI Til-3, whereas BARI Til-2 showed better performance in seed yield with 150 kg N ha⁻¹.

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VALUE CHAIN ANALYSIS OF PRODUCTION AND MARKETING OF FRESHWATER PRAWN, IN KHULNA AREAS OF BANGLADESH

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ABSTRACT

Freshwater prawn (galda) culture is an important activity in Khulna areas. The production and marketing system of prawn consisted of about 6 different stakeholder groups. The socio-economy of the stakeholders and value chain of the process were analyzed. A total of 325 sample questionnaires were filled in and collected from 5 stakeholder groups viz., farmers, depot owners, Chatal auctioneers, commission agents and factory workers. Galda farmers are small holders. The principal costs of production involved purchase of feed, seed and labor. The feeds used were made with local ingredients. The average production was 162 Kg acre⁻¹. The price of galda was variable; the farmers had no say on the rates and grades; the commission agents controlled it. The net annual profit acre⁻¹ on an average was Tk. 10,000. The marketing chain was plagued by various problems at different stakeholder levels. The depot owners were the big group. The agents were the rich and powerful in the chain and most exploited people were the farmers and small traders. The factory workers were ill trained, low paid and subjugated. In spite of poor socio-economy, the livelihood outcomes of the farmers and depot owners was positive. The export quantity had increased over the years, however, there was great concern about long term sustainability of the production system. A concerted effort is needed to upgrade the production and marketing chain of galda in Bangladesh.

Key words: *Macrobrachium rosenbergii*; value chain; production; processing; marketing

INTRODUCTION

Bangladesh has extensive water resources. The fisheries sector holds good promise for job creation, foreign exchange earning and supplying nutrition to the people. Presently 1.4 million people are engaged full time and 12 millions part times in fisheries sector for livelihood and trade (Chowdhury, A., 1994). Another 3.08 million fish and shrimp farmers are engaged in culture both at subsistence and commercial level. About 97% of the inland fish production is marketed

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internally for domestic consumption and the remaining 3% is exported. A large number of poor people find employment in the domestic fish marketing chain in the form of farmers, processors, traders, intermediaries, day laborers and transporters (Kleih *et al.*, 2003).

Fresh water prawn culture has experienced a boom in recent times in greater Khulna and Noakhali district. It is either done as monoculture or polyculture basis with Indian major carp species often integrated with paddy; the technology remained largely was traditional. At present the total estimated culture area is about 30,000 hectare in Khulna area. The farmers are mostly small holders. In Bangladesh the fishermen are illiterate and they are socially and economically disadvantaged (Rahman, 1994; Baily and Douhman, 1994; Chowdhury, A., 1994). Livelihood outcomes of the fishermen (72%) and traders (80%) were positive in spite of the poor socio-economic condition and they were in the position to improve situation through prawn farming (Ahmed, 2002).

The value chain of prawn consists of six different stakeholder groups with varied kinds of stakes in them. The groups are viz., the farmers, the depot owners; the Chatal auctioneers; the commission agents; the factory workers and the factory owners.

In the marketing system, the remote communities especially who are at the fore end of the chain are at serious difficulties due to lack of transport, ice and good road facilities. There are irreplaceable intermediaries establishing an artificial pricing policy and the farmers do not get the fair price of their product (Ahmed, 2001; Ahmed, 2003). Therefore it was imperative to analyze the value chain of the system of production and marketing together with the socio-economy of the people involved in the process. A total of 325 sample questionnaires were obtained from five stakeholder groups. The results obtained suggested that the prawn value chain suffers from various problems that need urgent attention.

MATERIALS AND METHODS

The study was conducted during March 2005 to February 2006 in three districts viz., Khulna, Bagerhat and Satkhira of greater Khulna areas. Structured questionnaires survey was made on the socio-economy, livelihoods and the value chain issues from six different stakeholder groups. A total of 75 farmers, 75 depot owners, 25 auctioneers, 25 commission agents, and 50 factory workers were interviewed from the three districts; FGDs were conducted; 6 each on farmers and depot owners and 2 on factory workers. The secondary data were collected from concerned government and non-government departments. The data were coded and entered into Microsoft Excel software system. SPSS was used to analyze the data and summarized using descriptive statistics.

RESULTS AND DISCUSSIONS

Distribution of Age, sex and education

Galda farmers of the three districts were mostly middle-aged consisting of 71% age category of 25 to 45 year. One hundred per cent of the farmers were male. The percentages of farmers having education at primary and SSC pass levels were each at 0.33. Farmers of bachelor level education were at 5%.

Family size and type and children's education

The percentages of school going children in Khulna, Satkhira and Bagerhat were 0.65, 0.75 and 0.67 and the non-school going was at 25, 18 and 19 per cent respectively. The percentages of below school going age were 0.10, 0.07 and 0.14 in the areas. The average members per family were at 6 in Khulna and 7 in both Satkhira and Bagerhat. The percentages of male and female were averaged at 0.51 and 0.49, 0.55 and 0.45, 0.54 and 0.46 in the areas respectively.

