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Dheerpura Society for Advancement of Science and Rural Development
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REVIEW ARTICLE

A Review on Solid Waste Management and its SWOT Analysis in Ganga Basin

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ABSTRACT

The present study focuses on the solid waste and its management scenario in Ganga basin cities. Our study covers the five major states i.e. Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal from which the holy river Ganga is flowing, before it finally ends in the Bay of Bengal. The study consists of a detailed review on the waste generated, its composition and its associated issues in Ganga basin. Our field visits to certain basin areas of the states like West Bengal and Uttar Pradesh also validate the waste issues in basin cities. In order to minimize the negative impact of the waste, the study of strength, weakness opportunities and threat of the existing situation and policies has been carried out. A framework of questions has been prepared in order to improve MSW management practices in Ganga basin. Urban local bodies of basin states i.e. Uttarakhand, Uttar Pradesh, Bihar, and West Bengal have been asked to fill a detailed questionnaire. We have collected information from the literature survey for the state Jharkhand. A capacity building program was also organized in Indian institute of Public administration, Delhi which further provided us the opportunity to have detailed sessions with the other state's ULBs. In this way we have gathered the information from all the 5 major state's ULBs (Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, West Bengal) and amalgamated them to develop the SWOT matrix. This developed SWOT matrix would be helpful to improve our existing waste management scenario, to improve our existing policies and plans for the waste management. Based on the SWOT analysis various recommendations have been provided.

Keywords *Solid waste, SWOT matrix, Ganga basin, Capacity building*

Rapid population growth and development activities in India have exacerbated resource depletion and environmental deterioration. This development has resulted in innumerable issues like rural-urban migration, urban impoverishment, and unsustainable resource consumption, as well as increasing greenhouse gas emissions and other pollution from Municipal Solid Waste (MSW) [15]. According to India's National Commission on Population (NCP), roughly 38.6% of Indians (600 million) will live in urban areas in the coming years (i.e., by 2036). Based on the UN estimation, India's urban population would nearly double between 2018 and 2050, from 461 million to 877 million. Solid waste is any refuse, garbage, or sludge that is a result of industrial, commercial, agricultural, or community activities and it can be solid, liquid or semi-solid [16]. According to the CPCB statistics for the year 2014-2015, India generates about 1,43,449 metric tonnes of municipal solid waste (MSW) every day [17]. To compound the matter, the country's total number of towns (statutory and census) climbed from 5,161 in 2001 to 7,936 in 2011, resulting in a 2,775 rise in municipal garbage generation in a decade [18]. It has been estimated that the country will need more than 1400 sq. km of land in case we are not able to dispose of the garbage in a systematic way. We will need land which equivalent to the size of Delhi by the end of the year 2047 [19].

India produces more than 1.5 lakhs metric tonnes of solid waste every day. Out of which 80% of the total collected waste is dumped in landfills and only 20% waste is processed [20]. In India, 70% of plastic is turned into waste in a short span of time. 1.5 million to 5 million waste pickers collect, clean & segregate our recyclable waste every day [21]. Pre-consumer textile waste is the 3rd largest contributor of solid waste [22]. The waste management sector has the potential to create 12-15 million indirect jobs and 3 million direct jobs.

Waste generation, which is a result of the rapid development, has increased the problem of MSWM.

Although Solid Waste Management (SWM) is a state subject, it is the urban local bodies (ULBs) that are directly responsible for it. The various duties of ULBs are to plan, design, operate, and maintain the SWM in their respective cities/towns. The current practices of the unmanageable disposal/dumping of untreated waste on the edges of towns/cities have created serious environmental problems including unabated pollution of rivers, emission of methane, etc (NMCG Action plan for municipalities). Thus it becomes imperative to formulate a visionary solid waste management policy that is sustainable. The present study focuses on the review of solid waste management in cities across the Ganga basin, its existing status, and the need for revision in existing policies based on the SWOT outputs to reach a sustainable waste management solution.

In India, the dominant waste consists of crop residues and domestic waste which includes human excreta and waste from the kitchen, and 90% of the MSW are disposed of on the land in an inadequate manner [11] [7]. Globally, the solid waste generation and composition are not determined similar is the case in basin areas, therefore there is a need to quantify the waste generation and their respective disposal techniques. In a study by Rajpal & Tyagi (2020), it has been found that the rural areas generate a lesser amount of waste as compared to the urban areas, also the dominant part of waste are food waste and other organic matter, their suggested ways of disposal is composting and vermicomposting [13] [14]. While, based on the various policies/ guidelines already existing in India, the various techniques that can be used for the disposal of the different waste are based on the thermochemical conversion and Biochemical conversion. The thermochemical conversion includes incineration, pyrolysis, and gasification and biochemical conversion include aerobic digestion and biomethanation. The selection of the techniques should be based on the calorific value, C/N ratio, moisture content of the waste [12]. The disaster waste management guideline of Australia includes the disposal techniques and the potential end use of the waste, this guideline can be used for the disposal of the day-to-day generated solid waste in India with a special focus on the Ganga basin areas.

Waste and its associated issues in Ganga and its basin areas

As far as the river basin cities are concerned, the cities are completely dependent on the river Ganga. There are a total of eight states which dump their waste into the river and makes it polluted [8]. Half of the total pollution is received from the state of Uttar Pradesh only [4] [8]. The MSW generation increases sixfold at the time of Ardh Kumbh in Haridwar and leads to the sanitation problem in the basin area [10].In basin city, Varanasi the 60% of waste comes from the Nagar Nigam and 15% of waste is from industries, and all these wastes are dumped into the river untreated. This industrial waste has a worse impact on the river than sewage waste. The maximum solid waste consists of road-sweeping waste and commercial waste [8]. The major factors responsible for the pollution of Ganga are sewage disposal and poor solid waste management. The major challenges faced by the river are waste dumping, proper sanitation, proper sewage treatment [8]. The dumping of dead bodies from the Rajghat bridge and Vishwa sundri bridge leads to an increase in the NPK content of the river. The other pollutant added from the basin cities leads to a decrease in the dissolved oxygen (DO) and Biological oxygen demand (BOD) and an increase in the Fecal coliform count (FCC). There are a total 132 number of discharge points that ultimately lead to the river, Ganga in the basin, Varanasi. Sometimes the waste gets accumulated in the filter of the powerhouse and leads to financial, technical, and management issues e.g. Pathri powerhouse in Haridwar [10].

Composition of MSW in river Ganga

In Varanasi, approximately 40% of MSW is not collected at all, which results in the spreading of MSW in nearby areas and finds its way into local drains and water bodies, choking and polluting surface water

[8]. As a result of unsorted waste collection and transportation, open dumping occurs, resulting in leachate and gaseous emissions as well as a nuisance in the local environment. The composition of the dumped garbage in Ganga consists of low organic waste, high ash content, and dust content. The estimated recyclable content is 13-20% and the combustible material is 80-85% [9].

The total waste generated by the 101 cities in the Ganga basin (Class I and Class II) is 8250MLD, while the treatment is available for the 3500MLD. In a city like Varanasi the capacity of the sewer system is one-tenth of the total population, therefore the over sewage waste flow directly into the river [8].

Existing policies and regulatory framework for Solid waste Management in India

In India, *MSW (Management and Handling) Rules 2000* and revised *SWM, Rules 2016* already exists for the waste management. According to which the Urban Local Bodies are responsible for MSWM and lays down the mandatory functions to be performed by various stakeholders. There are separate rules for other solid waste like Construction and Demolition waste, 2016. The *Revised Manual on Municipal Solid Waste Management, 2016 (MoUD),* provides implementation guidelines for all aspects of MSWM, including segregation, collection, transportation, treatment and disposal. The *Swachh Bharat Mission,2014(MoUD*), covers Household toilets, community and public toilets solid waste management with special focus on reorienting institutions as well as sensitizing citizens for developing citywide approach to sanitation including solid waste management through IEC and capacity building of the citizens and workers. *National Urban Sanitation Policy (NUSP), 2008*, it broadly covers aspects of urban sanitation, with a specific focus to eliminate open defecation in cities, and other special waste management policy includes *plastic waste management rules, 2011* which is further revised in 2016; *Bio-medical Waste (Management and Handling) Rules, 1998* and *amended 2003, 2011* and *Bio-Medical Waste Management Rules, 2016; E-Waste Management Rules, 2011* and revised in 2016 *Battery (Management and Handling Rules) 2001.*

The minimization of the negative impact of the waste can be done up to some extent by finding the strength and weakness of the existing situation and policies. Here comes the role of SWOT analysis in waste management [25]. The United States Environmental Protection Agency (USEPA) determines SWOT as a relevant perfect model for understanding the waste management in any region. A recent review study by Allesch & Brunner (2014) showed that there are limited studies that have been done on the application of SWOT in waste management. The present study focuses on the same research gap and provides a SWOT matrix of waste management in Ganga basin.

SWOT Analysis

SWOT analysis is the strategic analysis in order to understand the strength, weakness, opportunities and threats which are classified based on the internal and external factors. The strengths of solid waste management focuses on the building & enhancement and weakness focalize on the resolve and reduction, which all comes under the internal factors. The opportunities deliberate on expansion and last aspect i.e. threats, focalize on thwart and avoidance; all these parameters come under the external factors. With the aim of the generation of SWOT matrix, in order to improve MSW management practices in Ganga basin; a detailed questionnaire has been asked to fill by the ULBs during our field visits in the cities of Uttar Pradesh i.e. Allahabad, Kannauj, Kanpur, Banaras. For the rest of the four states i.e. Uttarakhand, Bihar, Jharkhand and West Bengal, we have gathered information from the literature. A capacity building program was also organized in Indian institute of Public administration, Delhi which further provided us the opportunity to have detailed sessions with the other state's ULBs. In this way we have gathered the information

Table 1: Activity worksheet for the SWOT analysis

Factors	Questions
Strength	What are the advantages in the waste management process?
	How the various initiatives help in solid waste management in Ganges Basin?
	What are the already existing policies/ guidelines in India for solid waste management?
	Are there any other agencies for the disposal of the waste except the Municipal corporation?
	Financial aid from the Govt. for the waste management activities?
Weakness	What is not done properly?
	What should be improved?
	What elements need strengthening?
	What obstacles prevent progress?
	What are the complaints coming from?
	Do the stakeholders support the plan willingly?
Opportunities	What Environmental and social benefits may occur?
	What is the scope of the waste?
	Financial benefits the opportunities in SWM can cause?
	What is the scope of the activities needed to be done for the better SWM in the basin area?
Threat	What obstacles does the SWM plan face?
	What is the scenario of the disposal of waste
	What are the possible issues it causes?

from all the 5 major state's ULBs (i.e. Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal) and amalgamated them to develop the matrix.

SWOT matrix

The following results in the Table 1 are amalgamation of the literature review of the solid waste management in Ganga Basin and the answers we received from the ULBs as an output of the questionnaire or interrogation which we conducted during our Capacity building program for stakeholders of River Ganga, under Namami Gange, conducted at IIPA (Figure1). The questionnaire was focused to get the answers of the targeted questions (Table 1)

Recommendations

- Though the various policies and guidelines are there for the disposal of the waste but the urban and rural waste vary in the composition and density because of the topographical, cultural, societal and financial conditions so determination of the disposal technique would be different in both the areas, which is not covered in the guidelines [7]. Based on the areas of waste generation the particular guidelines should be there to work at the microlevel.
- In rural areas, there is a shortage of the data related to the characteristics and calorific value of the rural waste, which further causes difficulty in making complete strategies of disposal [7].

Fig. 1: Capacity building program for stakeholders (ULBs) of River Ganga, under Namami Gange, conducted at IIPA

- In order to develop the design of the waste management program and to reduce the harmful effects of untreated waste on humans and the environment, the focus should be on the micro-level characterization of waste; this will reduce the economic losses as well. Micro level characterization of waste is best suited strategy for the sustainable waste management [7].
- As Ganga receives maximum of sewage waste without treatment, So, there is a need for the proper sewage plan for the Ganga basin cities because the existing plans have loopholes in it [8].
- The quantity of waste collection is less than the full potential waste generated by any city/ state, this uncollected waste ultimately finds its way to the river [8]. There is a need to recruit more skillful employees and focus on the collection of the waste.

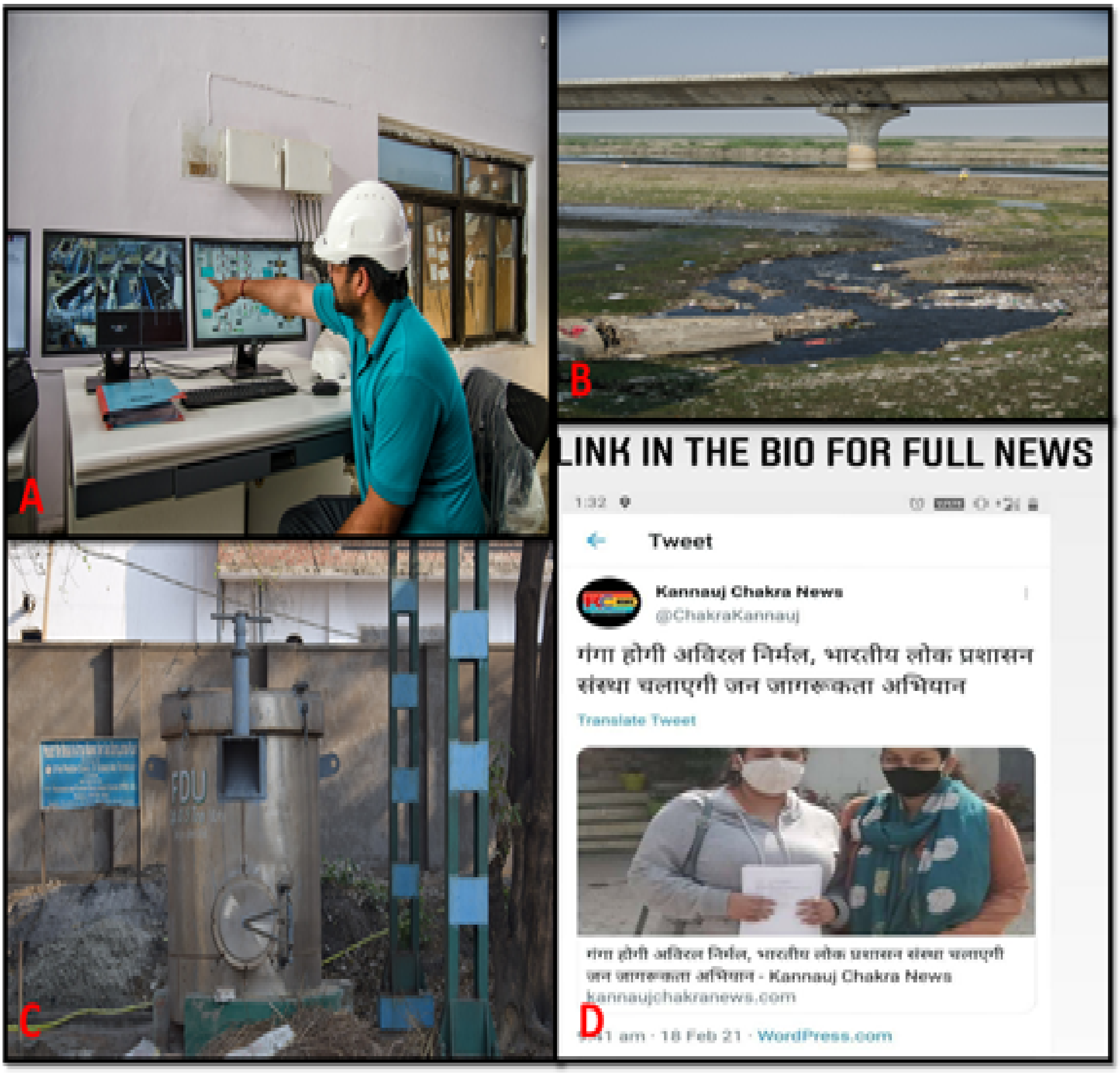

Fig. 2: A. Discussion on ULB's Waste management plan B. Patna river front area, consist of waste into the river C. FDDC plant, Kannauj (Uttar Pradesh) D. Awareness program conducted by IIPA for the development of clean Ganga.

- The waste should be treated before dumping into the river.
- Capacity building and awareness programs among the stakeholders and the local community are needed to make them understand the adverse impact on human health and the environment which is caused by the anthropogenic pollution of the river. This will motivate them to take the necessary action for the cleaning of the river at the individual level.
- There is a lack of information about the composition and quantification of the total quantity of the solid waste generated in the nearby areas of the Ganga river [7]. A complete document should be prepared for the same, in order to predict the maximum possible dumping in the river and preparation of the guidelines of the immediate steps to be taken for the same.

Table 2: SWOT matrix for Solid waste management in Ganga Basin

S. No.	Internal		External	
	Strengths	**Weakness**	**Opportunities**	**Threats**
1	Residents pay fixed charges per month which creates less pressure on the Municipal corporation	Lack of proper segregation of waste, which leads to unscientific disposal of organic waste at the disposal sites (Sajanpur, Shyampur, Kangri, Bhogpur and Dummanpuri of district Haridwar, uttrakhand faces the same issues) [25] [2] [7]	Suitable market for the recycle products and RDF [25].	Waste handlers are exposed to number of health risks due to lack of the awareness [25].
2	Other agencies like Resident welfare association (RWA) also contributes in MSW management	Lack of proper integrated and scientific approach for MSW management in certain cities. [2] [7]. Waste having high moisture and ash content and low calorific value leads to burning because of improper MSW management	Active participation in disposal process like composting and Segregation of the waste	Limited landfill sites
3	The combustible waste can be processed and convert into the Refused derived fuel (RDF)	Political interventions in the official work [2].	Exploration and expansion of the green consciousness among the residents	Environmental issues arising from the unscientific dumping sites (Sajanpur, Shyampur, Kangri, Bhogpur and Dummanpuri of district Haridwar, Uttrakhand)
4	Location of the waste separate stations in various cities, this aid the separation of the combustible waste fraction form the rest of the waste	The performance and efficiency of the waste management techniques to reduce the waste are still not known [3].	Capacity building of the stakeholders and paramilitary groups like NCC students at college level as they are the main role players in MSW management [2].	Mixed waste leads to the decrease in the quality of the energy deriving waste

S. No.	Internal		External	
	Strengths	Weakness	Opportunities	Threats
5	Policies and legal framework builds the solid waste management (plastic waste management rules, 2011,2016) ; (Bio-medical Waste (Management and Handling) Rules, 1998 ,2003,2011) ;(Bio-Medical Waste Management Rules, 2016);(E-Waste Management Rules, 2011, 2016) ;(MSW Rules 2000); (Solid waste management rules, 2016)	Delicacy in Practicing the aspects like sanitation as in past studies it was shown proper disposal of excreta can reduce the disease by 36% and washing hands periodically can reduce diarrhea by 45% [5] [6] [1]	Scope of adoption and promotion of cost sharing activities for MSW management by the community and other stakeholders [2].	Open dumping sites lead to leachate development and emissions of landfill gases, which results into the environmental pollution.
6	Door to door collection of waste is practiced	Community reluctance to participate in SWM like "Who cares syndrome" and the tourists carefree attitude towards socioeconomic and religious ethics leads to waste accumulation [10]	Opportunity of Energy generation from non-biodegradable waste	Certain towns in Haridwar district (Sajanpur, Shyampur, Kangri, Bhogpur and Dummanpuri)are not following the recommended measures for the proper disposal and segregation of the waste, this waste ultimately finds its way to Ganga especially in the rainy seasons and pollute the river system.
7	Waste management is investing in development of the skilled employees	People wait for the govt. to take any needful steps instead of helping	To maximize the self help among the stakeholders	
8	The main source of funds is government, who has experience in planning and implantation [1] [2]. The Ministry of drinking water and sanitation promotes such R & D activities by financing various projects. An Expert Committee has been constituted to examine the Innovative Technologies	Unavailability of door to door collection facility in certain cities like Lucknow, Haridwar [1] [7].	Strength the small organizations and community to enhance the economic standards of the MSW management workers	

S. No.	Internal		External	
	Strengths	Weakness	Opportunities	Threats
9		Insufficiency of Information, Education and communication (IEC) resource material for human resource development of community and sanitary workers(i.e. trainings and awareness) by ULBs and the Govt. (Sajanpur, Shyampur, Kangri, Bhogpur and Dummanpuri of district Haridwar, Uttrakhand)	Establishment of the Public-private-government partnerships for MSWM	
10		Lack of arrangements for season specific waste like tree leaves (Urban forestry)	The Financial gain opportunities can be generated by selling the recyclable waste by the end user	
11		Absence of active sanitary landfills and recycling units(e.g. Chandigarh) [25]	The biodegradable waste can be disposed by composting and vermicomposting kind of techniques which can further be used as a fertilizer in agriculture	
12		Mixing of miscellaneous fraction of waste like E-waste and biomedical waste end up in landfills	The waste management sector has the potential to create 12-15 million indirect jobs 3 million direct jobs [26].	
13		Cost effectiveness of waste processing		

S. No.	Internal		External	
	Strengths	Weakness	Opportunities	Threats
14		The total quantity of waste collection is lesser than the waste generated by the city, this is the causal problem for the ganga pollution [8]. Lack of garbage collection facilities like garbage storage centres, garbage collection bins in areas nearby Ganga (eg. Haridwar; [7]).		
15		Direct dumping of sewage waste into the river by the municipalities (e.g .Varanasi) [8]**.**		
16		Lack of information about the solid waste generation and composition of the waste alongside the river [7].		
17		Lack of vehicles for the transportation and collection of the waste		

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Forecasting Model for Mango (*Mangifera indica*) Malformation in New Delhi and Lucknow

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ABSTRACT

Data related to intensity of mango malformation and weather variables at New Delhi and Lucknow were collected. They were analyzed for their relation and for developing and validation of MLR prediction models. The resultant correlation matrix found less than 0.1 was considered not having relation to malformation intensity with that particular weather variable and was excluded in further multiple linear regression analysis. Data from 1993 to 2000 was used for developing prediction models and are validated by using data from 2001 to 2006 for both FBD (flower bud differentiation) and flowering stages. The percent deviation was calculated which gave good forecasting of disease intensity for all selected malformation prone areas. For Delhi the wind speed, RH2, minimum and maximum temperatures were positively correlated with mango malformation and the MLR models under predicted the disease intensity for both FBD and flowering stages. Lucknow, at flowering stage maximum temperature and minimum temperature showed significant relation with the mango malformation and the MLR model at FBD stage showed a very good estimate whereas for flowering stage it gave reasonable estimate. The model under predicted the disease during FBD stage whereas it was over predicted at flowering stage.