Household assets

Land holdingness and housing

Majority of the farmers were poor with average land holding of below 3 acres. In Khulna, Satkhira and Bagerhat, 72, 76 and 100 per cent farmers respectively had own cultivable land. Farmers having both own and leased-in cultivable land were 28, 40, and 60 per cent respectively. Forty eight, 68 and 52 per cent of the farmers had tin shed houses; the farmers having pucca houses were 32, 8 and 24 per cent and kancha houses were 20, 24 and 24 per cent respectively in the areas.

Household facilities

Electricity, drinking water supply and sanitation

The household facilities with respect to the above were not very satisfactory in the areas as a whole. Supply of drinking water situation is considerably better, however, supply of electricity and sanitation condition have not improved satisfactorily in the areas (Table 1).

Table 1. Household water supply and sanitation facilities in the study areas

Facilities		Regions		
Electricity		Khulna	Satkhira	Bagerhat
Per cent of farmer having supply		56	64	68
Using for number of year		25	15	15
Water supply				
Deep Tube-well	Per cent of households drinking	100	84	100
	Using for number of year	25	20	10
Per cent of household using filtered and/ or rain water		0	16	0
Pre cent of farmers having own tube-well		40	24	24
Toilet				
Per cent of farmers using Kancha toilet		4	0	4
Per cent of farmers using close pit		24	44	40
Sanitary	Per cent of farmer using	72	56	56
	Using for year	25	20	25

Gher size, ownership, lease value and farming involvement

The table 2 shows the size of gher used, ownership pattern, lease value and involvement of the farmers in the study areas.

Table 2. Gher size, ownership, lease value and farming involvement

Considerations		Regions		
		Khulna	Satkhira	Bagerhat
Gher size (acre)	Highest size	8	4.50	7.00
	Lowest size	0.75	0.37	0.26
Gher ownership (Per cent of farmers)	Own %	48	80	72
	Leased %	52	20.00	60.00
	Both%	8	44	32
Lease value acre ⁻¹ in Tk.	Average	7880	8520	9209
	Highest	10000	10000	12000
	Lowest	6000	7000	6400
Involvement in prawn Farming (Yr.)	Average	6.84	7.56	9.73
	First before	15	15	18
	Last before	2	3	3

Stocking density, survivability and over wintering management

The density of stocking though is practiced at higher level, the survivability rates were low; over wintering of the crop was a common phenomenon for achieving faster growth of the left over crop in the next season. The training situation of the farmers was disappointing which might indicate the state of their knowledge of farming (Table 3).

Table 3. Stocking densities, survivability and other management of the gher

Considerations		Regions		
		Khulna	Satkhira	Bagerhat
Stocking density (PL acre ⁻¹)	Average	6708	5800	7058
	Highest	10000	10000	11500
	Lowest	4000	4000	4000
Survivability percentage	Average	59.60	63.40	60.58
	Highest	75.00	90.00	85.00
	Lowest	40.00	50.00	50.00
Culture period	In month	6 to 10	6 to 10	7 to 10
Over-wintering	Per cent of farmer doing	100.00	80.00	100.00
	Per cent of crop left	24.00	18.00	22.69
Per cent of farmers keeping periphery canal		100	100	96
Per cent of farmers repairing periphery canal		100	100	96
Per cent of farmers taking training		24	32	44
Per cent of farmers using lime		92	100	100

Feed used, seed source and cost involved

Both prepared and commercial feeds were used. The local ingredients of prepared feed were crashed snail, boiled rice, wheat flour, rice and wheat bran, mustard oil cake and soybean oil cake.

Naturally collected seed was more preferable than hatchery seed with consequent higher price of natural seed; hatchery seed was claimed to have higher mortality. There was gimmick though in the trade; often the hatchery seed was sold in the name of natural seed. Seventy two per cent farmers of Khulna and 80 % of Satkhira and Bagerhat used natural seed; the rest used both the natural and hatchery seed. The average prices of natural seed were found to be Tk 2178, 2209 and 2353 PL1000⁻¹ in the areas respectively.

Production system and productivity

The farming is predominantly integrated with a few species of Indian major carps or Chinese carps with integration of paddy in the raised area of pond bottom and vegetables and fruit trees in the dykes. After gradual harvest of fish and prawn, the paddy is left until late winter; however, the vegetables are grown on the dikes throughout the year. In Satkhira area bagda (*Penaeus monodon*) was also cultured with prawn and fin fishes at a time in the same gher. In table 4 the culture systems and the production obtained in the study areas can be seen.