Keywords *Mango, Malformation, Forecasting, Weather variables,*

Malformation of mango (*Mangifera indica* L.) induced by *Fusarium mangiferae* (*Fusarium moniliformae var. subglutinans*) is considered as plant disease of international importance. Maksoud and Haggag (4 , 5) suggested predictin models to estimate percentage malformation in mango trees and prediction equation was proposed by regression analysis. Aguilera *et al.,* (1) correlated mango malformation with density of Fusarium spp., relative humidity and temperature. The pattern of changes in incidence of vegetative and floral malformation of mango with host age was expressed mathematically by Pandey *et al.,* (7). Relative humidity and temperature may influence malformation incidence in mango, which have direct relationship with fruit-set and yield and lower temperature usually favour the development of malformed panicle. (3). Chakrabarti *et al*., (2) made an attempt to identify predictors for forecasting incidence of floral malformation. Very little is known about the epidemiology of the disease because of the lack of uniformity in its occurrence and variation in the severity of disease from season to season. However no information is available regarding malformation intensity with different weather variables at FBD and flowering stages. Hence the studies were undertaken to know the correlation between mango malformation and different weather variables, and obtaining the forecasting models for New Delhi and Lucknow.

MATERIALS AND METHODS

The experiment was conducted at Division of Fruits and Horticulture technology, IARI, New Delhi during 2004 – 2007. Historical weather data of fourteen years from 1993 to 2006 for the New Delhi and Lucknow are collected, which were used for correlation and multiple linear regression analysis (MLR). The weather parameters included monthly average of maximum temperature, minimum temperature, RH_1, RH_2, rainfall, sun shine hours, evaporation and wind speed. Intensity of mango malformation disease data of New Delhi and Lucknow for fourteen years (1993 - 2006) were collected from secondary sources (journals and published articles and AICRP STF (All India Co-ordinate Research Project on Sub Tropical Fruits) annual reports) and used for analysis. The relationship between weather variables and mango malformation disease intensity per cent were analyzed by using the correlation analysis for their degree of association in development of disease for both flower bud differentiation (FBD) and flowering stages. If the resultant correlation matrix is less than 0.1 means no relation between malformation intensity with that particular weather variable and was excluded in further multiple linear regression analysis. Monthly mean values of weather variables along with disease intensity of mango malformation for both FBD and flowering stages were analyzed for eight years (1993 - 2000) of New Delhi and Lucknow. However for FBD stage also used the same malformation disease intensity per cent i.e. flowering period malformation intensity for both correlation and MLR analysis. The relationship between the weather variables and mango malformation intensity per cent were represented as in the following formulae

$$Y = a + b_1X_1 + b_2X_2 + \ldots\ldots + b_nX_n$$

Where, Y = Mango malformation intensity per cent

a = Intercept

b_1 = Regression coefficient for X_1

b_2 = Regression coefficient for X_2

The mango malformation intensity is predicted by substituting the monthly mean weather variables of six years (2001 - 2006) in regression model for New Delhi and Lucknow. The percent of deviation were calculated by using the following formulae

$$\text{Per cent deviation} = \frac{PDI - ODI}{ODI} \times 100$$

Where,

PDI = Predicted malformation disease intensity per cent

ODI = Observed malformation disease intensity per cent

RESULTS AND DISCUSSION

For New Delhi, the weather data for 8 years (1993-2000) was averaged for two stages *i.e.*, FBD stage (October-December) and flowering stage (February- March) separately based on the time of occurrence. The correlation analysis between weather variables and the mango malformation during the FBD stage revealed that the weather variables significantly differed with mango malformation intensity. The bright sunshine hours (-0.43), evaporation (-0.06) and rainfall (-0.03) had showed negative association with mango malformation intensity in ascending order. These are presented in Table 1. The wind speed, RH_2, minimum and maximum temperatures were positively correlated with mango malformation. The highest degree of association was noticed with wind speed (0.47) and bright sunshine hours (-0.43). The lower bright sunshine hours, low evaporation demand and less rainfall led to cloudy weather with low light intensity, which led to an increase in RH_2 values and minimum temperature. These conditions favoured the disease development. High wind speed during this period helped in spread of mango malformation.

The correlation analysis between the weather variables and mango malformation during the flowering stage showed that except rainfall and evaporation, all other variables had significant with mango malformation intensity. The wind speed (0.57) and RH_1 (0.12) are positively correlated, which is presented in Table 1. Among the negatively correlated variables highest degree of association was observed with minimum temperature (-0.56) followed by maximum temperature (- 0.54). The correlation analysis between the weather variables and mango malformation during the flowering stage showed that high wind speed, RH_1 values along with lower temperatures and sunshine hours increased the disease intensity. Similar results were obtained by Noriega – Cantu *et al.,* (6).

Multiple regression models of mango malformation intensity and weather variables at New Delhi at different growth stages revealed that during the FBD stage, coefficient of determination was R^2=0.79, whereas for the flowering stage it was of 0.99 (Table 2).

Table 1: Correlation matrix of mango malformation intensity and weather variables for New Delhi and Lucknow at flower bud differentiation and flowering stages from 1993-2000.

Period	location	T. max	T.min	RH_1	RH_2	WS	RF	SSH	EVP
Flower bud differentiation	Delhi	0.25	0.18	0.12	0.21	0.47	-0.03*	-0.43	-0.06*
	Lucknow	0.199	-0.255	0.294	0.179	0.357	0.525	-0.065*	0.054*
Flowering	Delhi	-0.54	-0.56	0.12	-0.32	0.57	-0.03*	-0.43	-0.08*
	Lucknow	0.522	0.610	0.073*	-0.267	0.184	0.567	0.226	0.207

* Correlation matrix less than 0.1 are considered as no relation with mango malformation intensity and were excluded for further multiple linear regression analysis

T. max - maximum temperature

T.min - minimum temperature

RH_1 - relative humidity maximum

RH_2 - relative humidity minimum

WS - wind speed

RF - rainfall

SSH - sunshine hours

EVP - evapotranspiration

Multiple regression model developed between the weather variables and mango malformation intensity for Delhi was further used for prediction of disease intensity of mango malformation from 2001-2006. The model developed for predicting the mango malformation at FBD stage showed a per cent deviation range from 6.0 to 17.9 (Fig.1), whereas these values for flowering stage ranged from 13.2 to 27.1, which are presented in Fig.2.

Similarly for Lucknow the weather data for 8 years (1993-2000) was averaged for two stages *i.e.*, FBD stage (October-December) and flowering stage (February-March) separately based on the time of occurrence. The correlation analysis between the weather variables as independent variables and disease intensity of mango malformation as dependent variable is presented in Table. 1. Weather variables significantly differed for their relationship with mango malformation intensity at FBD stage and the high degree of positive association was shown by rainfall

Table 2: Multiple regression models for New Delhi and Lucknow at flower bud differentiation and flowering stage

Period	location	Multiple regression model	R2
Flower bud differentiation	Delhi	$Y = 67.6 - 6.3X_1 -20.8X_2+7.7X_3 - 3.5X_4+0.9X_5 - 47.5X_7$	0.79
	Lucknow	$Y = -348.6+0.4X_1-5.0X_2+4.0X_3+0.5X_4+34.8X_5+0.4X_6$	0.9 4
Flowering	Delhi	$Y = 28.1 + 14.3X_1 - 25.2X_2 +1.4X_3- 0.7X_4 - 0.8X_5 - 28.5X_7$	0.99
	Lucknow	$Y = -175.1+7.9X_1-2.3X_2+0.2X_4-12.1X_5+2.4X_6+10.9X_7-6.1X_8$	0.73

X_1 - maximum temperature

X_2 - minimum temperature

X_3 - relative humidity maximum

X_4 - relative humidity minimum

X_5 - wind speed

X_6 - rainfall

X_7 - sunshine hours

X_8 - evapotranspiration

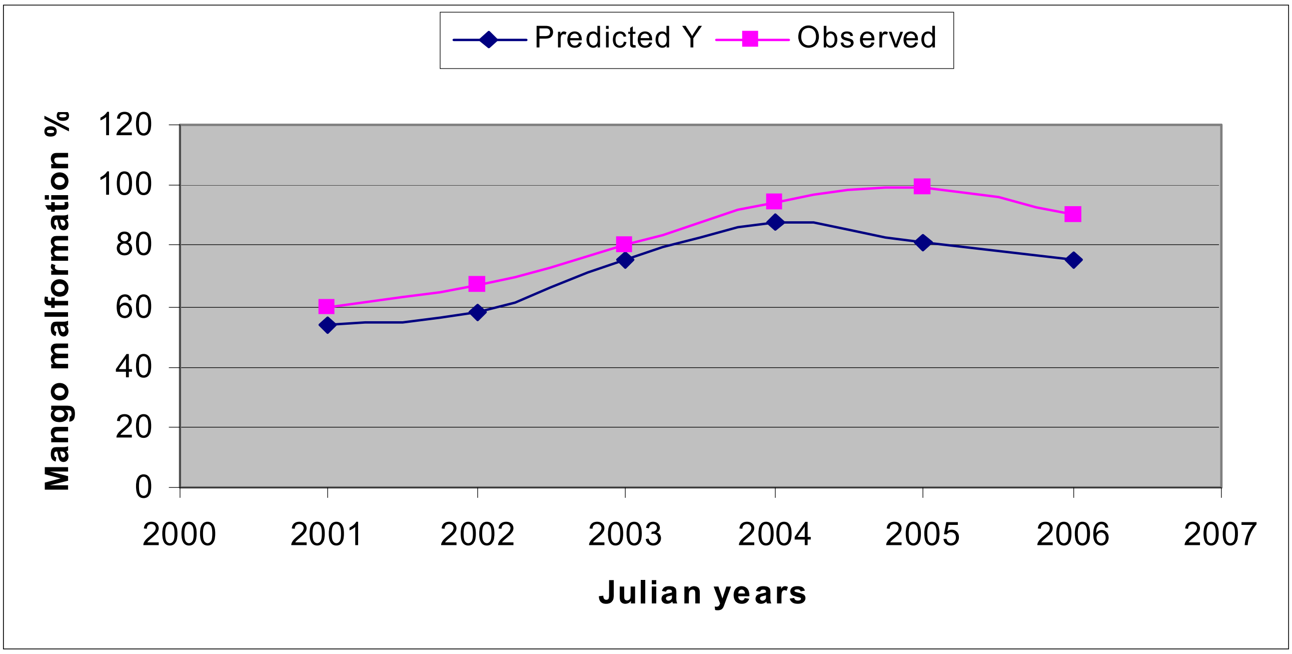

Fig. 1. Predicted and observed values of mango malformation intensity for Delhi at F.B.D stage (Oct-Dec) by using weather variables from 2001-2006

(0.53), followed by wind speed (0.36), RH_1 (0.29), maximum temperature (0.2), RH_2 (0.18) and evaporation (0.05). The correlation analysis between the weather variables and disease intensity of mango malformation at FBD showed that the high amount of rainfall along with wind speed, moderate high RH_1 and lower minimum temperatures favors disease development. These results are incongruent with Aguilera *et al.,* (2003) and Youssef *et al.,* (8). Whereas, at flowering stage, maximum temperature, minimum temperature and rainfall showed significant association with the mango malformation intensity. Only RH_2 showed negative correlation with mango malformation while all other variables were positively

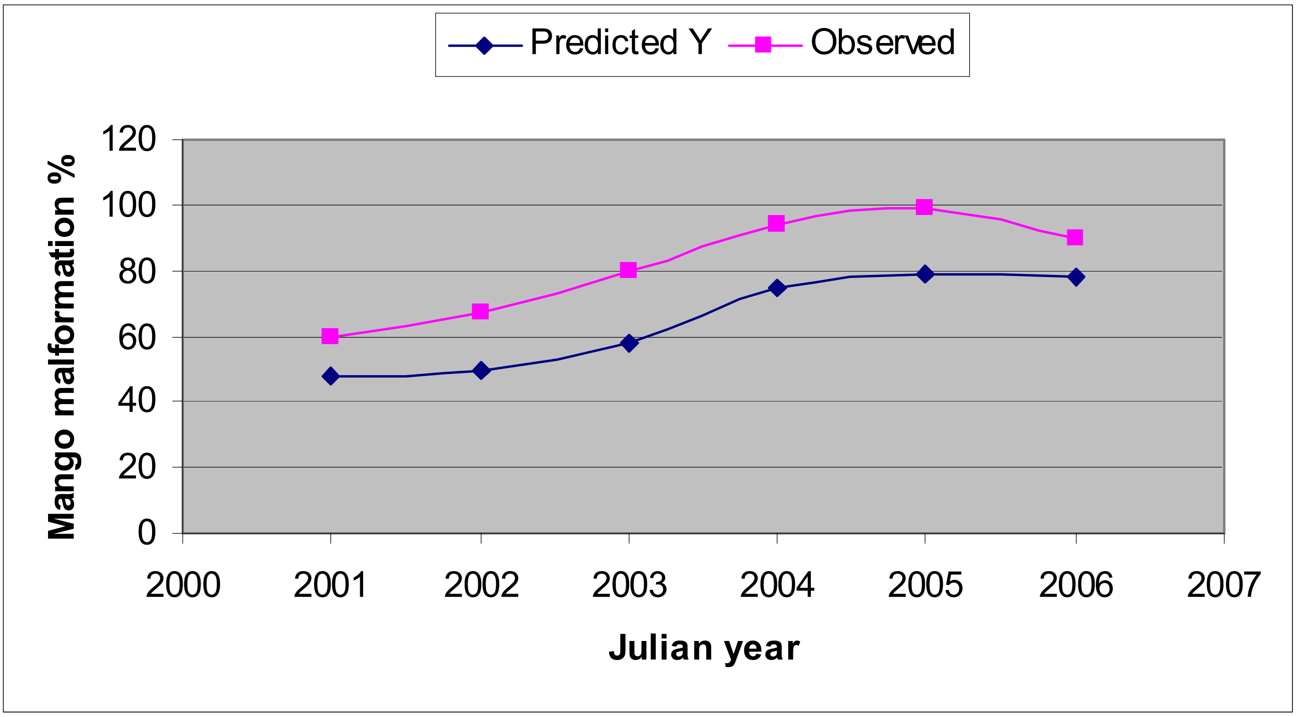

Fig. 2. Predicted and observed values of mango malformation intensity for Delhi at flowering stage ((Feb - Mar) by using weather variables from 2001-2006.

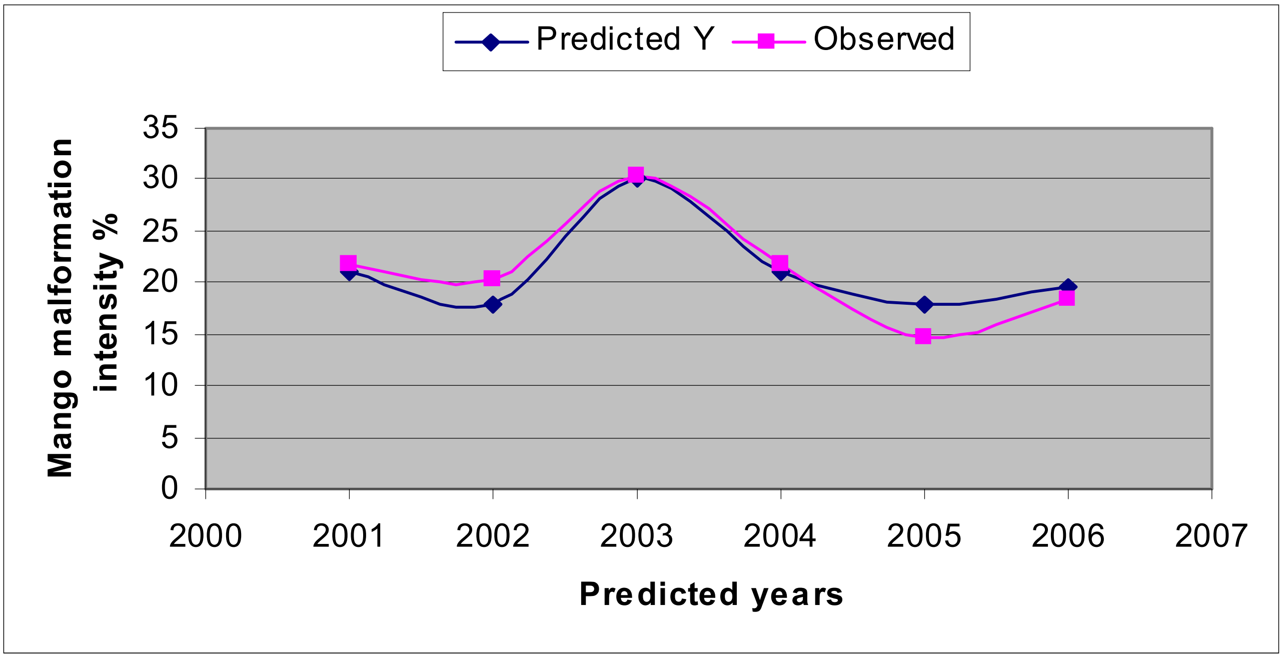

Fig. 3. Predicted and observed values of mango malformation disease intensity for Lucknow at F.B.D stage (Oct-Dec) by using weather variables from 2001-2006.

correlated (Table 1). During the flowering stage higher temperatures with higher amount of rainfall and lower RH_2 favour the disease development. These conditions might favor high moisture formation on panicle surfaces.

The multiple regression equation developed between the weather variables and mango malformation by using the data of 1993-2000 crop seasons at FBD stage showed a very good estimate with coefficient of determination of 0.94, whereas for flowering stage it gave reasonable estimate ($R^2 = 0.73$) , which is presented in Table. 2.

Multiple regression model developed between the weather variables and mango malformation for

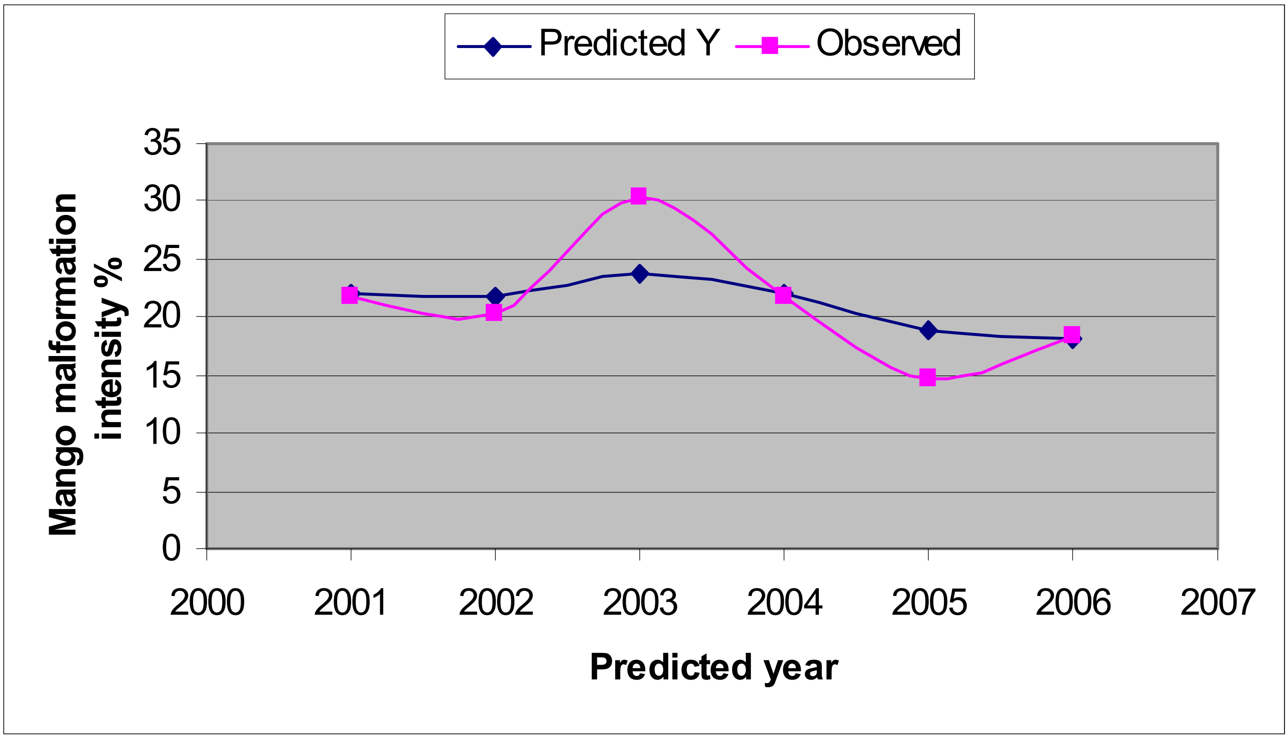

Fig.4. Predicted and observed values of mango malformation disease intensity for Lucknow at flowering stage (Feb - Mar) by using weather variables from 2001-2006.

Lucknow was further used for prediction of disease intensity of mango malformation from 2001-2006. The model developed for predicting the mango malformation at FBD stage showed a per cent deviation range from 1.3 to 20.3, which is presented in Fig.3, whereas deviations for flowering stage ranged from 0.9 to 27.0 (Fig 4).

Multiple regression models developed between the weather variables and mango malformation at FBD stage under predicted the disease intensity at New Delhi and Lucknow. At flowering stage the disease was over predicted at Lucknow whereas for New Delhi the model under predicted the incidence of malformation.

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Abundance, Colonization and Diversity if VAM Fungi Associated with Common Weeds of Durg District (C.G.).

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ABSTRACT

VAM fungi are ubiquitous in nature, are not host specific and tends to be generalists. The diversity of mycorrhizal fungi does not follow patterns of plant diversity. The present study was undertaken to examine the colonization, abundance, species richness and diversity of VAM fungi associated with common weeds of Durg District (C.G). Samples of roots and soils of twelve weeds were screened for root colonization and VAM spores. All weeds were found to be mycorrhizal. Avery wide range of % root colonization, spore count was recorded, indicating the richness of mycorrhizal fungi with weeds in the area. Altogether, 12 different VAM *species* of 2 *genera* i.e. *Glomus* and *Gigaspora* were recovered and identified from different weeds, minimum of 2 *species* in *Cynodon dactylon* to maximum of 9 species in *Parthenium hysterphorus*. The most frequent *genus* was *Glomus* and species was *Glomus mosseae,* followed by *Glomus microcarpum* and *Glomus aggregatum.*

Keywords *VAM Fungi, Diversity, Weeds, Root colonization, Spore count.*

The VAM fungi are obligate symbionts, ubiquitous, have a very wide distribution regarding host range and its environment (Neeraj,1982). The Vesicular- arbuscular mycorrhizal fungi and its biofertilizing potential to improve growth and yield as well as 'P' uptake capacity is now very well known in various agricultural crops especially (Bagyaraj *et al.*, 1992; Secilia and Bagyaraj, 1992; Gupta and Ali, 1993). The symbiosis is characterized by bi-directional movement of nutrients where carbon flows to the fungus and inorganic nutrients move to the plants, there by providing a critical linkage between the plant root and soil (Sylvia, 2003). Considerable evidences suggests that VAMF can affect the agro ecosystems in variety of ways (Francis & Read,1994; Jordan *et al.*, 2005).

Weeds are plants that grow unwantedly, often prolific and persistent, interfere with agricultural operations and reduce crop yields.

USEFULNESS OF WEEDS:

a. Add to organic matter content of the soils.

b. Help in controlling erosion, for fencing purpose.

c. Some posses aromatic oils, medicinal value or both., some fix atmospheric nitrogen.

Role of VAM with Weeds

- VAM can affect the nature of weed communities in agro-ecosystem in variety of ways including changing the relative abundance of mycotrophic weed species and non mycorrhizal species.
- It is quite plausible that interaction with VAM fungi can increase the beneficial effects of weeds on the functioning of agro-ecosystem.

Biodiversity, a term to describe variability between organisms, has different facets depending on the level of diversity considered (Barbault, 1992).The role of VAM fungi in the functioning and biodiversity of terrestrial ecosystems has received little attention (Hawkaworth, 1991). Mycorrhizal associations are potential factors determining diversity in ecosystems: they can probably modify the structure and functioning of a plant community, in a complex and unpredictable way (Grime, *et al.*, 1987; Read, 1990). On the other hand, the composition of the plant community may affect that of the fungal community (Giovannetti, *et al.*, 1988). Furthermore, different abiotic factors (CO_2, pollutants), human activities(chemical inputs, crop rotation, soil management) may have consequences for the diversity of the fungal community(Bethlenfalvay & Linderman, 1992). The present study was undertaken to examine the colonization, abundance, species richness and diversity of VAM fungi associated with common weeds of Durg District, C.G.

MATERIALS AND METHODS

Collection of soil and Root samples of different weeds: Rhizospheric soil and root of 12 common weeds around Durg district from 10 different sites were collected in poly bags for different studies were collected from September to November. Ten plants of each weeds and ten soil samples of each were brought to laboratory in polythene bags. VAM fungi were isolated by " Wet Sieving & Decantation Technique" – Gerdemann & Nicolson, 1963, purified and maintained following the methods of Menge & Timmer, 1982. Estimation of VAMF spores done by method of Gaur & Adholeya,1994. Morphological Characterization and Identification Of VAM Spores was done following INVAM Guidelines, Schenck & Perez, 1987. Roots of the plants were thoroughly washed and VAM infection was assessed by Root Clearing and Staining technique (Phillips & Hayman, 1970) and % Root Colonization was determined by Kormanik & McGraw Slide Method, 1982.

Species richness and diversity was calculated using Simpson index and Shannon wiener index (Magurran, 1988). The evenness was expressed by Pielous, 1975.

RESULTS

The pH of black soil ranged between 5.9 to 7.1 and that of red soil ranged between 6.4 to 7.5. All the 12 weeds showed colonization of VAM fungi: *Parthenium, Solanum nigrum* & *Oplismensus compositus* showed highest (100 % colonization) followed by(75 %) (Table 1). All the weeds showed VAM fungal spores in the rhizospheric soil. Spore abundance highest in *Parthenium hysterophorus* (27) followed by *Blumea lacera* (23) while lowest in *Solanum nigrum* (10)(Table-1). 12 VAM fungal species of two genera *Glomus* & *Gigaspora* were recovered from the rhizosphere soil of 12 weeds (Table 2). All the VAM fungi isolated were purified, mass

multiplied,and morphologically characterized on the basis of colour, wall layers and size. G-01,G-02 &G-07 showed widest host range as it colonized 5 weeds, followed by G-03,G-06 & G-11 (4 weeds),G-05 &G-05 &G-10 (3 weeds);G -04,G -09 &G-12 (2 weeds) and G-07 showed lowest host range colonization (1 weeds)(Table-3). Species of *Glomus* have been the common fungal species in the soils of weeds. *Gigaspora* was second common genus. The VAM species richness was highest in *Parthenium hysterophorus* (9), followed by *Physalis minima* (5) & lowest in 4 weeds as shown in Table 4.

DISCUSSION

Environmental factors such as temperature, light intensity & soil content may influence this symbiotic association.VAM investigation has importance in agriculture and land reclamations. High incidence of mycorrhiza has been reported in other studies (Gupta, 1991; Baby & Rao, 1992).Our findings are in accordance with Schenck & Kinloch, 1980; Lakshman, 1996; Burni & Ilahi, 2004; Thangavelu & Prakash, 2009, who studied morphological types of VAM in crops and agroecosystem. The present study showed multiple infection which is in accordance with Zainb & Burni, (2005). VAM morphology is dependent on individual plant species and the partne

Table 1: Weed plants showing % Root colonization & spore count

S. No.	Name of weeds	Family	% Root colonization	Spore count /100gm soil
1	*Blumea lacera*	*Asteraceae*	40	23
2	*Cynodon dactylon*	*Poaceae*	60	11
3	*Digitaria ciliaris*	*Poaceae*	10	20
4	*Eclipta alba*	*Asteraceae*	25	15
5	*Euphorbia hirta*	*Euphorbiaceae*	50	11
6	*Mimosa pudica*	*Fabaceae*	60	19
7	*Ocimum basilicum*	*Lamiaceae*	75	22
8	*Oplismenus compositus*	*Poaceae*	100	14
9	*Oxalis sps.*	*Oxalidaceae*	25	21
10	*Parthenium hysterophorus*	*Asteraceae*	100	27
11	*Physalis minima*	*Solanaceae*	20	13
12	*Solanum nigrum*	*Solanaceae*	100	10

Table 2: Morphological Characteristics of VAM Fungi

VAM isolates	Spore-colour	Sporecarp Formation	Spore diameter in µm	Shape of spore	No. of wall layers	Spore - surface	Spore content	Hyphal colour	Attachment with outer wall
Glomus sps .01	Yellow-Brown	-	(120)-160(180)	Globose	2	Smooth	Globular	Hyaline	Contiguous
Glomussps .02	Black-Brown	-	99-206x61-201	Globose	2	Smooth	Globular	Hyaline	Contiguous
Glomus sps.03	Yellow-Brown	+	(70-)130(-180)	Globose	2	Smooth	Globular	Hyaline	Contiguous
Glomus sps.04	Yellow-Black	+	60-95x55-90	Globose	3	Smooth	Globular	Hyaline	Contiguous
Glomus sps.05	Dark-Black	-	100-150	Globose	2	Smooth	Globular	Hyaline	Contiguous
Glomus sps.06	Yellow-Brown	+	150-310x110-305	Globose	2	Smooth	Globular	Hyaline	Contiguous
Glomus sps.07	Red-Black	+	130-170	Globose	2	Smooth	Globular	Hyaline	Contiguous
Glomussps .08	Yellow-Brown	-	140-330	Globose	2	Smooth	Globular	Hyaline	Contiguous
Glomus sps.09	Yellow-Brown	-	(40.5)98.5(-190)	Globose	2	Smooth	Globular	Hyaline	Contiguous
Gigaspora sps.1	Black	-	353-368x345-398	Globose	2	Smooth	Globular	Hyaline	Non-Contiguous
Gigaspora sps.2	Dark-Black	-	320-490	Globose	3	Smooth	Globular	Hyaline	Non-Contiguous
Gigaspora sps.3	Yellow-Brown	-	200-450	Globose	3	Smooth	Globular	Hyaline	Non-Contiguous

Table 3: Weed plants showing VAM host specificity & Species Richness

S. No.	Name of weeds	Gl -01	Gl -2	Gl -3	Gl -4	Gl -5	Gl -6	Gl -7	Gl -8	Gl -9	Gl -10	11 Gi-01	12 Gi-02	VAM species richness
1	*Blumea lacera*	–	+	+	–	–	–	–	+	–	–	+	–	04
2	*Cynodon dactylon*	–	–	–	–	–	+	–	+	–	–	–	–	02
3	*Digitaria ciliaris*	+	–	–	+	–	–	–	–	+	+	–	–	04
4	*Eclipta alba*	–	+	–	–	–	+	–	–	–	–	–	–	02
5	*Euphorbia hirta*	–	–	+	–	–	–	–	+	–	–	–	–	02
6	*Mimosa pudica*	+	–	–	–	–	+	–	–	–	+	–	–	03
7	*Ocimum basilicum*	–	–	+	–	–	–	–	+	–	–	–	–	02
8	*Oplismensus compositus*	+	+	–	–	+	–	–	–	–	–	+	–	04
9	*Oxalis sps.*	–	–	–	–	–	+	+	–	–	–	+	03	
10	*Parthenium hysterophorus*	+	+	+	–	+	–	+	–	+	+	+	+	09
11	*Physalis minima*	–	+	–	+	–	–	–	+	–	–	+	+	05
12	*Solanum nigrum*	+	–	–	–	+	+	–	–	–	03			
Total no. of Weeds associated with respective VAM species			5	5	4	2	3	5	1	5	2	3	4	3

Table 4: VAM Fungi Richness & Diversity associated with weeds

S. No.	Name of weeds	VAM Species Richness	VAM Diversity Index	Shannon Evenness	
		Simpson Diversity Index		Shannon Diversity Index	
1	*Blumea lacera*	4	0.075	1.124	0.585
2	*Cynodon dactylon*	2	0.017	1.769	0.921
3	*Digitaria ciliaris*	4	0.044	1.356	0.706
4	*Eclipta alba*	2	0.023	1.380	0.718
5	*Euphorbia hirta*	2	0.066	1.180	0.614
6	*Mimosa pudica*	3	0.013	1.886	0.982
7	*Ocimum basilicum*	2	0.016	1.795	0.934
8	*Oplismensus compositus*	4	0.012	1.909	1
9	*Oxalis sps.*	2	0.084	1.075	0.559
10	*Parthenium hysterophorus*	9	0.096	1.017	0.529
11	*Physalis minima*	5	0.018	1.744	0.908
12	*Solanum nigrum*	3	0.080	1.096	0.570

(Diskon,2004). Additionally environmental factors such as tempratue, light intensity & soil moisture content may influence VAM symbiotic association as these factors affect the growth and morphology of roots (Cavagnaro, *et al.*, 2001). Species of *Glomus* have been the dominant fungal species in the field soils studied C.G., might be due to high soil pH (Joshi & Singh, 1995). Results revealed varied VAM spore count which may be due to change from site to site, host plant, and, according to physicochemical properties of the soil, soil pH, mineral nutrients and other factors (Abbott & Robson, 1991).

CONCLUSION

% Root colonization, Spore count and VAM species richness during present survey of weeds revealed diversity of VAM fungi with weeds. All the VAM spores recovered belong to genus *Glomus* and *Gigaspora, Glomus* showing its dominance. Spore population ,% Root colonization & VAM species richness during present survey revealed diversity of VAM fungi & weeds. VAM species richness was highest in *Parthenium hysterophorus* followed by *Physalis minima*. The most frequent species were G-01,G-02 &G-08. G-07 was associated with any one weed i.e *Parthenium hysterophorus*.

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Performance of Rice Transplanter on Productivity and Profitability of Rice cv MTU 1010

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ABSTRACT

In old day's rice transplantation process is generally done manually. All the processes from the sowing the rice seeds to rice transplanting from the one place to other place to the cultivation of rice to the harvesting of rice and lastly to the collection of rice was done only by manually. This traditional method of rice transplanting is labor intensive, hazardous with low per hectare plantation of plants and time and cost consuming. Due to these factors the completion of rice cultivation suffers within the optimum transplanting period consequently farmers face the problem of low per hectare production with high production cost. Therefore, technology for small holding size plays a very important role in developing countries. The yield attributing characters of rice were found maximum under mechanical transplanting and yield enhancement due to mechanical transplanting was 24.36 and 30.03% over farmers practice.

Keywords *Rice transplanter, rice*

Rice is cultivated in 113 countries and it is the staple food of more than 50 percent population of the world. About 90 per cent rice area exists in Asia (Das, 2012). India is one of the world's largest producers of rice, accounting for 21% of total world's rice production with the annual production of 102.5 MT in 2015 (Anon., 2015). The average rice yield in India is only 2.09 t/ha, as compared to 6.58 t/ha in Japan and world average of 3.91 t/ha (Ibrahim and Ismail, 2014). Rice is cultivated in almost all the states of India but most of its cultivation is concentrated in the river valleys, deltas of rivers and coastal plains. The main rice producing states are Tamil Nadu, West Bengal, Andhra Pradesh, Bihar, Punjab, Orissa, Uttar Pradesh, Karnataka, Assam and Maharashtra. During various rice cultivation operations agriculture workers undergo high physical strain and fatigue. In overall rice cultivation process manual rice transplanting operation is one of the drudgery prone and back- breaking activity. Due to severe weed problem, farmers often prefer transplanting than direct sowing of seeds. Manual rice transplanting is a labour intensive operation which requires 200-250 man-h/ha. During peak season labourers are not available (Das, 2012). Therefore modern agricultural machineries play a vital role in developing countries. Mechanization increases land productivity by timely completion of farm operations. It increases labour productivity and reduce drudgery of human and animals. It increases production by precision and efficient placement of inputs such as seed, fertilizer, chemicals and irrigation water. Mechanization decreases cost of production by reducing labour needed for particular operation and economy of power and other inputs (Das, 2012). Though manual transplanting gives uniform crop stand it is quite expensive and requires lot of labour besides involving lot of drudgery. Singh *et al.* (1985) reported that transplanting takes about 250-300 man hours/ha which is roughly 25 per cent of the total labour requirement of the crop. Further, due to rapid industrialization and migration to urban areas, the availability of labour became very scarce and with hike in the wages of labour, manual transplanting is found to be costly leading to reduced profits to farmers. Under such circumstances a less expensive and labour-saving method of rice transplanting without yield loss is the urgent need of the hour (Tripathi *et al.,* 2004). The mechanical transplanting of rice has been considered the most promising option, as it saves labour, ensures timely transplanting and attains optimum plant density that contributes to high productivity. It also generates an alternate source of income for rural youth through custom services on nursery raising and mechanical transplanting.

MATERIALS AND METHODS

On Farm Trial (OFT) on assessment of rice transplanter in paddy crop were conducted by Krishi Vigyan Kendra, Umaria (M.P.) with an aim of reducing work load, stress and also enhancing the production potential of rice crop. The trials were carried out during *kharif*, 2018 and *kharif*, 2019 at four villages, namely Tali, Badwar, Chandiya of Karkeli block and Bharauli village of Manpur block of Umaria district. Five innovative and receptive farmers from four villages were selected for conducting the trial to ensure their active participation during *kharif* 2018 and seven farmers during *kharif* 2019. Twenty five days old seedling of rice cv. MTU 1010 was transplanted during both the years (*kharif*,2018 and *kharif*, 2019). Uniform fertilizer dose of 120: 60: 40 kg NPK ha^{-1} was applied to the field. Area under each treatment was 0.4 ha. Four considerations for the conduct of the above trials included farmer's perspective, farmer's participation, farmer's management status and suitability of site as suggested by Singh (1999). Two treatments were taken in the trial. Manualy transplanting (Farmer's practice)- T_1 and Mechanical transplanting i.e Paddy transplanter (Recommended practice)- T_2. Farmer's practice was treated as control for comparison. Observation on two major performance indicators viz. (i) yield and yield attributing characters like number of effective tillers $hill^{-1}$, panicle length (cm), panicle weight (g). spikelets $panicle^{-1}$, 1000- grain weight, grain yield (q ha^{-1}) and (ii) Economic indicator like cost of cultivation (Rs. ha^{-1}), gross return (Rs. ha^{-1}), net return (Rs. ha^{-1}) and B: C ratio were collected from the plots of farmer's practice and recommended practice and their feasibility and economic viability were assessed. Trials were also envisaged with four fundamental assumptions as suggested by Pillai (2003) viz. (i) when the technology is not acceptable for the farmers in it recommended form and need minor modification, refinement or change, (ii) it needs the integration of related indigenous knowledge of the farmers with the scientific recommendations in the process of refinement or modification, moreover the refinement or modification is a continuous process in the lack of available technological option specific to each microenvironment, (iii) the collaboration of farmers who have been experimenting on their own to evolve solutions to the constraints in their farm and of the extension system which is vital in the process of technology development, and (iv) the technology or practices generated through On Farm Trials will become farmer's recommendation comprising a basket of alternatives and are the most appropriate to solve problem. Keeping above in view the on farm trial was executed.

RESULTS AND DISCUSSION

Different characters of rice attributing to grain yield ; viz effective tillers $hill^{-1}$, panicle length, panicle weight, number of spikelets $panicle^{-1}$, 1000- grain weight and grain yield have been presented in Table 1. During both the years, the highest number of effective tillers was observed with recommended practice (RP). Recommended practice i.e mechanical transplanting (rice transplanter) produced the longest panicle during both the years as well as in case of mean. The heaviest panicle, highest number of spikelets $panicle^{-1}$ and 1000- grain weight were also noted with recommended practice during both the years. The data revealed that under recommended practice, the performance of rice yield was found to be higher than under farmers practice during both the years of study. The yield of rice under recommended practice was 35.47 q ha^{-1} and 37.45 q ha^{-1} during *kharif* 2018 and *kharif* 2019. The yield enhancement due to mechanical transplanting was 24.36 and 30.03 % over farmers practice. The cumulative effect of the technology over two years, revealed on average yield of 36.46 q ha^{-1} and 27.19 % higher over farmers practice.