Table 4: Culture system and production in the study areas

Culture system and production		Regions		
		Khulna	Satkhira	Bagerhat
Monoculture	Production of Prawn (Kg acre ⁻¹)	0	0	438
	% of farmer involved	0	0	4
Polyculture	Average production of Prawn (Kg acre ⁻¹)	300	0	156.6
	Highest Production (Kg acre ⁻¹)	300	0	210
	Lowest Production (Kg acre ⁻¹)	300	0	60
	White fish production (Kg acre ⁻¹)	80	0	287
	% of farmer involved	4	0	12
Integrated Culture	Average production of Prawn (Kg acre ⁻¹)	165.217	152.4	168
	Highest Production (Kg acre ⁻¹)	280	240	240
	Lowest Production (Kg acre ⁻¹)	100	110	100
	White fish production (Kg acre ⁻¹)	107.391	74	104.8
	Production of Bagda (Kg acre ⁻¹)	0	33.5714	0
	Production of paddy (Kg acre ⁻¹)	1652.17	1577.6	1972.3
	Vegetables/ acre in Tk.	3090.91	4200	4476.3
	% of farmer involved	96	100	88

Selling locations and rates

In Satkhira and Bagerhat the farmers usually sell prawn to the depots; in Khulna they sell in the Chatals as well as to the depots.

The rate for both head on and headless prawn of grade 5 was higher in Bagerhat than in Khulna and Satkhira. Mostly head-on prawn was sold in Khulna and Satkhira while in Bagerhat it was only headless prawn. In table 5 the rates for different grades prawn at the three areas of study are shown.

Table 5. Average selling rates (Tk. / Kg.) of different grades of prawn

Selling place/ type	Grade	Regions wise selling rates		
		Khulna	Satkhira	Bagerhat
Faria /Local depot (Head on)	5	550.5	550	580.0
	10	503.6	501.4	510.0
	20	383.0	381.4	385.0
	30	291.9	285.7	300.0
	50	187.7	175.0	185.0
Central depot (Head on)	5	550.0	501.8	
	10	500.0	507.2	
	20	398.8	396.3	
	30	298.8	297.2	
	50	195.5	158.1	
Chatal	Average	350.0	337.5	

Cost of prawn farming and source of fund**Benefit and cost of prawn production**

Table 8 below shows the cost and benefit of the farming. Net profit acre⁻¹ of prawn farming was Tk 10572, 8834, and 9859 in Khulna, Satkhira and Bagerhat respectively. Incomes from other sources stood at Tk 35583 in Khulna, 39667 in Satkhira and 47760 in Bagerhat. Annual saving of a farmer was found to be Tk. 8880, 9080 and 11667 in Khulna, Satkhira and Bagerhat respectively and the average percentage of the farmers making the saving was 0.73 in the areas. However most of farmer was unable to improve their status due to small amount of savings.

Depot level value chain**Distribution of age, sex and education**

The prominent age category of the depot owners was the 36-45 years and the average percentage of the owners of this category was 0.51; there were no owners below 25 years age. The percentages of age category 26-35 years and above 45 years were 0.29 and 0.20 respectively. On the average 17.33% owners had primary level education, 37.33% up to class VIII, 29.33% SSC, 6.33% HSC and 9.33% above HSC level; in Satkhira there were none above HSC level educated depot owners.

House holds assets**House condition and landholdingness**

The percentages of tin shed and pucca houses of the depot owners were 0.6 and 0.4, 0.44 and 0.56, and 0.48 and 0.52 in Khulna, Satkhira and Bagerhat respectively. On an average they had 3.15, 3.8 and 3.36 acres of own land and 2.25, 1.5 and 2.38 acres leased-in land in Khulna, Satkhira and Bagerhat respectively.

Household facilities**Electricity, water supply and sanitation**

On an average 81% household had electricity and 94% had deep tube well drinking water. Some households in Satkhira had the problem of drinking water supply. The percentage of households using sanitary latrine was 0.95 at Khulna and Bagerhat; in Satkhira every household had sanitary toilet. The percentage of close pit users in Khulna and Bagerhat was 0.8.

Depot size

Average sizes of the depots were found to be 280, 322 and 339 sq. ft. in Khulna, Satkhira and Bagerhat respectively. Maximum and minimum sizes of the depots were 600 and 96 sq. ft. respectively.

Depot facilities**Electricity supply, drainage systems, floor status and grading table used**

Every depot had electricity in the areas. With regard to drainage system the depots were categorized into 'good' 'up to the mark' and 'bad'. The percentages of 'good' 'up to the mark' and 'bad' depots in Khulna, Satkhira and Bagerhat were 0.36, 0.52 and 0.12; 0.36, 0.44 and 0.2; and 0.36, 0.44 and 0.12 respectively. Average percentages of mosaic floors and floor with neat cement finishing were 0.64, 0.76 and 0.64 and 0.36, 0.24 and 0.36 in the three areas respectively. In Khulna and Satkhira every depot had stainless steel grading table. The percentage was 0.92 in Bagerhat; the rest 8% used tin sheet table. Cent per cent depots in the areas used chlorine water as disinfectant.