The data on economic parameters (Table 2) revealed that the gross return was highest with recommended practice during both the years and with mean data. The net return from the rice production

Table 1 : Yield attributes and grain yield of rice cv. MTU 1010 as influenced by manual and mechanical transplanting

Year	Area (ha)	No. of farmers	Effective tillers/hill		Panicle length (cm)		Panicle weight (g)		Spikelets/panicle		1000-grain weight		Grain yield (q/ha)		% increase over FP
			RP	FP	RP	FP	RP	FP	RP	FP	RP	FP	RP	FP	
Kharif, 2018	2.00	5	5.79	3.64	23.90	22.65	3.19	3.07	154.78	131.24	23.67	22.49	35.47	28.52	24.36
Kharif, 2019	2.80	7	6.17	3.68	24.15	22.73	3.27	3.11	157.43	132.76	23.81	22.53	37.45	28.80	30.03
Total Mean	2.40	6	5.98	3.66	24.02	22.69	3.23	3.09	156.10	132.00	23.74	22.51	36.46	28.66	27.20

RP (Recommended practice)- Mechanical transplanting, FP (Farmers practice)- Manual transplanting

Table 2 : Economics of rice production as influenced by mechanical and manual transplanting

Year	Gross expenditure		Gross return		Net return		B C ratio	
	RP	FP	RP	FP	RP	FP	RP	FP
Kharif, 2018	19660	23400	60299	48484	40639	25084	3.06	2.07
Kharif, 2019	19922	23900	67410	51840	47488	27940	3.38	2.16
Total Mean	19791	23650	63855	50162	44064	26512	3.22	2.12

was calculated to be highest with recommended practice i.e mechanical transplanting during both the years and in mean basis. Benefit cost ratio was also highest under the recommended practice during both the year of study. Farmers practice resulted in least economic parameters during both the years and on the basis of mean observation.

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Screening of Rice Accessions for the Assessment of Deadheart and White Earhead Damage Against *Scirpophaga incertulas* Under Field Condition

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ABSTRACT

Forty five rice accessions were screened for their reaction to deadheart and white earhead damage by *Scirpophaga incertulas* under field condition at nearby village of Annamalai University, Annamalainagar-Chidambaram. Among the 45 accessions screened, only seven accessions registered under highly resistant category with a damage level of 0% deadheart (DH) and 12 accessions showed highly resistant reaction with 0% white earhead (WEH) damage. However, eleven accessions showed resistant reaction with 1-5% WEH damage and seven accessions showed moderately resistant reaction with 6-10% WEH damage. Accessions which are rated as resistant (or) highly resistant have to be screened in artificial conditions with high insect pressure and may be used as resistant donors in breeding programs against yellow stem borer, *Scirpophaga incertulas* for the development of resistant varieties in future.

Keywords *Rice, Accessions, Resistance, Yellow Stem Borer, Deadheart, White earhead.*

Rice (*Oryza sativa* L.) belongs to the family Gramineae or Poaceae. It is the most important staple food for more than 60 per cent of the world's population. Rice crop is affected by various factors like biotic and abiotic stresses. Among the biotic stresses, insect pests play a major role in limiting the production of rice. Approximately 52 per cent of the global rice produce is lost annually due to the damage caused by biotic factors. Out of which 21 per cent is attributed to the attack of insect pest fauna (Yarasi *et al*., 2008). Among all insect pests, the rice stem borers are the most destructive one and it is responsible for the economic yield loss under natural condition up to 5-10 per cent (Mahar and Hakro, 1979). Eight species of stem borers of rice are known to be significantly important in Asia. These stem borers' attacks the crop specifically during seedling stage and causes reduction in yield (Akinsola *et al*., 1984). Symptoms produced by this insect are drying of central shoot known as "Dead heart" at vegetative stage and "White ear head (or) Chaffy panicle" at reproductive stage which leads to no grain formation. Every year *Scirpophaga incertulas* causes 27-34 per cent of yield loss. Use of resistant varieties is the best method for pest control instead of using chemicals and thereby reducing the load of toxicity in the food stuff as well as in the environment. Field screening was conducted to identify the resistant genotypes of different rice accessions against yellow stem borer (*S. incertulas*) under field condition for the benefit of farming communities.

MATERIALS AND METHODS

The field experiment was conducted to evaluate rice accessions against yellow stem borer to identify the resistant sources. A total of 45 accessions used in this study. Nursery of these genotypes was prepared properly as per the common agronomic practices. Each accession was sown in raised nursery bed and transplanting of seedlings was done on 22 days after sowing. The seedlings were planted in two rows with spacing of 20 cm between rows and 15 cm between plants. The crop was left insecticides free throughout the entire study period. Ten plants were selected at random per accession for recording the deadheart and white earhead damage at vegetative and reproductive state on different days after transplanting (DAT) was calculated using the following formula (Heinrichs *et al*., 1985).

Per cent deadheart =

$$\frac{\text{Number of damaged tillers (deadheart)}}{\text{Total number of tillers}} \text{ X } 100$$

Per cent white earhead=

$$\frac{\text{Number of white earheads}}{\text{Total number of productive tillers}} \text{ X } 100$$

The damage rating and scale was given for the test accessions using IRRI Standard Evaluation System for rice (IRRI, 1998) (Table 1 and 2).

RESULTS AND DISCUSSION

Among 45 accessions screened under field

Table 1: Standard Evaluation System for deadheart damage rating and scale of rice accessions for resistance against yellow stem borer on per cent damage basis.

Deadheart (DH)		
Damage (%)	**Scale**	**Status**
0	0	Highly Resistant (HR)
1-10	1	Resistant (R)
11-20	3	Moderately Resistant (MR)
21-30	5	Moderately Susceptible (MS)
31-60	7	Susceptible (S)
61 & above	9	Highly Susceptible (HS)

condition for the assessment of per cent deadheart (DH) damage, the results revealed that seven accessions showed highly resistant reaction with a damage level of 0% DH (SES scale-0); 13 accessions showed resistant reaction with a damage level of 1-10% DH (SES scale-1) and 17 accessions showed moderately resistant reaction with a damage level of 11-20% DH (SES scale-3). It was also observed that five accessions showed moderately susceptible reaction with a damage level of 21-30% DH (SES scale-5). The accessions *viz*., BA-96, BA-142 and TN-1 with 31-60% DH (SES scale-7) showed susceptible reaction against YSB infestation. In this current investigation, no accession was enlisted as highly susceptible under Scale-9 (Above 60% DH) (Table-3).

At that point, when the per cent white earhead (WEH) infestation was evaluated following Standard Evaluation System (SES) for rice given by IRRI, Philippines, the outcomes revealed that out of 45 accessions screened, only 12 accessions showed highly resistant reaction with 0% WEH damage (SES scale-0) (Table-4). However, 11 accessions showed resistant reaction with 1-5% WEH damage (SES scale-1) and seven accessions showed moderately resistant reaction with 6-10% WEH damage (SES scale-3). While, two accessions showed moderately susceptible reaction with 11-15% WEH damage (SES scale-5) and one accession (BA-2) showed susceptible reaction with 16-25% WEH damage (SES scale-7). Altogether, the maximum white earhead infestation was observed in twelve accessions and showed highly susceptible reaction with 26% and above damage of WEH (SES scale-9) (Figure-1).

Similarly, Elanchezhyan and Arumugachamy (2015) evaluated 15 medium duration rice cultures during *Pishanam* season, 2013-2014 and reported that the entries AS 12035 and AS 12051 recorded grade

Table 2: Standard Evaluation System for white earhead damage rating and scale of rice accessions for resistance against yellow stem borer on per cent damage basis

White earhead (WEH)		
Damage (%)	**Scale**	**Status**
0	0	Highly Resistant (HR)
1-5	1	Resistant (R)
6-10	3	Moderately Resistant (MR)
11-15	5	Moderately Susceptible (MS)
16-25	7	Susceptible (S)
26 and above	9	Highly Susceptible (HS)

Table 3: Screening of rice accessions for Deadheart damage against *S. incertulas* under field condition

S.No.	Accessions	% Deadheart damage		Pooled Mean	Scale	Status
		35 DAT	55 DAT			
1.	BA-2	19.16	15.00	17.08	3	MR
2.	BA-11	15.00	20.00	17.50	3	MR
3.	BA-20	31.66	21.50	26.58	5	MS
4.	BA-24	14.99	10.00	12.49	3	MR
5.	BA-26	12.50	30.00	21.25	5	MS
6.	BA-48	2.50	5.00	3.75	1	R
7.	BA-50	0.00	0.00	0.00	0	HR
8.	BA-63	22.50	18.33	20.41	3	MR
9.	BA-64	0.00	0.00	0.00	0	HR
10.	BA-66	0.00	6.50	3.25	1	R
11.	BA-81	10.00	7.50	8.75	1	R
12.	BA-90	5.00	7.00	6.00	1	R
13.	BA-96	43.32	30.00	36.66	7	S
14.	BA-106	10.83	24.00	17.41	3	MR
15.	BA-109	19.99	17.50	18.74	3	MR
16.	BA-118	14.16	22.50	18.33	3	MR
17.	BA-125	0.00	2.00	1.00	1	R
18.	BA-132	0.00	0.00	0.00	0	HR
19.	BA-142	37.49	29.50	33.49	7	S
20.	BA-147	0.00	0.00	0.00	0	HR
21.	BA-151	25.83	15.00	20.41	3	MR
22.	BA-155	2.50	4.00	3.25	1	R
23.	BA-156	5.83	7.50	6.66	1	R
24.	BA-159	2.50	12.50	7.50	1	R
25.	BA-160	16.66	15.00	15.83	3	MR
26.	BA-167	15.00	20.00	17.50	3	MR
27.	BA-173	10.83	25.00	17.91	3	MR
28.	BA-174	19.16	24.50	21.83	5	MS

*DAT- Days After Transplanting, HR- Highly Resistant, R- Resistant, MR- Moderately Resistant, MS-Moderately Susceptible, S-Susceptible

Table 4; Screening of rice accessions for White earhead damage against *S. incertulas* under field condition

S.No.	Accessions	% White earhead damage		Pooled Mean	Scale	Status
		75 DAT	95 DAT			
1.	BA-2	20.00	30.00	25.00	7	S
2.	BA-11	27.50	44.99	36.24	9	HS
3.	BA-20	33.33	37.50	35.41	9	HS
4.	BA-24	44.16	50.00	47.08	9	HS
5.	BA-26	2.50	5.00	3.75	1	R
6.	BA-48	0.00	0.00	0.00	0	HR
7.	BA-50	0.00	0.00	0.00	0	HR
8.	BA-63	0.00	0.00	0.00	0	HR
9.	BA-64	4.50	4.50	4.50	1	R
10.	BA-66	34.16	47.50	40.83	9	HS
11.	BA-81	2.50	5.00	3.75	1	R
12.	BA-90	0.00	4.00	2.00	1	R
13.	BA-96	2.50	6.66	4.58	1	R
14.	BA-106	44.99	54.16	49.57	9	HS
15.	BA-109	5.00	8.33	6.66	3	MR
16.	BA-118	4.50	12.50	8.50	3	MR
17.	BA-125	32.50	32.50	32.50	9	HS
18.	BA-132	0.00	0.00	0.00	0	HR
19.	BA-142	0.00	2.50	1.25	1	R
20.	BA-147	0.00	0.00	0.00	0	HR
21.	BA-151	0.00	10.83	5.41	1	R
22.	BA-155	0.00	0.00	0.00	0	HR
23.	BA-156	0.00	0.00	0.00	0	HR
24.	BA-159	0.00	17.50	8.75	3	MR
25.	BA-160	7.50	15.00	11.25	5	MS
26.	BA-167	39.16	38.00	38.58	9	HS
27.	BA-173	35.83	30.00	32.91	9	HS
28.	BA-174	0.00	17.50	8.75	3	MR

*DAT- Days After Transplanting, HR- Highly Resistant, R- Resistant, MR- Moderately Resistant, MS-Moderately Susceptible, S-Susceptible

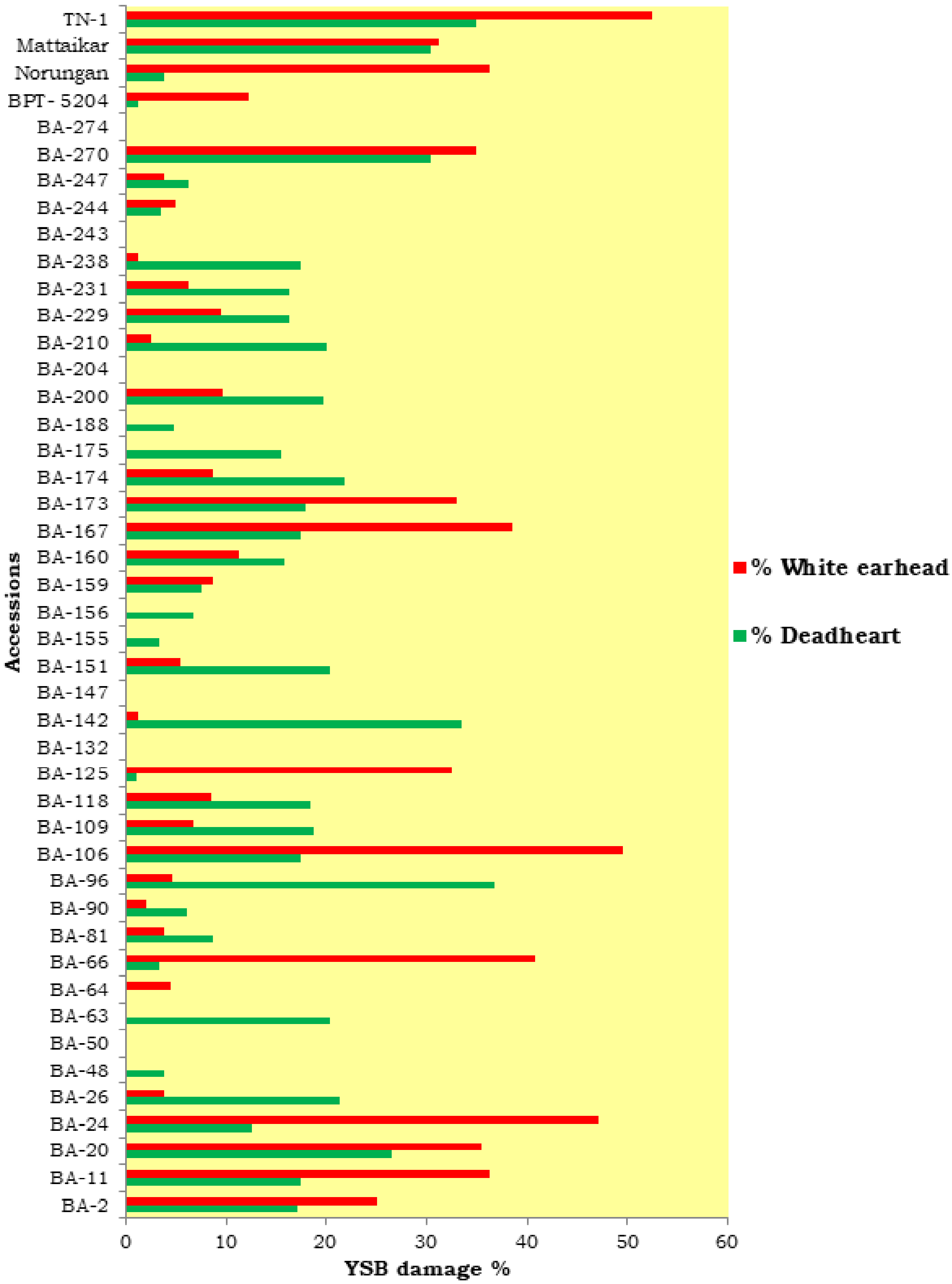

Fig. 1. Screening of rice accessions for their resistance against *S. incertulas* under field condition

1. The cultures AS 12005, AS 12050, AS 12104 and AS 12001 recorded grade 3. The resistance in rice accessions may be due to the presence of a strong repellent or antifeedant stimuli by the plants and either due to the presence of toxic chemical or nutritional deficiencies in the plant for insect. Chandler (1968) reported that yellow stem borer resistance is offered from several characteristics of rice plant. Rice accessions with closely arranged vascular bundles than the width of the larval head offered resistance to larval boring. Varieties with thin layers of sclerenchyma tissue were usually escaped from yellow stem borer

attack than those with thick layers. Similarly, the internal factors such as silica content and other chemical properties may be involved in stem borer resistance.

CONCLUSION

In this way, identification of factors that confer resistance or susceptibility and study of their inheritance in rice plants would greatly improve breeding strategy to release the resistant variety against insect pests. Still now no rice variety is completely resistant to stem borer attack. Varieties resistant to one species of stem borer are not essentially resistant to other borer species. All categories, level or scale of resistance from moderate to high are seen in rice genotypes. However, 100 per cent immunity or very highly resistance against stem borer was not noticed in any of the genotypes. In sometimes, even the resistant varieties also suffer from some minor damage beneath heavy insect populations. Several wild rice species also have high levels of resistance to stem borers. Development of stem borer resistant varieties are mainly inexpensive, least problematical, very safe and ecological friendly advantageous for the control of insect pest damage. However, continuous steps have taken to incorporate moderate levels of resistance from several donor parents into improved varieties.

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Improved Production Technology of Semi Irrigated Wheat (*Triticum aestivium L.*) Through Front Line Demonstration in Umaria District of Madhya Pradesh

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ABSTRACT

Front Line Demonstration is one of the most powerful tools for transfer of technology. Krishi Vigyan Kendra, Umaria, conducted 28 front line demonstrations on wheat crop at farmer's field of three adopted villages within one block during *rabi* season of 2015-16, 2016-17 and 2017-18 for transfer of technology. The front line demonstrations of wheat were conducted in twenty eight farmers fields to demonstrate production potential and economic benefit of improved technologies consisting semi irrigated variety JW 3211, nutrient (60:30:15 kg/ha NPK) in partial irrigated conditions. The productivity of wheat ranged from 27.80 to 36.00 q/ha with mean grain yield of 32.00 q/ha under recommended practice on farmers field as against a grain yield under farmers practice which ranged from 16.89 to 28.30 q/ha with a mean of 24.30 q/ha. Wheat grain yield was increased by 36.06% over the farmers practice. Yield of the front line demonstration and potential yield of the crop was compared to estimate the yield gaps which were further categorized into technology index. Cultivation of wheat under improved practices fetch higher net return of Rs. 24118 to Rs. 35777/ha compared to farmer practice of Rs. 7,824 to Rs.27673/ha. The average B: C ratio of recommended practice was 2.46 in comparison of farmer practice mean B: C ratio was 1.97. The extension gap, technology gap and technology index (%) were observed to be 7.72 q/ha, 13.00 q/ha respectively and the technology index of 28.80 %.

Keywords *FLD, Semi irrigated wheat, yield, Extension gap, technology gap and index*

Wheat is one of the most imperative and consumed principal foods at global level. Particularly the wheat species *Triticum aestivum* (L.) accounts for one-fifth of the total calories delivered to the world population (Reynolds *et al.,* 2010). Wheat has a surfeit of uses nowadays including making different types of bread, biscuits, cakes, pasta, noodles and grain alcohols. Wheat is second most important staple food crop after rice in India and generally provides about 50 percent of the calories and proteins requirement to a vast majority of India's population. Increased population together with eating preferences has resulted in a considerable upsurge in mandate for wheat in last 50 years (Kajla *et al.,* 2015). Consequently, wheat is now grown more widely than any other crop with global wheat production pegged at 748 million tons (FAO 2017). Wheat is the most important source of carbohydrate in a majority of countries. Wheat also contains a diversity of minerals, vitamins and fats (lipids). With a small amount of animal or legume protein added, a wheat-based meal is highly nutritious. Wheat is grown in India over an area of about 266.92 lakh ha. with a production of 721.40 lakh tonnes. The major Wheat producing States are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, Maharashtra, Gujarat, Karnataka, West Bengal, Uttaranchal, Himachal Pradesh and Jammu & Kashmir. These States contribute about 99.5% of total Wheat production in the country. Remaining States namely, Jharkhand, Assam, Chhattisgarh, Delhi and other North Eastern States contribute only about 0.5 % of the total Wheat production in the country. Among food grains, Wheat stands next to Rice, both in area and production. The share of Wheat in total food grain production is around 35.5% and share in area is about 21.8% of the total area under food grains. Yield potential of wheat in Umaria district of M.P. is not being exploited fully due to many factors, among which delayed sowing, low yielding varieties, poor nutrient and irrigation management are the most important ones. The productivity of wheat in the district is only1.68 t/ha, as compared to the national average of 2.7 t/ha (Mukharjee, 2008). Around 50% of the wheat in the district is cultivated under rainfed condition, while irrigated area is only 25%. Comparatively cooler season and long crop duration in this region provides congenial condition to achieve fairly good yield. Hence, an effort made by the KVK scientists by introducing the recommended technologies of wheat

Table 1: Comparison between demonstration practice and farmer's practice in semi irrigated wheat crop

S.No.	Input	FLDs	FP
1.	Wheat variety	JW 3211	Very old variety WH 147
2.	Seed rate (kg/ha)	100	150
3.	Seed treatment	Carboxin @ 3 g/kg seed	No seed treatment
4.	Seed inoculation	Azotobacter and PSB @ 10 g/kg of seed	No seed inoculation
5.	Sowing method	Line sowing	Broadcasting method
6.	Fertilizer management	Balance use of fertilizer	Imbalance use of fertilizer
7.	Weed management	2,4-D @ 500 g a.i/ha	No weedicide application

* FLDs = Front Line Demonstrations and FP = Farmers Practice

production with JW 3211 through front line demonstration on farmers field.

MATERIALS AND METHODS

Field demonstrations were conducted under close supervision of Krishi Vigyan Kendra, Umaria. Total 28 front line demonstrations under real farming situations were conducted during rabi season of 2015-16, 2016-17 and 2017-2018 in three different villages i.e Tali, Dhaurkhoh and Sallaiya of Karkeli block of Umaria district. The area under each demonstration was 0.40 ha. Before conducting of FLDs a list of farmers was prepared from group meetings and specific skill training was imparted to the selected farmers regarding different aspects of wheat cultivation. The KVK scientists visited the FLDs field regularly on different critical stages of crops to ensure timely application of nutrients, weedicides and plant protection measures and also to give other suggestive measures to the farmers and collect the feedback information on each stage for further improvement in research and extension programme. The data were collected through personal interview schedule consisting of set of questions, which were asked from the FLD farmers by the investigator in face to face situation to give their response about each improved production technology of wheat. To compare the production and profitability of crop the yield data of FLDs and control plots were collected from each farmers and averaged out in each year at all locations during the study. Improved variety JW 3211, with seed rate of 100 kg/ha along with recommended dose of fertilizer and weed control measures were used. The crop received full dose of P2O5 and K2O and half dose of nitrogen as basal dose and remaining nitrogen in 2 equal splits i.e. at tillering and at boot stage. Weed control measures mainly include, post emergence application of 2, 4 D @ 500 ml/ha was given at 26 DAS (days after sowing). Farmer's practice constituted seed of age old variety of WH 147. Crop was sown on the same time as demonstration, broadcasting method of sowing, higher seed rate (150 kg/ha), imbalance dose of fertilizers applied , no seed

Table 2: Ranks for different constraints given by farmer (n=28)

S.No.	Constraints	Per centage	Rank
1.	Non availability of seeds of high yielding varieties	78.67	I
2.	Low technical knowledge	74.81	II
3.	Insect infestation	72.49	III
4.	Damage caused by wild animals	67.23	IV
5.	Use of high seed rate	63.52	V
6.	Low soil fertility	59.73	VI
7.	Weed infestation	42.85	VII

Table 3: Yield performance of semi irrigated wheat under FLDs

Year	Area (ha)	No. of farmers	No. of effective tillers/m^2		Grain yield (q/ha)			% increase over FP
			FLD	FP	Potential	FLD	FP	
2015-16	3.60	9	286	232	45	36.00	28.30	27.20
2016-17	5.60	14	262	209	45	27.80	16.89	64.59
2017-18	2.00	5	275	226	45	32.33	27.76	16.40
Total mean	11.20	28	274	222	45	32.00	24.30	36.06

treatment, no plant protection measures were adopted. Crop was harvested on the same time of harvesting of demonstration plots. Harvesting and threshing operations done manually and thresher, respectively; 5m × 4m plot harvested in five different locations in each demonstration and average grain weight taken. Similar procedure adopted on FP plots under each demonstration then grain weight converted into quintal per hectare (q/ha). Before conduct the demonstration training to farmers of respective villages was imparted with respect to envisaged technological interventions. All other steps like site selection, farmer's selection, layout of demonstration, farmers participation *etc.* were followed as suggested by Choudhary (1999). Visits of farmers and extension functionaries were organized at demonstration plots to disseminate the technology at large scale. Yield data was collected from farmers practice and demonstration plots. The grass returns, cost of cultivation, net returns and benefit cost ratio (B:C ratio) were calculated by using prevailing prices of inputs and outputs and finally the extension gap, technology gap and technology index were worked out. Technology gap, extension gap and technology index were measured as per procedure given by Samui *et al.* (2000) and Sagar *et al.(* 2004).

- Technology gap = Potential yield – Demonstration yield
- Extension gap = Demonstration yield – farmers yield
- Technology index = [(Potential yield – Demonstration yield) /Potential yield] x 100
- % increase over farmers practices = Recommended practices – Farmers practices / farmers practices x 100

RESULTS AND DISCUSSION

Constraints in wheat production

Problems faced by the farmers in wheat cultivation were documented during the study. Perusal of the data from Table 2 indicated that non-availability of improved varieties of wheat (78.67%) was given the top most rank followed by low technical knowledge (74.81%), incidence of insect (72.49%), damage caused by wild animals (67.23%), use of higher seed rate (63.52%), low fertility status (59.73%) and weed problem (42.85%) were the major constraints to wheat cultivation. Dhruw *et al.* (2012) and Meena *et al.* (2014) have also reported similar constraints.

Wheat yield

The yields contributing characters like number of effective tillers/m^2 wheat obtained over the years under recommended practice as well as farmers practice are presented in table 3. Observation revealed

Table 4: Yield gap analysis under FLDs

Year	Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)
2015-16	9.00	7.70	20.00
2016-17	17.20	10.91	38.22
2017-18	12.67	4.57	28.15
Total mean	13.00	7.72	28.80

Table 5: Economics, additional cost and returns in semi irrigated wheat under FLDs vs farmers

Year	Gross expenditure (Rs./ha)		Gross returns (Rs./ha)		Net returns (Rs./ha)		Additional cost of cultivation (Rs./ha) in FLD	Additional net return (Rs./ha) in FLD	B: C ratio	
	FLD	FP	FLD	FP	FLD	FP			FLD	FP
2015-16	19515	18315	52650	41465	33135	23150	1200	9985	2.69	2.26
2016-17	20000	19000	44118	26824	24118	7824	1000	16294	2.20	1.41
2017-18	23000	22000	58777	49673	35777	27673	1000	8104	2.50	2.25
Total mean	20838	19771	51848	39320	31010	19549	1066	11461	2.46	1.97

that, the number of tillers/m^2 of wheat from mean of 274 under recommended practice as against a mean value of 222 recorded under farmers practice. The productivity of wheat ranged from 27.80 to 36.00 q/ha with mean grain yield of 32.00 q/ha under FLD on farmers field as against a grain yield under farmers practice which ranged from 16.89 to 28.30 q/ha with a mean of 24.30 q/ha. Wheat grain yield was increased by 36.06% over the farmers practice. The results are in close conformity with the research results of Sharma *et al.* (2016).

Extension and Technology gap

The extension gap ranging between 4.57- 10.91 q/ha during the period of study emphasized the need to educate the farmers through various means for the adoption of improved agricultural production to reverse the trend of wide extension gap (Table 4). The technology gap is the difference or gap between the demonstration yield and potential yield and it was varies during the year of observation. The trend of technology gap ranging between 9.00-17.20 q/ha reflected the farmer's cooperation in carrying out such demonstration with encouraging results during the period of study.

Technology index

The technology index indicates the feasibility of the evolved technology at the farmer's fields. The lower the value of technology index more is the feasibility of the technology. The data (Table-4) showed that technology index value 20.00 % was noticed in the year 2015-16, 38.22 % in the year 2016-17 while in the year 2017-18 the value was 28.15%, whereas the average value of technology index was recorded 28.80%.

Economic analysis

The higher cost of cultivation Rs 20,838 involved in FLDs as compared to Rs. 19,771 under Farmers practice (Table-5). The FLDs plots fetched higher mean gross returns (Rs. 51,848/ha) and net returns (Rs. 31,010/ha) with higher benefit: cost ratio (2.46) as compared to (gross returns Rs. 39,320), (net returns Rs. 19,549) and (benefit: cost ratio 1.97) with farmers practice. Hiremath and Nagaraju (2009), Sreelakshmi *et al.* (2012) and Joshi *et al.* (2014) also reported higher net returns and B:C ratio in the FLDs on improved technologies compared to the farmers practices and are at par with results of the present study which also resulted in higher net returns through FLDs on improved technologies.

Additional cost of cultivation and returns

Further, data (Table-5) revealed that the average additional cost of cultivation (Rs. 1,066/ha) under demonstrations and has yielded additional net returns of Rs. 11,461 / ha.

CONCLUSION

Frontline demonstrations were carried out in a systematic and scientific manner on farmer's field to show the worth of improved production technology of wheat and convincing farmers for further adoption. Response receives from different farmer's revealed that farmer were satisfied with potentialities of demonstrated technology. Wheat FLDs were perceived by the farmers as effective method of transfer of technology. Frontline demonstration were also found effective in upgrading the knowledge base of farmers regarding improved production technology of wheat which will be helpful in enhancement of the wheat productivity of the area.

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Interaction Between Different Growth Regulator Concentration and Bamboo Species through Branch Cutting

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ABSTRACT

The present investigation was carried out to develop an easy and cheap protocol for mass propagation of four bamboo spices *B.balcooa, B.bambos*, *D.strictus* and *C.pergracile* with different auxin concentration IBA 100, IBA 200, IBA 500 ppm and compared with control in green house condition of College of Agriculture Balaghat, Madhya Pradesh, India during year 2020-21.The experiment was laid out in factorial completely Randomized Design (FCRD). There were three treatment including control with four bamboo speices replicated six times in which several growth regulator IBA 100 ppm, 200 ppm and 500 ppm including control investigated the most effective growth regulator was IBA 500 ppm which gave better results with sprouting and rooting behavior compared to control. So it can be recommended that IBA 500 ppm as a most effective growth regulator among the all treatments concentration. As far as bamboo species performance was order: *B.balcooa*>*B. bambos*>*D. strictus*> *C.pergracile.*

Keywords Branch cutting, Growth regulator, Bamboo species, and Concentration.

With the gradual increase of demand of timber species to meet the present requirement, there is a tremendous pressure on raw material in the last few decades and people are forced to look forward for the search of non-timber forest product to substitute the wood. In this process during later part of the last century bamboo has emerged as a material for the ecological, economic and social upliftment, because of its ability to grow in the wasteland, amazing growth rate, high yield and multiple uses. They are now considered as world's greatest natural and renewable vegetable resources, which may be considered as cash crop to generate income needs for the rural communities. To meet the growing demand, there is a need for quality planting stock to enhance productivity is a need for quality planting stock to enhance productivity and large scale commercial cultivation. Therefore, an ideal nursery is a per requisite for fulfil the demand of planting materials for large scale plantation. Bamboo can be propagated through seeds, stem, roots, and rhizome vegetative means. Bamboos are monocotyledonous perennial grasses and most diverse group of plants in the grass family, and the most primitive sub-family belonging to Bambusoidae of the family Poaceae (Gramineae). They are distinguished by having woody culms and complex branching, a complex and generally robust rhizome system, and flowering at long intervals. Bamboo has an extensive fine root system, which ramifies horizontally and vertically binding the particles together (Sujatha *et al*., 2008). Bamboo grows on elevated grounds and river banks (Nath *et al.,* 2008) and can cope with temporal floods (Kaushik *et al.,* 2005). In many areas, bamboo is planted for tapping collapsed soil in ravines (Higake *et al.,* 2005).

Availability of suitable planting material of bamboo is always a problem as the unavailability of seeds every year as well as difficult conventional vegetative propagation methods. Vegetative propagation is not a breeding method but a way to rapidly multiply and disseminate the desired clonal material according to its genetic potential. In vegetative propagation, the genetic potential of a species, including the non additive variance, is automatically transferred to the new plant. However, in nature the tree populations are highly heterozygous and vegetative population helps to utilize maximum genetic gains in the shortest possible time. The success of vegetative propagation depends upon a proper environment, genetic component and the physiological status of cuttings etc. Vegetative propagation is a good tool for propagating the selective genotype. Cloning by rooting of cuttings has developed a lot because it became possible to use improved genetic material in the establishment of seed orchards, in nutrition trials, in increasing hybrids with more genetic accuracy for tests and establishment of large industrial forests through mass propagation of clonal planting material. Due to unavailability of seeds every year propagation techniques for many bamboo species is a major break. Keeping this problem in view, branch cuttings of bamboo species, which are easily available were tried for their rooting response to produced quality planting material and the results are given in this paper.

MATERIALS AND METHODS

The present investigations were conducted in the year 2020 for one season in the nursery area of Bamboo setum, College of Agriculture Balaghat. Madhya Pradesh is centrally located and 37.84% of the total area of the state is notified as forest (Annon, 1995). K. P. Sahoo *et al.,* 2008 have reported the study sites comprise of various forest communities spread all over Balaghat district. The district is located in the south eastern Madhya-Pradesh between Latitude-21° 19´ to 22° 24´ North and Longitude 79°-31´ to 81°3´ East in the eastern part of Satpura plateau. Total geographical area of the district is 9200 sq.kms, out of which 4051.8 sq.kms areas comes under forest cover amounting of 46% of the total area. The district presently has two territorial division viz. North and South Forest division.

Soil: The district has alluvial soil in the lowland and black to brown clay loam soil in the plateau and tablelands. The most fertile soil is found in the plain areas of Waraseoni & Balaghat tehsil.

Climates: Summer hot season- March to June, Rainy Season- June to Sept. Post Monsoon Traditional Climate from Sept. To Oct. Mild cold winter season- Nov. February. Overall climate of the district is moderate with a minimum temp. Of 4.4°C in January and Maximum temp. 44 °C in May.

Rainfall: Rainfall pattern is of monsoonal type, Rain in the district start in mid june & last upto the earlier part of Oct.

Four different species viz. *Bambusa balcooa, Bambusa bambos, Cephalostachyum pergracile* and *Dendrocalamus strictus* were selected for the culm branch cutting experiment. The thick-walled roots of all bamboo species often produce thick branches with basal nodes of primordia-bearing branches. These branches are carefully cut and removed from 1-3 year old culverts. 3-4 nodular cuttings are prepared from such branches. The branch cuttings of this bamboo species were collected from the already established clumps of this species growing in College of Agriculture Balaghat Bambusetum in rainy season. The cuttings were collected fresh and put in a plastic buckets filled with water to avoid desiccation of the vegetative materials. The branch cuttings collected were treated with 100, 200 and 500 ppm IBA (Indore Butyric Acetic Acid) and control. The branch cutting material were treated by soaking the basal portion (1/3) in the solution for 24 hours and after that transplanted in polybags containing a mixture of soil, sand and vermicomposed in the ratio 2:1:1.

Observation on rooting, root length, number of roots sprouting and survival percentage was observed with using completely randomized factorial design with three replication and two factors *i.e* species and IBA treatment. All the data pertaining to rooting and subsequent growth was loaded in Microsoft excel and subjected to analysis of variance using Genstat statistical package. In the analysis of variance for studied parameters, the mean values of each replication were estimated.

RESULTS AND DISCUSSIONS:

The present investigation was undertaken with a view to know the impact of various Indore Butyric Acetic Acid concentration (100, 200 and 500 ppm) on cutting of different bamboo species during the growing season of 2020-21. The whole experiment was conducted in greenhouse at College of Agriculture, Balaghat. It was notices from the analysis that the percentage of sprouting of different bamboo species was observed significantly maximum in *B.Balcooa* in all IBA (Indore Butyric Acetic Acid) treatment which was followed by *B.Bambos* and *D.strictus* and least found in *C.pergracile* and influence of different growth regulator concentration found maximum in IBA 500 ppm followed by IBA 200 and IBA 100 and least in control as well as different treatment of IBA in bamboo species found significantly maximum mean in IBA 500ppm and least in control (Fig 1).

Overall the potential of bamboo species for rooting was found to be in the order: *B.balcooa>B. bambos>D.strictus>C.pergracile* as well as impact of IBA concentration was maximum IBA 500 ppm and least in control (Fig2). The Overall mean result was found maximum in IBA 500 ppm (70.5%) and least in control (59.5%). The number of roots was highest in *B.balcooa* (24.0) which was at par with *B.bambos* and followed by *D.strictus* and least was *C.pergracile*

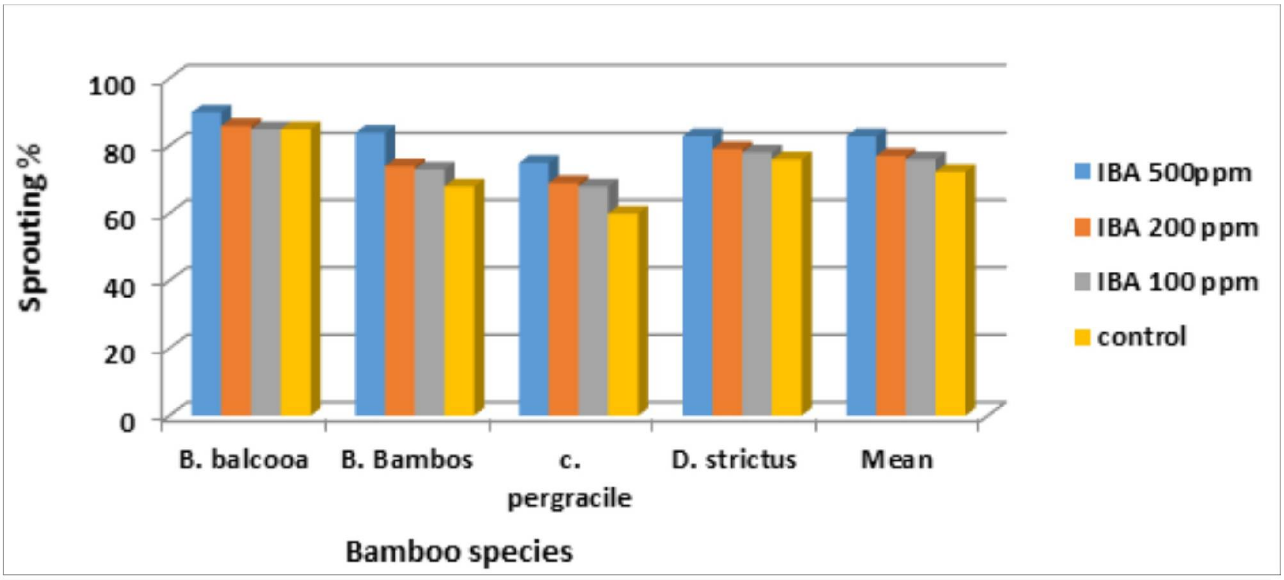

Fig. 1: Impact and interaction on sprouting between different IBA concentration and bamboo species

(Fig3). Impact of different IBA concentration was found maximum in IBA 500 ppm followed by IBA 200 ppm and IBA 100ppm. Least number of root recorded in control (12). Root length was maximum in *B.balcooa*, which was at par with *B.bambos* and least was in *C.pergracile* (Fig4). Impact of IBA concentration in root length was found highest in IBA 500 ppm and least in control. Mean of all IBA concentration and bamboo species root length was found highest in *B.balcooa* with IBA 500 ppm. The variations in sprouting and rooting parameters in bamboo species cuttings may be attributed due to the genotypic characteristics, the endogenous food reserve, environmental factors and the interaction between them (Banik, 1984; Dubey *et al.,* 2008; Singh *et al.* 2006; Kaushal and Tewari, 2009). The variations in sprouting and rooting behavior in different bamboo plant species have also been reported by Saharia and Sen, 1990; Banik, 2000;Gulabrao *et al.* 2011. In general, IBA was found to enhance the sprouting and rooting parameters as compared to control. Two way interaction of species and IBA revealed that all the parameters was significantly influenced. In the view of present investigation the most effective growth regulator was IBA 500 ppm which gave better results with sprouting, root percentage, root length and number of roots compared to control and other treatment concentration, so it can be recommended

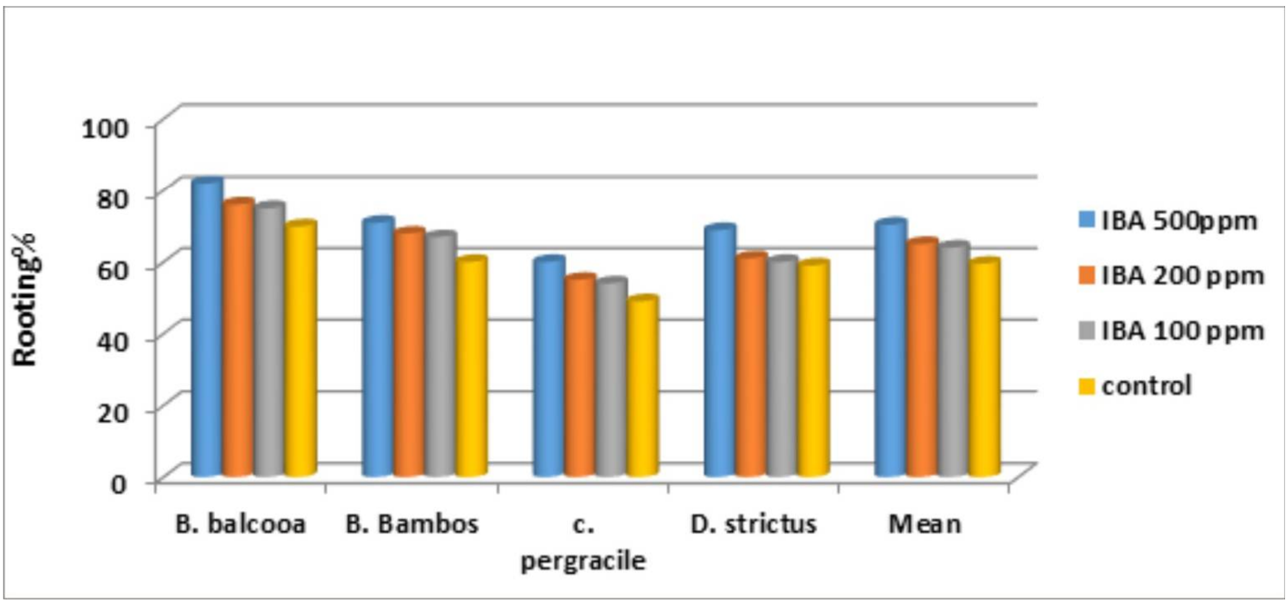

Fig 2: Impact and interaction on rooting between different IBA concentration and bamboo species