Duration of storage and storage condition

This was an important index in quality control. The duration of storage time ranged from 6 to 14 hours and was averaged at 8.28, 9.32 and 8.08 hours in Khulna, Satkhira and Bagerhat respectively. Prawn were mostly stored in 1:1 ice – prawn ratio and were averaged at 88, 100 and 84% in the areas respectively.

Beheading and seasonal turnover

Cent per cent depots of Khulna and Satkhira did beheading of prawn by themselves; in Bagerhat the percentage was 0.32; the rest of the depots obtained prawn that were deheaded by the farmers or local depots prior to disposal which was simply deplorable. Average seasonal turnover of the depots was 18016, 12392 and 17728 kg in Khulna, Satkhira and Bagerhat respectively.

Purchase and selling rates

The depots mainly purchased prawn from the local depots, farmers and Chatahs and sold to the factories through the commission agents. Purchase rates were similar in Khulna and Satkhira, the rate for grade 5 prawns was higher in Bagerhat. The selling rates were also similar in the areas; however, in Bagerhat again, the rates were higher because, prawns from that area often were sold to Chittagong market with higher price (Table 6).

Table 6. Average purchase and selling rates Tk.kg⁻¹ of different grades

Types	Grades	Regions					
		Khulna		Satkhira		Bagerhat	
		Purchase rate	Selling rate	Purchase rate	Selling rate	Purchase rate	Selling rate
Head-on	5	564.4	x	564.4	x	585.4	x
	10	515.4	x	512.4	x	509.4	x
	20	392.4	x	391.2	x	402.2	x
	30	298.4	x	290.8	x	301.0	x
	50	185.6	x	170.0	x	183.3	x
Headless	5	1140.5	1148.8	1150.2	1156.0	1192.3	196.8
	8	1050.8	1046.8	1045.6	1050.0	1086.4	1090.0
	12	700.5	700.8	690.8	696.8	707.1	718.0
	20	490.5	498.4	490.5	492.4	506.3	517.4

Mode of payment given and taken

The depots made 50% direct cash payment or paid in advance (dadon) to the farmers/primary depots/Chatal and 50% payment later, the duration of which ranged from 1 to 10 days. The payment taken from the commission agents was similarly divided; 50% was taken on the spot and other 50% was taken later, from 1 to 10 days duration. On the whole, it was a matter of mutual arrangement between the two parties.

Costs involved in depot marketing

The costs were divided into two - overhead and maintenance. In table 7 the different items of cost have been shown. It is seen that the bigger costs were involved with grading table, mosaic floor, ice and labor and the costs were almost similar in all the areas. When a depot was not rented, the cost involved in this establishment of depot ranged between Tk. 80,000 to 1,50,000

Table 7. Average marketing cost involved in secondary depot

Items		Regions		
		Khulna	Satkhira	Bagerhat
Overhead costs	Grading table	11600	14480	14160
	Drum and baskets	5360	6080	6160
	Furniture	3840	4100	4500
	Depot construction/ repair/ Mozaic	18600	26440	25667
Maintenance costs	Depot rent	9200	11152	11176
	Electric bill	3380	3876	3756
	Ice cost	24800	15316	25970
	Carrying cost	16480	14008	23420
	Wages of labor	48875	53440	54625
	Miscellaneous	10240	12920	12000

Chatal level value chain

Chatal auctioning

Chatal auction system was a new intervention in prawn marketing. They were run under multiple ownership; the number of owners varied from 4 to 10 in the areas. Chatals were more frequent in Khulna, few in Satkhira and none in Bagerhat. White fish was the major component of sale in Chatals; however, during September to December prawn became the major item of auction sale. Average floor size of the Chatals was 180 sq. ft. and the average seasonal turn over was 23,000 kg. There was no use of ice. The sanitation was not satisfactory on the whole. Only 10% Chatals had mosaic floors and the rest were either with neat cement finishing or brick soling. Thirty per cent Chatals had no grading tables, 60% had tables made of tin sheet and only 10% had stainless steel tables. Chatal auctioneers sold the product of the farmers with 2-3% commission. For getting immediate payment and comparatively at higher rate, the farmers preferred selling at the Chatals.

Commission agent level value chain

Commission Agents

Commission agents are the agents of the factory owners holding accounts. They can have agency of multiple factories. Many, however, were seen not to have agency to any factory at all. They are the penultimate agent in the marketing chain helping to buy products for the factories, from intermediaries at the back end of the chain, for commission at certain percentage. They were mainly situated near the factory sides; however, often they were located at a place in the remote areas having cluster of depots and production farms. In Rupsha, Khulna about 200 commission agents were situated where most of the processing plants were located.

They buy both head-on and headless prawn; however, quantity bought was always more for headless ones. Twenty five per cent agents did not have receiving room and used to deliver the products directly to the factory gate. The over all sanitation of the receiving rooms was good with clean and disinfected mosaic floor; all using stainless steel grading tables. They take commission of up to Tk. 100 to 300 40kg⁻¹ from the factories depending upon the prevailing purchase rate set by the factory owners.