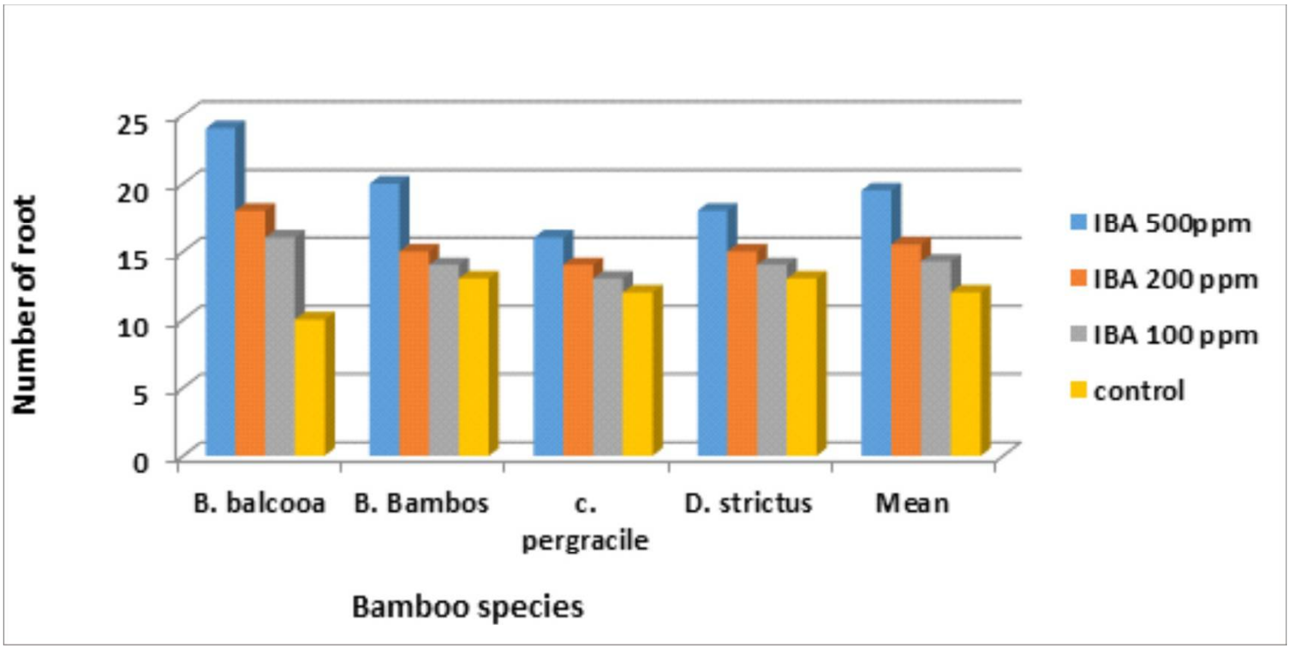

Fig. 3: Impact and interaction on number of root between different IBA concentration and bamboo species

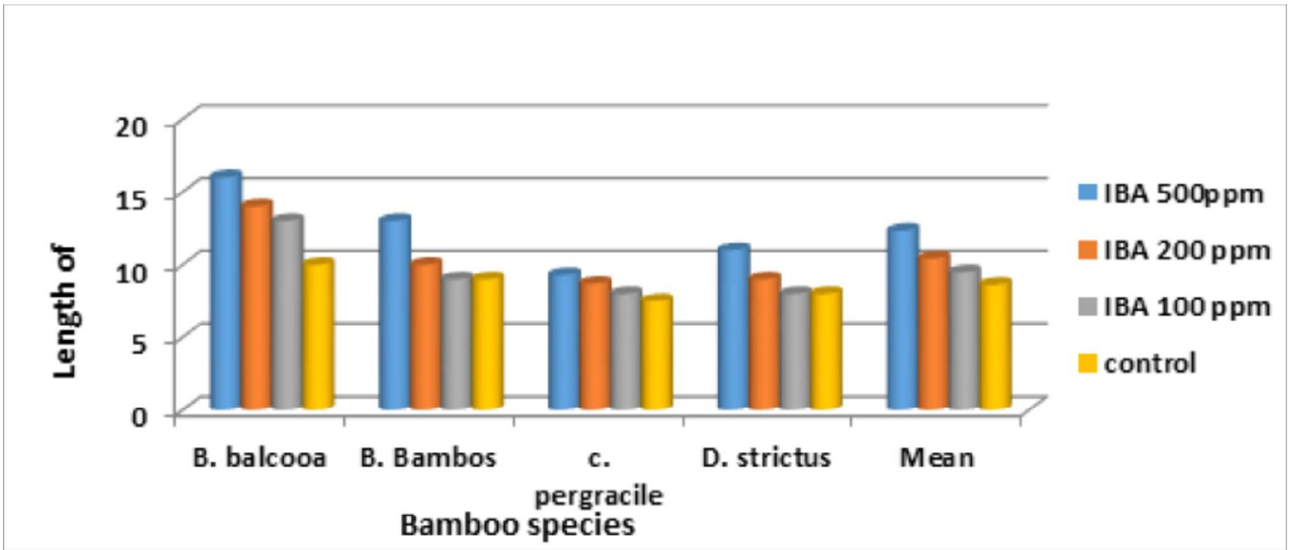

Fig. 4: Impact and interaction on length of root between different IBA concentration and bamboo species

that IBA 500 ppm as a most effective growth regulator among the all treatments. Auxin IBA 500 ppm influences polysaccharide hydrolysis resulting in increased content of physiologically active sugar, which is required to provide energy for meristematic tissues and later for root primodia and formation of root (Nanda *et al*., 1974; Husen and Pal, 2007). Anon (1985) and Hossain *et al.* (2006) found IBA to enhance rooting and sprouting responses of bamboo species.

CONCLUSION

Considering the forgoing scenario, as well as the rapidly increasing demand of economically important bamboo species many innovating techniques for rapid mass multiplication have been developed during the past few years. Propagation of bamboo through branch cuttings could be a useful approach because of their availability, non destruction of clumps and ease in handling. From the present study it was concentration of IBA 500 ppm showed highest impact in sprouting and rooting behavior and different bamboo species showed enhanced performance in the order; *B.balcooa>B.bambos>D.strictus>C. pergracile.* Thus cutting of bamboo species with IBA treatment help in production of vegetatively reproduced plants with more sprouting and rooting vigour for easy establishment.

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Genetic Variability Studies of Yield and Yield Related Traits in F_3 Families of Rice (*Oryza Sativa* L.) Under Aerobic Condition

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ABSTRACT

Rice (*Oryza sativa* L.) breeding strategy mainly depends on the available genetic variability, which involves assembling the genotypes from different geographical region or generating variable population or by selfing hybrids developed from different parents (Sanjeev Kumar *et al.*, 2005). Choice of individuals in the early generation breeding materials with high order of expression for the yield components is paramount importance for crop improvement. F_2 population which has high mean coupled with high variability as the ideal source for exercising selection. It is achieved through adopting suitable selection procedures involving the basis of selection, stage of selection, methods of selection and intensity of selection. The basic aim of the breeder is to perpetuate the best progeny of the best family. In the present study, to identify a few good crosses from each of the 10 F_3 populations of rice, the nature of variance heritability and genetic advance, the nature of association between economic traits, parent offspring regression of F_3 means on F_2 values of 16 metric traits were analyzed and the results are discussed below:

Keywords *Rice, Variability, Selection, F_3 population, early generation*

Rice (*Oryza sativa* L.) is the world's most important food crop and a primary source of food for more than half of the world's population. More than 90 per cent of the world's rice is grown and consumed in Asia where 60 per cent of the people on earth live. Rice accounts for 35 to 75 per cent of the calories consumed by more than 3 billion Asians. It is grown worldwide in 154 million hectares in a wide range of environments (IRRI, 2002).Among the rice growing countries in the world, India has the largest area under rice crop and ranks second in the production next to China. It is an important cereal crop of India and cultivated in about 45.54 m ha with an annual production of 99.18 million tonnes and a productivity of 1460 kg / ha. Rice contributes to 43 per cent of the total food grain production and 46 per cent of the total cereal production in India. Among the rice producing states of India, Tamil Nadu ranks sixth in production (http: //www. Indiastat.com /2006). Of the rice area, 50 per cent is irrigated; 35 per cent is rainfed medium and lowland; 12 per cent is under rainfed upland and the remaining 3 per cent falls under deep water cultivation (FAO, 2007). Drought is defined as water stress mainly due to lack of rain. About 45% of the world's rice is cultivated in rainfed ecosystems. These areas often experience severe water deficits due to low and uneven rainfall distribution patterns and yields are largely reduced by drought.

In Tamil Nadu, rice is cultivated in an area of about 18 lakh hectares, with the production and productivity of 56 lakh tonnes and 3.0 tonnes per hectare, respectively ( ). Although the production of rice has increased over time in the wake of green revolution and other technological advancements, major shortfalls caused by climatic aberrations such as drought and flooding are frequent. Drought is one of the major constraints in rice production. Nearly 10 lakh hectares of rice are prone to drought in Tamil Nadu. Hence the present investigation was undertaken with aforesaid points in view to study the F_3 generations with 10 cross combinations of rice with the following objectives to find out the nature and extent of variability for economic traits in each of the 10 segregating populations and also to know how far these traits are heritable and how much genetic advance can be expected for each trait.

MATERIALS AND METHODS

The Present study was conducted in the Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai. The F_3 generation was raised during *Kharif* 2011. The biological materials involving seven A lines, *viz.,* IR 73328A, IR 70369A, COMS 24A, COMS 14A, IR 79128A, IR 79156A and eight restorer (R) lines, *viz.,* IR 69726-29-1-2-2R, IR 79582-21-2-2-1R, IR 81178-2T-2-2-3R, IR 79200-45-2-2-1R, IR 80286-22-3-6-1R, IR 80402-88-3-1-3R, IR 7925A-428-2-1-1R, IR 05N496 and varieties *viz.,* MAS-946-1, KMP-149, MAS-26, BR-2655, KMP-105, BI-33 and KMP-148 obtained from the rice germplasm collection maintained in the Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai were utilized as the experimental material in the present study.

Table 1: The parents and their crosses involved in F_3 generation

Symbols	Parents involved
Cross 1	IR 73328A x IR 69726
Cross 2	COMS 24A x IR 79200
Cross 3	COMS 14A x IR 80286
Cross 4	IR 70369A x BI33
Cross 5	IR 70369A x IR 7925
Cross 6	COMS 24A x IR05N496
Cross 7	IR 73328A x IR 80402
Cross 8	IR 73328A x IR 05N496
Cross 9	IR 79128A x IR 79200
Cross 10	IR 79128A x KMP 105

Selection was effected at three levels, *viz.,* Mean (L_1), Mean + LSD (L_2), Mean - LSD (L_3) for grain yield and five plants were marked randomly and studied for each level of selection per cross. The selected materials were studied in F_3 generation. One hundred and fifty F_3 families were raised along with check in a Randomized Block Design with two replications. In a replication, each family was represented by a row of 20 plants for each genotype. Recommended cultivation practices were followed for raising F_3 progenies. The observations *viz.,* Plant height, Productive tillers, panicle length, Filled grains, 100-grain weight, days to 70% relative water content, leaf rolling, leaf drying, Chlorophyll stability index, Root Length, Dry root weight, Root volume, Root-shoot ratio, Harvest index and grain yield per plant were recorded on five randomly selected single plants from each family in each replication.

Data analysis

The Phenotypic and Genotypic coefficient of variations were calculated based on the methods advocated by Burton (1952). Heritability in broad sense was calculated using the following formula advocated by Lush (1940) and expressed in percentage. The heritability percent was categorized as suggested by Robinson *et al*. (1949). Genetic advance and also as percent of mean was estimated by the method formulated by Johnson *et al*. (1955).

Unit analysis

The estimates of mean, standard deviation and coefficient of variation were computed for the parents and cross combinations in respect of all the plant traits taken up for the study adopting the statistical methods suggested by Panse and Sukhatme (1964). The range of coefficient of variation was categorized as suggested by Sivasubramanian and Madhava Menon (1973) i.e., Less than 10 per cent low, 10-20 per cent moderate and more than 20 and above high.

Phenotypic and Genotypic variance

According to Goulden (1952), the variance existing in F_2 and F_3 progenies is considered as phenotypic variance whereas the variance existing in parents is considered as environmental variance. Therefore, genotypic variance is calculated by subtracting the environmental variance from the phenotypic variance. The average of phenotypic variance of the parents involved in that particular cross was taken as the environmental variance (Empig *et al*., 1970).

PCV and GCV were calculated based on the methods advocated by Burton (1952).

$$PCV = \frac{(\text{Phenotypic variance})^{1/2}}{\text{Mean}} \times 100$$

Heritability in broad sense was calculated using the following formula advocated by Lush (1940) and expressed in percentage.

$$GCV = \frac{(\text{Genotypic variance})^{1/2}}{\text{Mean}} \times 100$$

The heritability percent was categorized as suggested by Robinson *et al*. (1949).

Rating	Heritability (percentage)
Low	0-30 per cent
Moderate	31-60 per cent
High	Above 60 per cent

Genetic advance was estimated by the method formulated by Johnson *et al*. (1955)

$$\text{Genetic advance} = \frac{\text{Genotypic variance}}{\text{Phenotypic standard deviation}} \times K$$

Where

K = Selection differential (at 5 per cent selection intensity),

K = 2.06, (Falconer, 1967)

Genetic advance (GA) was also expressed as percentage of mean.

$$\text{GA as per cent of mean} = \frac{\text{Genetic Advance}}{\text{Grand Mean}} \times 100$$

The genetic advance as percent of mean was categorized as suggested by Johnson *et al*. (1955)

Rating	Genetic advance (percentage)
Low	Less than 10 per cent
Moderate	10 – 20 per cent
High	More than 20 per cent

RESULT AND DISCUSSION

Mean and variability

Among the 10 crosses studied in F_3 generation cross 7 registered the widest range of variability followed by crosses 3, 9, 8, 2, 4, 10, 6 and 5. The mean for plant height in F_3 generation was ranged from 92.41cm (cross 3) and 68.19cm (cross 7). The GV and PV were higher in F_3 for all the crosses except cross 7. The PCV and GCV estimated for this trait were also higher in F_3 generation for all the crosses. The heritability estimated for plant height was ranged from 99.17(cross 7) to 17.03 (cross 2). The genetic advance (GA) as per cent of mean ranged from 25.64 (cross 7) and 1.01 (cross 2). High heritability with moderate genetic advance as per cent of mean in cross 5 and high heritability with low genetic advance as per cent of mean in crosses 9, 10, 6, 8 and 1 were recorded (Table 2). Knowledge on nature and magnitude of genotypic and phenotypic variability present in any crop species plays an important role in formulating successful breeding programme (Allard 1960). In case, the variability is very much limited due to continued selection, it is warranted to plan for recombination breeding programme for further genetic amelioration (Bharadwaj *et al*., 2007). The estimate of genetic variability (GCV and PCV) helps to select potential cross. A genotypic coefficient of variation measures the range of genetic diversity in traits and enables them to have a comparison of genetic variability in the quantitative traits (Allard, 1960). Garner (1972) reported that the expression of crosses in the advanced generation, following selection would depend upon the mean and genetic variation created in the population.

Cross 4 in F_3 generation revealed a wide range of variability for number of productive tillers per plant. The mean ranged from 24.80 (cross 10) and 9.80(cross 8). The GV and PV were maximum in cross

Table 2: Range, mean and variability parameters for plant height in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range (cm)	78.50-92.45	80.60-97.35	90.60-110.26	86.20-100.35	65.70-74.43	67.40-78.56	74.90-98.26	73.10-91.32	80.21-99.36	82.70-94.41
Mean (cm)	80.21	82.44	92.41	89.87	68.95	70.75	68.19	78.13	82.16	84.67
CV (%)	2.18	2.48	2.22	3.83	5.93	4.72	10.31	4.55	2.20	2.64
PV	4.45	5.68	5.77	17.45	21.35	16.59	73.26	12.61	0.90	7.23
GV	2.94	0.9	2.75	7.492	15.97	13.92	72.65	9.19	0.84	6.12
PCV (%)	2.63	2.89	2.60	4.64	6.70	5.75	12.55	4.54	1.15	3.17
GCV (%)	2.13	1.19	1.79	3.04	5.79	5.27	12.50	3.88	1.12	2.92
Heritability (%)	66.07	17.03	47.60	42.93	74.79	83.91	99.17	72.88	93.74	84.64
Genetic advance	2.87	0.83	2.35	3.69	7.12	7.04	17.48	5.33	1.83	4.69
Genetic advance as per cent of mean	3.58	1.01	2.55	4.11	10.32	9.95	25.64	6.82	2.23	5.53

Table 3: Range, mean and variability parameters for Productive tillers/plant in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range	12.80-17.65	19.40-26.30	10.80-18.80	16.30-28.20	11.70-20.90	18.50-25.51	17.40-26.80	7.30-15.20	19.00-26.60	23.20-27.34
Mean	13.73	20.93	14.10	23.10	14.90	17.91	19.53	9.80	22.10	24.80
CV (%)	13.19	6.58	18.48	22.06	22.78	20.06	10.39	17.89	12.38	5.10
PV	4.90	0.19	10.00	37.51	16.96	17.84	6.16	4.01	11.14	2.32
GV	3.80	0.16	6.00	17.26	14.40	17.15	5.06	1.76	3.30	1.68
PCV (%)	16.13	2.09	22.43	26.51	27.64	23.59	12.71	20.42	15.10	6.14
GCV (%)	14.20	1.93	17.37	17.98	25.47	23.12	11.52	13.52	8.22	5.23
Heritability (%)	77.51	85.73	60.00	46.01	84.91	96.09	82.11	43.82	29.62	72.40
Genetic advance	3.54	0.77	3.91	5.80	7.20	8.36	4.20	1.81	2.04	2.27
Genetic advance as per cent of mean	25.76	3.68	27.72	25.13	48.34	46.69	21.51	18.43	9.22	9.16

4 (17.26, 37.51) in F_3 generation. The GCV ranged between 25.47 (highest) in cross 5 and 1.93(lowest) in cross 2 in the F_3 generation. The PCV ranged between 27.64 (cross 5) and 2.09 (cross 2).In F_3, the heritability estimates ranged from 96.09 (cross 6) to 29.62 (cross 9). The GA as percent of mean ranged from 48.34 (cross 5) to 3.68 (cross 2). High heritability with low genetic advance as percent of mean in crosses 10 and 2 were recorded (Table 3). The increase in the 100 grain weight in F_3 might be due to persistence of heterozygosity and expression of hidden genes in F_2. The PCV and GCV values were also low in most of the characters in F_3 generations. The low variability might be due to the involvement of short duration parents which yielded early segregants in a large measure. Similar results were observed for this estimates by Sivasubramanian and Menon (1973), in F_2 and F_3 generations of rice.

Table 4: Range, mean and variability parameters for Panicle length in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range (cm)	18.60-23.50	17.30-24.50	17.30-23.20	18.30-26.10	17.50-24.40	23.90-28.40	20.40-28.70	18.20-23.30	20.48-26.30	20.40-26.70
Mean (cm)	20.05	22.05	19.05	24.55	19.50	26.23	22.48	20.03	24.78	23.13
CV (%)	6.07	8.29	8.89	6.66	11.05	5.97	6.63	8.70	5.18	11.41
PV	0.61	1.37	0.93	2.89	1.85	3.31	1.02	4.45	0.37	10.08
GV	0.61	0.88	0.77	2.40	1.04	1.75	0.30	2.05	0.35	2.52
PCV (%)	3.88	5.31	5.05	6.92	6.98	6.94	4.50	10.54	2.46	13.73
GCV (%)	3.88	4.25	4.59	6.31	5.23	5.04	2.44	7.15	2.39	6.87
Heritability (%)	99.99	64.21	82.68	83.05	56.20	52.83	29.33	46.04	93.97	25.00
Genetic advance	1.60	1.55	1.64	2.91	1.58	1.98	0.61	2.00	1.18	1.64
Genetic advance as per cent of mean	7.99	7.02	8.60	11.85	8.08	7.55	2.72	9.99	4.77	7.07

Table 5: Range, mean and variability parameters for Filled grains/panicle in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range	149.73-173.54	160.26-185.78	85.92-110.92	162.54-211.54	134.66-156.28	173.42-200.15	178.69-211.53	159.93-175.23	184.81-210.32	181.42-211.21
Mean	154.08	152.66	89.75	174.66	118.95	177.91	177.08	161.84	189.70	192.75
CV (%)	4.19	1.45	5.08	8.30	4.18	9.81	10.40	1.44	3.00	7.32
PV	46.84	4.82	27.60	294.45	33.46	428.00	426.57	3.97	46.36	273.13
GV	20.75	3.66	9.36	261.34	29.19	344.82	206.21	1.77	43.31	213.29
PCV (%)	4.44	1.44	5.85	9.82	4.86	11.63	11.66	1.23	3.59	8.57
GCV (%)	2.96	1.25	3.41	9.26	4.54	10.44	8.11	0.82	3.47	7.58
Heritability (%)	44.30	76.01	33.93	88.76	87.24	80.57	48.34	44.63	93.43	78.09
Genetic advance	6.25	3.44	3.67	31.37	10.40	34.34	20.57	1.83	13.10	26.59
Genetic advance as per cent of mean	4.05	2.25	4.09	17.96	8.74	19.30	11.61	1.13	6.91	13.79

Panicle length revealed a wide range of variability in cross 7. The mean for this trait ranged from 24.78 (cross 9) to 19.05 cm (cross 3). Cross 10 recorded maximum GV (2.52) and PV (10.08). The PCV ranged between 13.73 (cross 10) and 2.46 (cross 9). The heritability estimates ranged from 99.99 (cross 1) to 25.00 (cross 10) (Table 4). The crosses showed low magnitude of variability in F_3 generation under study. The findings of Manickavelu *et al*. (2006) revealed low variability with low genetic advance for plant height in F_3 generation which is similar to the findings of the current investigation. The findings of Nandeshwar *et al.* (2010) revealed moderate heritability for plant height in F_2 generation of rice genotypes which is similar to the present findings.

Among the 10 crosses studied, cross 10 revealed

Table 6: Range, mean and variability parameters for 100 grain weight in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range (g)	2.24-3.86	1.62-3.54	1.12-3.10	1.78-3.63	1.71-4.01	1.65-3.68	1.93-4.01	2.07-3.52	2.65-3.75	1.95-4.02
Mean (g)	2.65	1.96	1.87	3.17	3.22	2.34	2.78	2.66	3.05	3.19
CV (%)	15.70	20.93	50.44	11.85	17.90	40.17	35.03	25.75	16.75	31.08
PV	0.26	0.19	1.23	0.04	0.39	1.12	1.35	0.67	0.34	1.36
GV	0.22	0.13	0.98	0.03	0.31	0.61	1.27	0.55	0.25	1.20
PCV (%)	19.13	22.31	59.11	6.08	19.39	45.18	41.86	30.74	18.99	36.61
GCV (%)	17.73	18.65	52.87	5.53	17.25	33.31	40.54	27.88	16.35	34.28
Heritability (%)	85.90	69.88	80.00	82.70	79.13	54.36	93.79	82.24	74.11	87.68
Genetic advance	0.90	0.63	1.82	0.33	1.02	1.19	2.25	1.39	0.89	2.11
Genetic advance as per cent of mean	33.86	32.12	97.41	10.35	31.61	50.60	80.88	52.08	29.00	66.13

Table 7: Range, mean and variability parameters for Spikelet fertility in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range (%)	65.23-82.57	70.11-84.58	58.92-72.35	71.73-88.56	65.47-74.54	82.15-91.26	85.17-94.36	62.82-74.04	76.31-88.54	74.17-89.63
Mean (%)	67.76	72.22	60.39	78.98	68.61	78.08	80.20	66.34	80.23	82.63
CV (%)	2.78	2.69	2.41	11.02	4.03	3.85	8.83	3.93	3.50	7.93
PV	4.12	5.65	3.06	112.77	10.26	10.60	73.19	6.64	3.74	47.42
GV	3.61	3.62	1.20	102.88	10.21	8.90	47.38	5.97	1.13	45.32
PCV (%)	3.00	3.29	2.90	13.45	4.67	4.17	10.67	3.88	2.41	8.33
GCV (%)	2.80	2.63	1.81	12.84	4.66	3.82	8.58	3.68	1.32	8.15
Heritability (%)	87.45	64.09	39.16	91.23	99.52	83.93	64.74	89.90	30.14	95.56
Genetic advance	3.66	3.14	1.41	19.96	6.57	5.63	11.41	4.77	1.20	13.56
Genetic advance as per cent of mean	5.40	4.35	2.34	25.27	9.57	7.21	14.23	7.19	1.50	16.41

a wide range of variability for filled grains per panicle. The mean ranged from 192.75 (cross 10) to 89.75 (cross 3). The PCV and GCV estimated for this trait in F_3 generation, the GCV ranged from 9.26 (cross 4) to 0.82 (cross 8). The PCV ranged between 11.66 (cross 7) and 1.23 (cross 8). The crosses 5 and 6 recorded high variability in F_3 as shown by the PCV and GCV values which were more than 20 per cent. The number of productive tillers per plant exhibited high variability in F_3 generation as reported by Anbanandan *et al*. (2009) in rice genotypes. Moderate variability for this trait was registered by the crosses 1 and 7 and low magnitude of PCV and GCV were recorded by cross 10. These results were in accordance with the findings of Shivani and Reddy (2000), Suresh and Reddy (2002) for moderate variability in rice genotypes. Interestingly, the crosses 3, 4 and 8 had high PCV values but the GCV values were in

Table 8: Range, mean and variability parameters for Days to 70% RWC in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range (%)	82.18-92.45	86.53-94.43	83.41-88.21	84.56-92.77	82.27-94.35	85.25-95.26	81.87-92.36	86.28-93.64	81.26-91.25	89.63-94.43
Mean (%)	90.19	88.99	85.48	87.18	92.62	92.93	89.25	88.87	88.98	90.74
CV (%)	2.50	2.29	2.41	3.00	1.91	2.22	2.62	2.86	1.94	1.31
PV	5.57	4.27	1.79	6.54	1.23	1.12	5.98	9.09	1.16	1.96
GV	5.02	4.26	1.34	5.61	0.85	0.61	5.44	9.06	0.85	0.09
PCV (%)	2.62	2.32	1.57	2.93	1.20	2.06	2.74	3.39	1.21	1.54
GCV (%)	2.48	2.32	1.36	2.72	0.99	2.02	2.61	3.39	1.03	0.33
Heritability (%)	90.08	99.91	75.03	85.84	68.84	96.68	90.96	99.61	73.29	4.68
Genetic advance	4.38	4.25	2.07	4.52	1.57	1.19	4.58	6.19	1.62	0.14
Genetic advance as per cent of mean	4.86	4.78	2.42	5.19	1.70	4.09	5.14	6.96	1.82	0.15

Table 9: Range, mean and variability parameters for Leaf rolling in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range	1.80-5.10	2.40-9.20	3.20-7.00	1.20-5.80	4.20-8.40	1.20-4.80	2.80-7.20	2.20-5.00	2.40-5.60	2.40-4.80
Mean	2.53	7.90	5.65	3.30	7.05	2.60	5.85	3.75	4.75	3.75
CV (%)	24.92	14.69	25.75	59.89	19.84	42.13	17.52	31.51	20.16	30.60
PV	0.58	1.30	0.05	5.78	0.73	1.78	1.53	1.49	1.25	1.93
GV	0.52	1.26	0.04	3.22	0.48	0.78	0.72	1.40	0.44	1.68
PCV (%)	30.23	14.43	3.96	72.85	12.12	51.31	21.14	32.55	23.54	37.05
GCV (%)	28.56	14.21	3.54	54.38	9.83	33.97	14.50	31.55	13.96	34.56
Heritability (%)	89.27	96.92	79.97	55.71	65.75	43.82	47.06	93.96	35.20	87.05
Genetic advance	1.40	2.28	0.37	2.76	1.16	1.20	1.20	2.36	0.81	2.49
Genetic advance as per cent of mean	55.59	28.82	6.52	83.61	16.42	46.32	20.50	63.00	17.07	66.43

moderate magnitude. (Table 5)

Low variability for number of filled grains per panicle was recorded by Vanniarajan *et al.* (1996) in F_4 generation and Abdus Salam Khan *et al.* (2009) in rice genotypes. Whereas, moderate variability was observed by Kole *et al*. (2008) in M_4 generation. Among the crosses studied in F_2 generation the cross 25 recorded the higher value of variability for number of filled grains per panicle. The findings of Ahmed Mustafa and Yassir Elsheik (2007) in rice genotypes revealed high variability for number of filled grains per panicle.

In F_3, cross 5 recorded the highest mean value (3.22 g) and the lowest of 1.87 g was observed in cross 3 for 100 grain weight. The coefficient of variability ranged from 50.44 (cross 3) to 11.85 (cross 4). In F_3 generation, cross 7 recorded maximum GV (1.27) and cross 10 maximum PV (1.36). The PCV

Table 10: Range, mean and variability parameters for Leaf drying in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range	2.80-5.80	1.20-3.80	4.80-7.80	1.60-4.40	0.80-3.80	1.80-5.80	1.80-3.80	3.40-7.20	1.40-4.20	2.40-6.80
Mean	5.35	1.80	6.55	1.25	2.05	1.60	2.20	6.15	1.60	1.00
CV (%)	8.29	39.54	13.28	64.50	65.87	56.83	19.64	12.56	51.03	63.25
PV	0.29	0.58	0.73	0.85	2.33	1.16	0.20	0.65	0.50	0.58
GV	0.20	0.42	0.48	0.36	2.08	0.80	0.16	0.56	0.14	0.42
PCV (%)	10.07	42.31	13.04	73.76	74.46	67.31	20.33	13.11	44.19	76.16
GCV (%)	8.36	36.00	10.58	48.00	70.35	55.90	18.18	12.17	23.39	64.81
Heritability (%)	68.96	72.41	65.75	42.35	89.27	68.97	80.00	86.16	28.00	72.41
Genetic advance	0.77	1.14	1.16	0.80	2.81	1.53	0.74	1.43	0.41	1.14
Genetic advance as per cent of mean	14.30	63.11	17.67	64.35	136.93	95.63	33.50	23.27	25.49	113.61

Table 11: Range, mean and variability parameters for Chlorophyll stability index in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range (%)	85.47-92.29	78.59-95.68	85.12-95.08	82.55-94.32	83.35-90.18	71.06-92.36	88.97-95.93	87.48-94.91	85.41-90.90	81.43-90.05
Mean (%)	96.85	93.91	93.12	92.30	85.89	90.45	91.74	92.87	87.52	84.52
CV (%)	1.25	1.43	2.41	2.33	2.64	2.00	3.45	2.03	2.72	2.81
PV	1.75	2.59	7.05	6.69	7.67	4.80	12.88	5.25	3.48	6.17
GV	1.74	1.39	4.71	4.77	6.55	1.79	10.84	2.61	1.87	5.87
PCV (%)	1.37	1.71	2.85	2.80	3.22	2.42	3.91	2.47	2.13	2.94
GCV (%)	1.36	1.25	2.33	2.37	2.98	1.48	3.59	1.74	1.56	2.87
Heritability (%)	99.55	53.43	66.81	71.33	85.33	37.23	84.14	49.74	53.75	95.09
Genetic advance	2.71	1.77	3.66	3.80	4.87	1.68	6.22	2.35	2.06	4.87
Genetic advance as per cent of mean	2.80	1.89	3.93	4.12	5.67	1.86	6.78	2.53	2.36	5.76

and GCV estimated for this trait, GCV ranged from 52.87 (cross 3) to 5.53 (cross 4). In F_3, the PCV was recorded between 59.11 (cross 3) and 6.08 (cross 4). The heritability estimate was moderate to high, it ranged from 93.79 (cross 7) to 54.36 (cross 6). The genetic advance as per cent of mean ranged from moderate (10.35) and high (97.41) in F_3 generation of all the ten crosses (Table 6). The characters exhibited moderate phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) values, are likely to allow reasonable scope of improvement through selection in respective environment owing to their moderate genetic variability (Garg *et al*. 2011, Tiwari *et al*. 2011).

High variability was observed for 100 grain weight in F_3 of the crosses *viz*., 3 and 6. The PCV and GCV values were more

Table 12: Range, mean and variability parameters for Root length in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range (cm)	21.37-27.63	18.47-28.32	20.20-25.34	18.54-24.82	16.63-23.53	16.21-27.23	21.59-27.36	19.13-26.37	18.49-25.34	18.23-25.68
Mean (cm)	26.15	26.95	23.74	23.79	18.52	17.85	25.99	24.59	20.71	19.56
CV (%)	3.97	5.02	7.65	4.03	9.80	7.04	5.09	7.33	10.39	7.46
PV	1.28	2.57	4.52	0.97	4.55	1.56	0.15	1.72	6.85	3.13
GV	0.79	2.56	1.99	0.93	4.54	1.50	0.15	1.26	4.78	2.78
PCV (%)	4.33	5.95	8.95	4.15	11.52	7.00	1.49	5.33	12.64	9.04
GCV (%)	3.40	5.93	5.94	4.05	11.50	6.86	1.48	4.57	10.56	8.52
Heritability (%)	61.76	99.47	44.02	95.46	99.66	96.00	99.02	73.44	69.74	88.87
Genetic advance	1.44	3.29	1.93	1.94	4.38	2.47	0.79	1.98	3.76	3.24
Genetic advance as per cent of mean	5.51	12.19	8.12	8.16	23.66	13.85	3.03	8.06	18.16	16.55

Table 13: Range, mean and variability parameters for Dry root weight in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range (g)	1.11-3.09	1.73-3.75	1.95-3.21	1.83-4.02	1.95-3.20	1.92-3.62	1.41-3.41	1.86-3.79	1.86-3.45	2.05-3.43
Mean (g)	2.52	2.13	2.50	3.05	2.63	2.66	2.63	2.76	2.61	2.45
CV (%)	17.00	20.90	21.00	31.73	22.62	26.64	20.79	28.74	25.02	26.93
PV	0.22	0.21	0.40	1.17	0.50	0.32	0.28	0.44	0.33	0.41
GV	0.19	0.16	0.03	1.11	0.49	0.27	0.20	0.42	0.32	0.06
PCV (%)	18.51	21.77	25.26	35.51	26.80	21.29	20.12	23.97	22.15	26.04
GCV (%)	17.39	19.02	6.36	34.62	26.53	19.62	16.83	23.47	21.82	9.78
Heritability (%)	88.24	76.39	6.34	95.07	97.98	84.91	69.97	95.83	97.00	14.10
Genetic advance	0.85	0.73	0.08	2.12	1.42	0.99	0.76	1.31	1.15	0.19
Genetic advance as per cent of mean	33.65	34.25	3.30	69.54	54.10	37.23	29.01	47.32	44.27	7.56

than 20 per cent. These are in agreement with the findings of Sao and Motiramani (2004) for high variability; Ananda Kumar and Indubala (2005), Sanjeev Kumar *et al*. (2005) for moderate variability in F_2 generation of rice. The moderate variability was observed in the crosses 1, 5 and 8 of F_3 generation as reported by Sanjeev Kumar *et al*. (2005) in F_2 generation of rice. Among the cross combinations cross 25 in F_2 and cross 3 in F_3 generation recorded higher variability for 100 grain weight which is in agreement with the findings of Sabesan *et al*. (2009) in rice genotypes.

Cross 10 recorded the highest mean value (82.63%) and the lowest was observed in cross 3 (60.39%) for the trait Spikelet fertility. A high trend of coefficient of variability was recorded for this trait in all the crosses for F_3 and it ranged from

Table 14: Range, mean and variability parameters for Root volume in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range (cc)	18.35-25.17	6.54-13.41	14.68-22.84	7.72-18.69	8.32-14.25	10.23-22.11	9.25-18.32	18.05-24.08	10.23-16.56	14.17-22.29
Mean (cc)	23.53	9.67	21.08	15.03	11.28	8.34	11.51	20.38	12.28	20.95
CV (%)	7.99	30.15	6.59	17.57	21.64	16.56	19.20	8.48	11.67	9.17
PV	5.15	9.49	0.57	8.04	5.63	2.74	7.18	3.29	1.89	4.50
GV	4.68	9.13	0.44	6.21	5.63	0.40	4.41	2.89	1.30	2.08
PCV (%)	9.64	31.85	3.59	18.87	21.03	19.85	23.28	8.90	11.18	10.12
GCV (%)	9.19	31.23	3.14	16.58	21.03	7.55	18.24	8.33	9.29	6.88
Heritability (%)	90.89	96.14	76.68	77.18	0.00	14.47	61.41	87.74	68.97	46.25
Genetic advance	4.25	6.10	1.19	4.51	4.89	0.49	3.39	3.28	1.95	2.02
Genetic advance as per cent of mean	18.05	63.09	5.67	30.00	43.31	5.92	29.45	16.08	15.89	9.64

Table 15: Range, mean and variability parameters for Root/shoot ratio in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range	0.02-0.10	0.05-0.14	0.02-0.14	0.08-0.18	0.06-0.15	0.14-0.27	0.08-0.21	0.02-0.17	0.10-0.19	0.11-0.22
Mean	0.08	0.07	0.05	0.13	0.09	0.12	0.08	0.05	0.10	0.10
CV%	22.04	30.58	47.62	33.63	39.54	21.28	36.19	57.97	35.95	25.66
PV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PCV	26.60	34.48	47.62	34.41	42.31	15.34	44.12	70.61	37.95	20.11
GCV	18.25	33.79	46.66	33.47	36.00	14.74	32.07	63.16	36.46	13.80
Heritability (%)	47.06	96.00	96.00	94.59	72.41	92.31	52.83	80.00	92.31	47.06
Genetic advance	0.00	0.07	0.07	0.09	0.07	0.00	0.07	0.07	0.07	0.00
Genetic advance as per cent of mean	25.79	68.19	94.17	67.05	63.12	29.17	48.02	116.37	72.17	19.50

11.02 (cross 14) to 2.41 (cross3). The estimates of PCV and GCV were also high in F_3 generation. The heritability estimates for this trait was ranged from 19.96 (cross 4) to 1.14 (cross 3). The Genetic advance as per cent of mean ranged between 25.27 (cross 4) and 1.50 (cross 9). In F3, high heritability with moderate genetic advance as percent of mean in crosses 7 and 9 and high heritability with high GA as percent of mean in cross 4 and high heritability with low genetic advance as per cent of mean in crosses 5, 8, 1, 7 and 2 (Table 7).

For the trait spikelet fertility, low magnitude of variability was recorded by all the crosses of F_2 and F_3(less than 10 per cent) except the cross 4 which showed moderate variability in F_3 generation. None of the crosses showed high variability for this trait under study. Similar results were reported by Kole *et al*. (2008) in rice

Table 16: Range, mean and variability parameters for Harvest index in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range	0.38-0.54	0.46-0.62	0.24-0.32	0.51-0.67	0.45-0.54	0.49-0.62	0.48-0.60	0.52-0.64	0.48-0.60	0.44-0.62
Mean	0.49	0.57	0.26	0.59	0.48	0.54	0.56	0.59	0.52	0.47
CV%	11.17	8.73	6.63	12.15	6.19	10.85	6.52	8.55	10.99	13.23
PV	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
GV	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
PCV	13.20	10.69	7.00	13.85	3.74	10.66	7.99	8.55	12.83	12.88
GCV	11.12	9.28	6.73	13.83	3.59	7.59	7.14	8.37	8.49	12.83
Heritability (%)	71.01	75.34	92.32	99.62	92.33	50.77	80.00	96.00	43.82	99.31
Genetic advance	0.10	0.10	0.00	0.17	0.00	0.08	0.09	0.09	0.07	0.13
Genetic advance as per cent of mean	19.30	16.60	13.31	28.43	7.11	11.15	13.16	16.90	11.58	26.35

Table 17: Range, mean and variability parameters for Grain yield/plant in F_3 generation

Crosses	Cross 1	Cross 2	Cross 3	Cross 4	Cross 5	Cross 6	Cross 7	Cross 8	Cross 9	Cross 10
Range (g)	39.81-47.26	49.37-57.41	18.52-28.37	50.57-58.26	40.11-46.67	54.34-62.39	59.74-66.59	22.47-30.70	57.38-64.38	60.28-68.41
Mean (g)	44.89	51.20	20.29	52.21	42.31	59.40	62.78	24.53	59.62	67.67
CV (%)	4.20	3.30	7.64	3.01	5.43	3.68	1.39	7.71	3.68	1.43
PV	1.40	2.91	2.71	3.62	2.77	5.35	1.05	5.36	5.94	1.06
GV	1.32	2.76	2.70	1.70	1.85	4.48	1.00	3.98	5.66	0.65
PCV (%)	2.64	3.33	8.12	3.64	3.94	3.89	1.63	9.43	4.09	1.52
GCV (%)	2.56	3.25	8.09	2.50	3.22	3.56	1.59	8.13	3.99	1.19
Heritability (%)	93.91	95.06	99.41	46.99	66.76	83.68	95.07	74.23	95.34	61.40
Genetic advance	2.29	3.34	3.37	1.84	2.29	3.99	2.01	3.54	4.79	1.30
Genetic advance as per cent of mean	5.11	6.52	16.62	3.53	5.41	6.71	3.20	14.43	8.03	1.93

genotypes. All the crosses showed low magnitude of variability for days to 70% relative water content both in F_2 and F_3 generations.

In F_3 generation, cross 5 showed the widest range followed by crosses 3, 5, 10, 2, 7, 4 and 9 for days to 70% relative water content. The mean was ranged from 92.93 (cross 6) to 85.48 (cross 3). The GV and PV were recorded maximum in cross 8(9.06, 9.09). The F_3 revealed higher heritability estimates ranged from 99.91 (cross 2) and 4.68 (cross 10) (Table 8).