Commission agent took dadon (advance) from the factory owners and remained bound to sell his purchase to the one from whom he took 'dadon'. Sometimes they also sold their purchase to the factory owners other than from they took dadon and it depended on the situation of market. In general, commission agents were not found to take loan from banks but who had accounts of the factories, took loan both from government and private commercial banks. Annual seasonal turnover of prawn of the commission agents was found to be 15 to up-to 50 metric tons. Agents who had no account of the factories were found not only to sell their products direct to the factories but also through the commission agents having accounts of factories.

Factory workers level value chain

Female workers

Distribution of age and education

Forty eight per cent female workers were of the age group of 16-25 years; the next age group was 26-35 with average percentage of 0.32. The workers over 35 years were averaged at 0.16 while workers within or below 15 years age was averaged at 4 per cent. Forty per cent of them were illiterate, 36% had primary level and 20% read up to class VIII.

Marital status, relationship with the head of the household and torture

The status of the female workers were divided into 4 categories as married, unmarried, abandoned and widowed. Early marriage and multiple marriages were common and abandonment of the females by the husbands was frequent. The percentage of married women was averaged at 0.32; the women being abandoned were averaged at 40 per cent. Both the abandoned and unmarried young women had to earn for their families. Fifty two per cent of them live with their

father, 8% with their brother and 8% with other relatives. Twenty eight per cent of them were reported to be tortured physically, mentally or both by the head of the households.

Household members, children and their education

The female workers' household averaged 2.4 male and 3.2 female members. The number of child family⁻¹ averaged was 1.68 and percentages of school going and drop out children were averaged at 0.62 and 0.38 respectively. The cause of drop out was mainly economic.

Household assets and facilities

Eighty eight per cent of the female workers had no house of their own. They were outsiders coming from other regions/districts for work. The average house rent was Tk. 200-300 month⁻¹. Ninety six per cent of the houses were of tin shed with Kancha floor. Fifty two per cent houses had electricity supply, 44% had radio/TV/cassette player for recreational purposes. All houses used tube well water for drinking. Households using sanitary latrines, close pits and Kancha latrines were averaged at 0.56, 0.32 and 0.12 in Khulna, Satkhira and Bagerhat respectively.

Type of work, working hour, duty, mode of salary and income

On an averagely 28% women did washing and beheading, 44% packaging, 12% panning and 16% IQF (Individual Quick Freezing). The women doing washing and beheading were appointed on temporary basis; their salary was based on amount of work. They earned from Tk.100 – 150 day⁻¹ during full moon, Tk. 60 – 70 during new moon and Tk. 40 – 50 during off season. Beheading (supervisor), packaging, panning and IQF were done by the permanent worker women and they were paid on monthly basis. Their working hour was officially 12 hour but actually there was no limit. The salary of the permanent workers depended upon their experiences. The salaries of the women workers are shown in table 8.

Table 8. Types of works Salary of the women workers

Type of works	Salary range
Washing	Tk. 5 / Bowl (1 bowl =10 kg)
Beheading	Tk. 3 / kg
Beheading (supervisor)	Tk. 2000 –2500 month ⁻¹
Packaging	Tk. 1500 – 2000 month ⁻¹
Panning	Tk. 1500 – 2000 month ⁻¹
IQF (Individual Quick Freezing)	Tk. 1500 – 2200 month ⁻¹

Male worker

The male workers were mainly involved in receiving, grading, store-keeping, cold storage, and supervising in areas of panning, packaging, beheading and IQF. The workers involved as graders were appointed temporarily and their wages were paid on the basis of amount of work; others were appointed permanently and paid on monthly basis. The male workers were also low paid. Average salary status of the worker is shown in table 9.

Table 9. Types of works Salary of the male workers

Type of works	Salary range
Receiver	Tk.1800- 2500
Supervisor	Tk. 2000- 2500 /month
Store keeper	Tk. 1500- 2000 / month
Cold storage in charge	Tk. 1500 – 2200 / month
Grader	Tk. 20 per maund (1 maund = 40 Kg.)

Prominent age group of male workers was 31- 40 years covering 36%; next to that was 21 to 30 years with 32%. The worker of age group 16 to 20 was averaged at 0.16 and that of over 40 years was 12 percent. Majority of them had primary level education being averaged at 32%; next to that was eight pass with average percentage of 0.2. The percentage of illiterate male workers was averaged at 0.24. Working hours for the male workers was 12 hours but the graders and receivers had no limit of working hour.

DISCUSSIONS

This study was aimed to bring into light the socio-economy of the different stakeholder groups involved in production, processing and marketing of prawn in greater Khulna areas and analysis of value chain of the process. Initially the principal stakeholder groups involved in the chain from the producers to various people in the distribution channel were identified. Freshwater prawn has an important role in the economy of the country and therefore an idea about the socio-economy of the relevant stakeholders and problems and prospects in the total chain from production to export is imperative. The stakeholders included in the investigation were the farmers, depot owners, chatal auctioneers, commission agents and the factory workers. The investigation covered three districts in greater Khulna viz., Bagerhat, Khulna and Satkhira. Together with the major socio-economic features of the stakeholder groups, the study focused on the key indicators viz., the physical structure, ownership, production, processing system, sanitation, source of funds, transportation, manpower, salary, education, and problems associated with etc. The farmers and so also the farias, and the depot owners were mainly the small holders. The commission agent / the account holders of the factories were comparatively the richer and powerful ones in the chain.

The socio-economy of the farmers and others in the bottom of the chain was characterized by small land holdingness, averaging at about 2.3 acres of land. The dominant age group in the farmers was 36 to 45 years and majority having primary to class VIII level education. The households using modern amenities of life, like better house condition, safe drinking water, use of electricity, safe latrines, schooling and education of the children all featured that the facilities were improved since recent time in the rural settings of prawn culture areas in the region.

Prawn culture in the areas mostly depends on natural PL. The average stocking densities were at 6,708, 5,800 and 7,058 PL acre⁻¹ in Khulna, Satkhira and Bagerhat respectively which was comparable with the stocking rates of 20,000 PL hectare⁻¹ as suggested by Hoq *et al.* (1996) and 30,000 PL hectare⁻¹ by Khatun (2000). Stocking densities practiced in the areas were in commensuration with the financial support and ability of the farmers. Farmers of Khulna and Satkhira preferred using natural PL than the hatchery PL because of the former's better performance in terms of growth and survivability.

Prawn was fed with both commercial and prepared feeds. Saudi Bangla, Niribili and CP etc, were the widely used commercial brands of feeds. Rice bran, cooked rice, dal, wheat bran, oil cake, wheat flour, blood meal and crushed snail were frequently used ingredients of home made feed. Use of both commercial and home-made feed, especially snail meat, yielded higher economic production. Integrated culture system with prawn, paddy, white fish and vegetables was widely practiced because of its higher profitability than either mono or polyculture system.

Production costs were mainly for seed, feed and labor. The cost of production had increased significantly over the recent years because of sharp increase of price of various necessities with consequent decreasing trend in profitability of prawn farming. Supply of good quality seed and feed made from local ingredients as well as management improvement reducing mortality were suggested for better profit in the venture.

Average cost of prawn farming was about Tk.55, 000 acre⁻¹ and even this amount was higher for the small holder farmers and only 16, 12 and 28 percent farmers in Khulna, Satkhira and Bagerhat respectively were found to utilize their own fund in the farming; the majority had to take Dadons from depot owners, local Mohazons, NGOs and relatives with exorbitant interest. Often the farmers were compelled to sell prawn to the depots giving the loan.

Production and profitability was a matter of sound management and culture practice, which in turn are linked with farmers' education and training and capability for high investment. Prawn farmers were the poor and with low level of expertise, the average production being obtained (160kg acre⁻¹) had remained all times low.

The average annual net profit (Tk.9, 755 acre⁻¹) was small in comparison with the high investment of Tk. 54,521 acre⁻¹, and since in the production cost the costs for lease and self labor were not incorporated, in reality, the net profit acre⁻¹ was higher than what is calculated and because of that farmers having own gher and / or self labor got more profit from the venture.

Almost cent per cent depots had electricity facility. They were located all around the places, at the road sides, local markets and cross roads and at some more centralized areas with

comparatively better road communication. Almost all the depots used shallow tube well water for washing prawn; in Bagerhat and Satkhira tube wells water having arsenic contamination were used for prawn washing which was deplorable.

Sanitation at the depots was a major concern for hygiene of the products. Excepting a few centrally located depots the over all hygiene and sanitations were not satisfactory in the depots. Mosaic floor and use of stainless steel grading tables similarly were in maximum use in the depots located in sub urban areas than in ones located in the rural areas.

Even though beheading of prawn was not allowed in the depots, some were doing it illegally; the commission agents preferred buying headless prawn, for headless prawn fetches more commission since the cost of beheading was higher in the factory than in the depots.

The depot owners often did not have profit margin in purchase and sale. Since they buy in lots with mixed sizes; they grade the prawn for differential higher price for the higher grades from the commission agents. They also make gimmick in the weight they provide to the farmers. The commission agents charge 1 Kg more for every maund (40kg) prawn from the depot owners; the factories, in turn, provide 0.5 to 1Kg less for every maund prawn to the agents on the plea for ice-melt remnant water in the prawn.

Chatal was a new intervention in prawn marketing. White fish was the major component; however, prawn was also sold in lots by auction for commission. Unlike in the depots, in the Chatal the payment was made by direct cash. The over all sanitary conditions in the Chatal were poor.

The pricing system was quite vague. There was no way for the farmers and the depot owners to know the actual price; the same was determined by the factory owners.

Prawn was transported from gher to depot mainly in aluminum pots, plastic bags and bamboo baskets either by bi-cycle/ cycle van or by hand and from depots to commission agent or processing plants by pickup vans and trucks in case of long distance and cycle van and auto rickshaw for shorter distance.

The general ratio of icing was 1:1; however there was variability at different levels of transportation. The farmers often do not use ice at all. At the depot level, there were often crisis of ice during peak season of harvest due to frequent power failure. Prawn kept at minimum ice for 8 hours can remain organoleptically acceptable for up to 12 days and its shelf life can be up to 17 days if ice is applied immediately after harvest (Jayaweera and Subasinghe, 1990).

The female factory workers were dominated by the younger age category of 16-25 year (48%). They were low paid and subjugated more than the male worker. Maximum worker both male and female come from and live in the vicinity of the factory areas. The male workers live in boarding; the female worker mainly in rented houses of very poor conditions. Forty per cent of them were abandoned by their husband. Majority of the workers work for 12 hours a day; there is no formal appointment letter, no job security rather depend on the mercy of the authority. The females were mainly paid daily with a few categories monthly. They were found with fungal infection on skin, nails and feet because of working with naked hands and feet. At the time of

visits of foreign buyers to the factory, they were sobbed up of hiding the miserable. They were threatened not to disclose their vagaries.

In the generalized prawn marketing channel, the agents were the powerful group. They organize the wholesale marketing and secure their income from commissions; the average of which stood at Tk.300 maund⁻¹ (40Kg). They had a dominant position in the market which they exercise to their advantage; they manipulate prices to secure high returns. They received high income and their income included elements for both marketing services they offer and the money lending services they processed. The agents are the major factor for hindrance in the enhancement of livelihood of the stakeholders. The depot owners were exploited by the agents and farmers were exploited by the depot owners in the chain. The level of exploitation by traders both at the upper and lower chain down to the producers at the farm level is highly discrete, controversial and undesirable.

The major constraints found in the marketing system of prawn were lack of loan facilities either for the farmers or depot owners from govt. organizations, poor road and transport facilities, insufficient supplies of ice, poor infrastructure of markets, poor electricity and water supply, inadequate drainage system, poor sanitation and unhygienic condition. Another major constraint in prawn marketing was that some unscrupulous traders pushed different materials in prawn to get more weight, which tremendously affected the acceptance of the products in the international market.

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EVALUATION OF BARLEY (*Hordeum vulgare*) GENOTYPES AGAINST MULTIPLE DISEASES

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Barley (*Hordeum vulgare* L. emend. Bowden) is an important food, feed and industrial cereal crop. It suffers from diseases like stripe or yellow rust (*Puccinia striiformis* Westend), leaf or brown rust (*Puccinia hordei* Otth), stem or black rust (*Puccinia graminis* Pers. Pers.), leaf blight (spot blotch by *Bipolaris sorokiniana* (Sacc.) Shoemaker and neck blotch by *Drechslera teres* (Sacc.) Shoemaker teleomorph *Pyrenophora teres* (Drechs) and cereal cyst nematode (CCN) caused by *Heterodera avenae* Wollenweber. The diseases are known to cause accountable losses in barley whereas CCN causes poor vigour in plants (Mathre 1977; Singh, 2004). The deployment of resistant cultivars at strategic locations and endemic zones is the best approach to manage biotic stresses and losses caused due to these in barley. The resistant sources are the prime requirement for developing disease and nematode resistant varieties to achieve effective management in field and curtailing the yield losses. A number of entries have been identified possessing resistance to an individual disease in India (Singh *et al.*, 2004; Verma *et al.*, 2002). The present study deals with the identification of confirmed sources of resistance to multiple diseases as well as to CCN in barley.

A total of 93 high yielding genotypes of both feed and malt type barley from advanced and initial yield trials were evaluated at hot spot locations under artificially inoculated conditions during 2003-04 and 2004-05 crop seasons. The screening against stripe rust was done at Karnal, Dhaulakuan, Bajaura, Almora, Hisar and Durgapura; for stem rust at Dharwad; leaf rust at Kanpur; leaf blight at Faizabad, Varanasi and Karnal whereas for CCN, the test locations were Durgapura, Ludhiana and Hisar. The most virulent rust pathotypes of stripe rust, 4S0, 0S0-1, 0S0,1S0 and 5S0, stem rust pathotypes, 79G31, 75G5, 62G29, 19G35, 37G19 and 7G11 and mixture of pathotypes of leaf rust were used for screening. One row of 1 m length of each test entry was planted by keeping row to row distance of 30 cm. One row of a mixture of highly susceptible varieties like Jyoti, RD 2085 and RD 2508 for rusts and RD 2503 for leaf blight was repeat planted after every 20 test entries as well as on borders all around the screening block. The initial inocula of rust pathotypes were obtained from DWR RS, Flowerdale, Shimla and multiplied on the pots of susceptible genotypes inside polyhouse. The fresh inocula were collected from plants in polyhouse using cyclonic spore collector and spore suspensions @ 10⁴ spores/ml were used for inoculation. Few drops of 'Tween 20' (a spreader) were also added. The inoculations were done on infector lines initially using hypodermic syringe and later on foliar sprays. Favourable moisture conditions were maintained in the field as post inoculation. For leaf blight pathogens, the inoculum was prepared by growing individual pathogen on autoclaved sorghum grains for 15-20 days and later by harvesting the spores in water. The inoculations were done on infector lines as foliar sprays at tillering stage till boot leaf stage. The disease scoring and

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categorization for resistance were done by following standard rating scales and procedures. The rusts were recorded based on per cent plant area covered and observing infection types as per Peterson *et al.* (1948). In case of leaf blight, area under disease was recorded on flag (F) and a leaf below it (F-1) as per the method proposed by Singh *et al.* (2003) in case of wheat. The promising genotypes for rusts were having average coefficient of infection (ACI) ranging from 0-10.0 whereas for leaf blight the score range from 00-13 and 14-35 was considered as resistant and moderately resistant. For CCN, 7-8 larvae and eggs per gram of soil were used for evaluation under field conditions. The numbers of cysts per plant were counted by removing roots carefully after 75 days of sowing and the categories were: resistant (0-4 cysts per plant), moderately resistant (4.1-9.0 cysts per plant) and susceptible (>9.1 cysts per plant).

Of the 93 barley genotypes screened at various locations in India against diseased and cyst nematode, the resistant genotypes have been categorized as follows:

- (i) Highly resistant to leaf, stripe and stem rusts (ACI-0.0): BHS 355, BHS 357, BHS 362, BH 364, BH 646, RD 2637, RD 2657, RD 2658, RD 2660, RD 2666, RD 2667, RD 2669, RD 2670
- (ii) Resistant to leaf, stripe and stem rusts; and leaf blight: BH 657, VLB 91, DWRUB 52, RD 2552, RD 2624, DWR 47, DWR 49
- (iii) Resistant to leaf, stripe and stem rusts; leaf blight and CCN: RD 2035
- (iv) Resistant to leaf, stripe and stem rusts; and CCN: BH 553
- (v) Resistant to stripe and stem rust: JB 58, BHS 355, RD 2632
- (vi) Resistant to stem and leaf rusts; and CCN: JB 17
- (vii) Resistant to stripe rust and CCN: RD 2508, RD 2624, RD 2634, RD 2637, DWR 46

Out of above genotypes, DWR 46, DWR 47, DWR 49 and DWRUB 52 are of malt type barley. The seeds of these genotypes are deposited in gene bank at DWR, Karnal. These genotypes can be utilized as sources of resistance in the resistance breeding programme. Bonman *et al.* (2005) screened a number of germplasm lines of barley over the years at USDA, Agricultural Research Service (ARS), National Small Grains Collection (NSGC) against disease and insect resistance. This study analyzed resistance to barley yellow dwarf (BYD), spot blotch (SB), neck blotch (NB), and stripe rust (SR) diseases and to Russian wheat aphid (RWA). The 'Centers of concentration' for certain resistances were identified. These were, Eastern Africa for several diseases, Western Turkey and the Caucasus for SR resistance, Eastern Asia for adult plant resistance to NB, and South-Central Asia for RWA resistance. The SR was also associated with accessions originating from high altitude in Eastern Africa (Ethiopia). The NB seedling resistance and SR resistance were associated with many grain characteristic descriptors, such as black aleurone and lemma; winter habit was positively associated with resistance to NB (seedling and

adult plant), SB (adult plant), SR, and RWA and negatively associated with BYD resistance; landrace status was negatively associated with SB adult plant resistance and positively associated with SR resistance; and associations with the hulled character varied. A total of 48 accessions showed multiple resistance based on the field disease data and the RWA greenhouse data, including many with SR resistance as one component of the combination, many accessions from Ethiopia, and many accessions of unknown origin. The SR testing at two locations, California and Bolivia, supported the conclusion that winter habit accessions were more resistant to the disease than were spring habit accessions. The use of resistant cultivars is the most economical and environmentally sound means of controlling spot blotch in barley. Six rowed malted barley cultivars in the upper Midwest of United States have remained resistant to spot blotch caused by *B. sorokiniana*. This durable resistance was originally derived from a breeding line NDB 112. The two row barley do not possess the same level of resistance as in case of six row barley (Mathre, 1997). Helm *et al.* (2001) developed barley cultivars such as Falcon, Tukwa, Seebe, Kasota, Mahigan, Peregrine, Niska, Vivar and Trochu, in Alberta using multiple resistant genetic stocks developed at ICARDA and CIMMYT.

The diseases and CCN in barley may be managed effectively by using host resistance. The multiple disease resistant genotypes along with high yielding characters may serve better donors in breeding for resistance in barley. The identified resistant varieties such as RD 2508, RD 2035, DWRUB 52, RD 2552 and RD 2624 may be cultivated in disease prone areas. Out of these, RD 2035 is resistant to CCN.

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