The cross 2 (6.80) revealed the widest range of variability for leaf rolling in F_3 generation. The mean was ranged between 7.90 (cross 2) and 2.53 (cross 1). GV and PV were recorded maximum GV (3.22) and PV (5.78) in cross 4. Both GCV and PCV were high in cross 4 (54.38 and 72.85). The heritability estimates was moderate to high in F_3 generation. The F_3 revealed higher heritability estimates and it was between 96.92 (cross 2) and 35.20 (cross 9). (Table 9). In F_3 generation, cross 10 showed the widest range followed by crosses 6 and 8 for the trait leaf drying. The mean for this trait ranged from 6.55 (cross 3) to 1.00(cross 10). The GV and PV were maximum in cross 5 (2.08 and 2.33) (Table10).

Cross 4 in F_3 generation revealed a wide range of variability for the trait Chlorophyll stability index. The mean for this trait ranged from 96.85 (cross 1) to 84.52 (cross 10). The PV values were higher in cross 7 (12.88) which recorded the higher value for this estimate. In F_3, cross 7 (10.84) exerted higher value of GV for this trait. GCV and PCV were high in cross 7 (3.59, 3.91). The heritability estimates ranged from it ranged from 99.55 (cross 1) to 37.23 (cross 6) (Tables 11).

In F_3, cross 2 recorded the highest mean value (26.95 cm) and the lowest at 17.85 cm was observed in cross 6 for root length. The coefficient of variability was low to moderate it ranged from 10.39 (cross 9) and 3.97 (cross 1). In F_3 generation, cross 9 (4.78, 6.85) recorded maximum value for this estimate. The GCV ranged from 12.64 (cross 9) and 11.50 (cross 5) and PCV ranged from 12.64 (cross 9) and 1.49 (cross 7). The heritability estimate was moderate to high, it ranged from 99.66 (cross 5) to 44.02 (cross 3). The genetic advance as per cent of mean ranged from low to high (3.03 to 23.66) in F_3 (Tables 12). Among the F_3 populations, cross 4 revealed the wide range of variability for dry root weight. The mean ranged from 3.05 (cross 4) to 2.13 (cross 2). The maximum

GV and PV were recorded in cross 4 (1.11, 1.17) in F_3.The GCV ranged from 36.88 (cross 21) to 0.40 (cross 10) while in F_3, it was between 34.62 (cross 4) and 6.36 (cross 3). The PCV ranged from 35.51 (cross 4) and 18.51 (cross 1). In F_3 population, it also ranged from low (cross 3) to high (cross 5). The range for GA as per cent of mean was from 69.54 (cross 4) and 3.30(cross 3). In F_3 progenies, GA as per cent of mean was high in crosses 4, 5, 8, 9, 6, 2, 1 and 7 and low in crosses 10 and 3 (Tables 13).

For Root volume in F_3 population, cross 6 revealed the widest range of variability. For F_3, cross 1 showed the highest mean value (23.53) and the lowest value (8.34) was observed in cross 6. The coefficient of variability was high (cross 2(30.15)) to low (cross 3 (6.59)) in F_3 generation. The genotypic variance ranged from 9.13 (cross 2) to 0.40(cross 6) in F_3. Low to high estimates of PCV and GCV were observed for this trait in F_3 progenies. GCV was the highest (31.23) in cross 2 and the lowest (3.14) was in cross 3. In F_3, high estimate of heritability was observed for this trait in all the crosses except crosses 6 and 5 (Tables 14 and 15). The trait root volume showed low variability for most of the crosses in F_3 generation. The variability was high only in the crosses 2 and 5 of F_3 generation. Padmaja *et al.* (2008) also observed high variability in rice genotypes for this trait whereas, the moderate variability was observed in the cross 4 in F_3 generation. In F_3 population, GCV and PCV was ranged from high (cross 4(99.62)) to moderate (cross 9(43.82)) for the trait harvest index (Table 16).

Grain yield/plant

In respect of F_3, cross 10 recorded the highest mean (67.67 g) and the lowest (20.29 g) was observed in cross 3. The coefficient of variability for this trait was low in F_3 (1.39 to 7.71). In F_3, the genotypic variance was generally moderate and it was between 4.48 (cross 6) and 0.65 (cross 10). Moderate values of PCV and GCV were observed in F_3 for this trait and the GCV value ranged from 8.13 (cross 8) to 1.19 (cross 10) (Fig 8a). The characters exhibited moderate phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) values, are likely to allow reasonable scope of improvement through selection in respective environment owing to their moderate genetic variability (Garg *et al*. 2011, Tiwari *et al*. 2011). A high value of heritability was observed in F_3 for the character grain yield/plant in all the ten crosses. Genetic advance as per cent of mean was low in all the crosses except in crosses 8 and 3 (Table 19a). The existence of high variability for grain yield in rice has also been reported earlier by Ahmed Mustafa and Yarsir Elsheikh (2007), Singh *et al*. (2008), Raut *et al*. (2009), Idris *et al*. (2012). The combination of mean, variability, heritability and genetic advance will be useful to make an efficient selection (Sivasubramanian and Madhava Menon, 1973). Johnson *et al*., (1955) suggested that the use of heritability coupled with genetic advance in formulating evaluation suitable for selection procedures.

High heritability along with high genetic advance would indicate an additive gene action in the expression of characters (Johnson *et al.,* 1955). While high heritability with low genetic advance implied a non-additive gene action (Panse, 1957). Heritability denotes the additive genetic variance as per cent of the total variance. The additive portion of the genetic variance reflects degree to which the progenies are likely to resemble the parents (Wright, 1921). Low estimates of GCV and PCV were observed for number of productive tillers per plant and Root/ Shoot ratio indicating little scope of improvement in these traits due to lack of requisite variability. High value of genetic advance as percent of mean together with high heritability for character indicates additive gene action and selection will be rewarding, while as high heritability along with low genetic advance indicating presence of non additive gene action, which epistasis, dominance and genotypic and environment interaction (Tikka *et al.,* 1977). Hence response to selection would be poorer.

In the present study, high heritability combined with low GA as per cent of mean was recorded for number of filled grains per panicle in most of the crosses of F_2 and F_3 generations. Whereas, the cross 25 of F_2 and 4, 7 and 10 of F_3 registered high heritability coupled with moderate genetic advance as per cent of mean. Mass selection procedure can be used to improve this trait (Sathish *et al*. 2004). In $F_{3,}$ the heritability estimates are quite high in all the crosses except the cross 10 which had low heritability combined with low genetic advance. These results are in accordance with the findings of Chandra and Pradhan (2003) in rice varieties.

CONCLUSION

From the above foregoing investigation it could be concluded that the the mean performance alone was taken as the criterion for selection, the cross IR 79128A x KMP 105 performed well compared to other crosses for grain yield per plant in F_3 generations. The estimates of heritability were found with an increasing trend in F_3 generations for productive tillers per plant, panicle length, 100 grain weight, leaf rolling, root length, dry root weight and grain yield per plant. Among the traits, productive tillers per plant (COMS 24A x IR05N496); panicle length (IR 73328A x IR 79200); 100 grain weight (IR 73328A x IR 80402); leaf rolling (COMS 24A x IR 79200); root length (IR 70369A x IR 7925); dry root weight (IR 70369A x IR 7925); grain yield per plant (COMS 14A x IR 80286) had high heritability coupled with high genetic advance as percent of mean. High heritability along with high genetic advance would indicate an additive gene action in the expression of the above characters. When mean, genotypic variability, heritability and genetic advance were taken as the selection criteria, the selection will be effective in COMS 14A x IR 80286, COMS 24A x IR 79200, IR 73328A x IR 80402, IR 79128A x IR 79200 as these crosses exhibited higher mean value and high heritability along with high genetic advance for yield and its attributing traits. The above mentioned cross combinations also showed high to very high mean performance for several other yield components. The superior lines identified for grain yield and other characters may be used as donor parents in hybridization programme for improving the characters for which they showed high mean performance.

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AUTHOR'S CONTRIBUTION

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Studies on Effectiveness and Efficiency of Gamma Rays in Soybean Js-335

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ABSTRACT

The effectiveness and efficiency, yield parameters and statistical analysis for M_2 and M_3 generation of Soybean cultivar JS-335 was studied using gamma rays treatment. Effectiveness and efficiency was recorded at increase for low concentration and decrease for high concentration level. The most of the treatment were exhibited positive and negative shift. The statistical analysis such as high phenotypic coefficient of variation and genotypic co-efficient of variation and high to moderate heritability and high genetic advance as a percentage of mean was recorded for all five characters studied i.e. plant height, number of branches plant^{-1}, number of pod plant^{-1}, 100 seed weight and seed yield plant^{-1} in M_3 generation. This indicated that all these traits where influenced by additive gene action operating in the expression of these traits in M_3 generation and hence help as a criteria for making selection.

Keywords *Soybean, Mutation, Effectiveness, Efficiency, Frequency*

Soybean (*Glycine max* (L.) Merrill) is referred as "Golden bean" and "Miracle crop" of 21st century. It is one of the important oilseed as well as legume crop. It contributes more than 50% to the global production of edible oil. Soybean contains 20% oil and 40% Good quality protein. Soybean protein is rich in all essential amino acids, minerals, salts, vitamin A, B and D; health promoting phytochemicals like isoflavones which protect human body against chronic diseases such as cancer, Osteoporosis, blood pressure, coronary heart disease etc. The soy protein stands unique by supplying all sixteen essential amino acids. Soybean oil is used as edible oil in Indian diet. Hence, soybean referred as "Wonder crop". The soy protein stands unique by supplying all sixteen essential amino acids. Soybean oil is used as edible oil in Indian diet.

Soybean is originated in North Eastern China. It entered in India during 6th century AD. USA, Brazil, China, Argentina and India are the major soybean producing countries in the world. These countries accounts for 90% of the world production. India ranked 5th position with respect to area and production. The largest soybean producing states in India are Madhya Pradesh, Maharashtra and Rajasthan. In India, Maharashtra ranks second in area and production.

The concept of inducing mutation and utilizing them in plant breeding was first given by *Hugo de vries* (1903) for generating variability and achieving the goal of generating new strains of cultivated crop plants. Among the various kinds of irradiation used for producing variation in crop plant, X-ray and gamma rays produce gene mutation more efficiently. Both these are ionizing radiations and have many identical properties, but differing in the form of origin. Gamma rays an ionizing physical mutagen capable of inducing mutation in plants. The present research work was, therefore, undertaken using seeds of soybean cultivar JS-335 subjected to treatment of different doses of gamma rays and hence improve its production.

MATERIALS AND METHODS

Dry healthy and genetically pure seeds of JS-335 were used in this study. Four different lots of soybean seed cultivar JS-335 were made. Every lot was of 500 g seed weight. The three lots of seed were sent to Bhabha Atomic Research Centre, Trombay, for irradiation with three different doses of gamma rays treatment. These seed were treated by three different doses of gamma rays *i.e.* 200 Gy, 250 Gy, 300 Gy (Co^{60} at BARC Trombay, Mumbai) and used for raising M_1 during kharif2017 and individual plant in each treatment were harvested separately. The harvested seed were used to raise M_2 generation in rabi 2017 and (62) mutants were identified.

In *kharif* 2018 all the harvested seed from each (62) mutants of M_2 generation along with 2 checks (MAUS-158 and JS-335) were sown to raise M_3 generation in replicated trial using Randomized Block Design replicated thrice.

Table 1: Frequency of induced mutants in different gamma rays treatments in M_2 generation

Sr. No.	Type of mutation	T_1	T_2	T_3	Total
1.	Chlorophyll Deficient	0.09	0.12	0.17	0.38
2.	Early flowered	0.12	0.15	0.17	0.44
3.	Late flowered	0.06	0.09	0.17	0.32
4.	Early matured	0.06	0.09	0.17	0.32
5.	Late matured	0.09	0.09	0.17	0.35
6.	Dwarf	0.18	0.15	0.25	0.58
7.	Tall	0.15	0.18	0.17	0.5
8.	Root length increased	0.09	0.15	0.17	0.41
9.	100 seed weight above 13 g	0.12	0.15	0.09	0.36
10.	Small leaf	0.12	0.09	0.09	0.3
11..	Wrinkled leaf	0.09	0.06	-	0.15
12.	Viney type	0.06	0.03	-	0.09
13.	Sterile	0.09	-	-	0.09
14.	High yielder	0.15	0.22	0.25	0.62
15.	More pods	0.12	0.22	0.09	0.43
16.	More branched	0.15	0.18	0.25	0.58
Total		1.74	1.97	2.21	5.92

All the parameters were recorded in mean value, phenotypic coefficient and genotypic co-efficient of variation, heritability and genetic advance as per cent of men were used for ANOVA for RBD method.

Mutation frequency was estimated on M_2 plant basis. Mutagenic effectiveness is a measure of the frequency of mutation induced by unit of mutagen, whereas mutagenic efficiency gives an indication of the proportion of mutation in relation to undesirable change like lethality and injury.

RESULTS AND DISCUSSION

Mutation frequency, effectiveness and efficiency

Mutation frequency of each visible mutant in M_2 generation was calculated as suggested by Gaul (1958) and is represented in table 1 and graphically in fig 1. The table revealed that the treatment T_3 induced the highest mutation frequency (2.21%) followed by T_2 (1.97%) and the lowest in T_1 (1.74%). The frequency of mutation was comparable in all the treatments. The present results confirm these earlier reports in

Table-2: Mutagenic efficiency and effectiveness of gamma rays treatments in soybean (*Glycine max* (L.) Merrill)

Sr. No.	Treatments	Per cent Lethality	Per cent mutant 100 M_2 plant^{-1}	Mutagenic efficiency	Mutagenic effective-ness
1.	T_1 (200gy)	5.49	2.58	0.55	0.0081
2.	T_2 (250gy)	6.44	2.75	0.51	0.0074
3.	T_3 (300gy)	7.77	3.05	0.49	0.0071
4.	T4 (Control)	4.12	-	-	-

Table-3 : Effectiveness of gamma rays on yield and contributing traits in soybean (*Glycine max* (L.) Merrill)

Doses of mutagen	Seed yield $plant^{-1}$ (g)	100 seed weight (g)	No. of pod $plant^{-1}$	No. of branches $plant^{-1}$	Plant height (cm)
Generations	M_2	M_2	M_2	M_2	M_2
200 Gy	5.97	12.12	25.62	4.19	41.62
250 Gy	6.97	11.77	35.78	4.95	46.09
300 Gy	6.24	10.94	29.65	4.53	44.21
Control	5.39	12.98	22.00	5.97	55.90

Table 4 : Genetic parameters estimates for different characters in M_3 generation

Parameters	Seed yield $plant^{-1}$ (g)	100 seed weight (g)	No. of pods $plant^{-1}$	No. of branches $plant^{-1}$	Plant height (cm)
GCV (%)	43.37	35.68	44.53	37.18	39.97
PCV (%)	58.30	49.06	63.38	54.90	52.66
Heritability (%)	55.34	52.90	49.37	45.86	57.60
G.A(per cent of mean)	6.89	4.01	30.71	1.64	17.08

soybean (Khan and Tyagi 2010). Das and Kundagrami (2000) observed the chlorophyll mutations in the two varieties of gamma irradiated grass pea and also found that spectrum and frequency increased with increased amount of gamma rays.

The efficiency and effectiveness of mutagens were estimated as suggested by Konzak *et al.* (1965) and are presented in table 2. From the table, it is noticed that T_1 displayed the highest mutagenic efficiency (0.55), while T_3 (0.49) showed the lowest. It was observed that the mutagenic efficiency increased in low doses and decreased in high doses of gamma rays. Among the treatments the utmost mutagenic effectiveness was observed in T_1 (0.0081) followed by T_2 (0.0074), while the lowest was noticed in T_3 (0.0071). Further it was noticed that the mutagenic effectiveness reduced with the enhance in the dose of gamma radiation. Pavadai *et al.* (2010) observed that increase in effectiveness and efficiency in low concentration and decrease in high concentration level in soybean. Satpute and Fultambkar (2012) also reported that mutagenic usefulness and efficiency decreased by the increase in concentration of mutagen in two cultivar of soybean (MAUS-158 and JS335).

Mean performance in M_2 generation

The effectiveness of plant breeding programme is depending upon the amount of genetic variability present in the segregating generation. Therefore, for increasing variability in segregating generations, improvements in the quantitative characters have to be made through accumulation of genes affecting their expression in a positive and negative direction. So, in the present experiments, it is observed that the mean for different quantitative characters shifted both in positive and negative direction due to mutagenic treatments. The most of the treatment were exhibited positive and negative shift the maximum values were recorded in 250 Gy gamma rays treatment for M_2 (Table 3). Similar findings were also observed by previous workers in soybean (Dhole *et al*., 2003 and Pavadai, 2006).

Statistical analysis

The present study shows high phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) and high to moderate heritability (h^2) and high genetic advance as a percentage of mean was recorded. In accordance to these results high genotypic coefficient of variation and phenotypic coefficient of variation for number of pod $plant^1$and seed yield $plant^{-1}$ were also reported by Malek *et al.* (2014) and Patil and Sharma (2016), high heritability for yield and yield components were also reported by Pavadai *et al.* (2010) and Patil and Sharma (2016) and high genetic advance as a percentage of mean was also reported by Malek *et al.*(2014) and Pavadai *et al.* (2010) in Soybean.

When all the genetic parameters for nine characters where considered, it was found that Seed yield plant^{-1} and its contributing characters *viz.,* 100 seed weight, number of pods plant^{-1}, number of branches plant^{-1} and plant height exhibited high genotypic and phenotypic coefficient of variation, moderate heritability along with high genetic advance as percentage of mean (Table 4). This indicated that all these traits where influenced by additive gene action operating in the expression of these traits in M_3 generation and hence help as a criteria for making selection.

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Bio-efficacy of Selected Botanicals Against Wilt Disease of Linseed (*Linum usitatissimum L.*)

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ABSTRACT

Bio-efficacy of aqueous extracts of five angiospermic plants belonging to commonly available herbs, shrubs and trees were evaluated against *Fusarium oxysporum* **f. sp.** *lini* **causing wilt disease of linseed(***Linum usitassimum L.).* **All checked the growth of mycelium at all concentration of extracts.** *Eucalyptus globulus* **and** *Phyllanthus nurai* **control the fungal growth from 70 to 90% there existed no correlation between fungitoxicant effect of plant extracts and the type of crop the pathogen infest. The poison food technique was employed for the evaluation of antifungal activity of the extracts at three different concentrations (5% 10%, & 20%) on mycelia growth of pathogen. This study indicates that the botanical extracts could be a good alternative in developing a potent plant based fungicides which can be used in organic farming for the management of** *Fusarium oxysporum* **f. sp.** *lini.* **because chemical fungicides causes serious environmental problems and are toxic to non-target organisms as well. To combat the disease through eco-friendly approach is need of the hour . All the experiments were performed** *in vitro***.**

Keywords *Fusarium oxysporum* f.sp.*lini.*, linseed, Plant extract, Poison food technique, Wilt disease

Linseed (*Linum usitatissimum* L.*)* is a dual purpose rabi crop. In India, it is grown mainly for extracting oil, fiber and medicinal value**.** Linen and paper is made from the fibre. The oil is obtained from seeds and used to produce linoleum flooring and paints. However, recently the importance of flax seed as health promoting food for human and animals has been recognized because of its high omega – 3 fatty acid content (Kislev et al., 2011). The crop is attacked by all classes of pathogens such as fungi, bacteria, viruses and nematodes (Gill 1987). Of these, *Fusarium oxysporum* f. sp. *lini.* Is cause of the most devastating disease of the crop i.e. linseed wilt (Shukla and Kamthan 1996). The bio- efficacy of angiosperms as potent biocontrol agents against phytopathogens is now an established fact. Extracts of such higher plants with specific action have been found effective in controlling several plant diseases (Tiwari et al.2000, Singh and Singh 2007 and Sahni and Saxena, 2009). Hence an attempt has been made to evaluate extract of five angiospermic plants *viz. Agave americana, Eucalyptus globules, Parthenium hysterophorus, Phyllanthus nurai* and *Vernonia cinere* against wilt disease of linseed caused by *Fusarium oxysporum* f.sp. *lini in vitro.*

MATERIALS AND METHODS

The study was conducted to test the bio-efficacy of plant extracts against mycelia growth of *Fusarium oxysporum* f. sp. *lini* causing wilt disease of linseed. The fungi were isolated purified by single spore culture technique and Koach postulates were proved using conventional methods .The inhibition of mycelia growth of the fungi was studied by poision food technique (Nene and Thaplial, 1993) . Different leaves, plant & plant parts were collected from locally available herbs, shrubs and trees as mentioned above and were thoroughly washed with sterilized water. Excess water was soaked off with the help of cheese cloth; 100g of each was macerated to pulp in a warring blender and was mixed with 100ml of sterilized distilled water. This was filtered through Whatman no. 1 filter paper and was centrifuged at 500rpm.

The supernatant was taken and was mixed separately in molten P.D.A. medium in conical flasks to get 5, 10 and 20 percent of leaves extract. Medium amended with extract was sterilized at 15 lbs/psi pressure for 20 min. This was poured in pre sterilized petri dishes and was allowed to solidify for 12 hrs. Each plate was then inoculated with 5mm disc of mycelial culture taken from periphery of 7 days old culture of *Fusarium oxysporum* f. sp. *lini* growing on P.D.A. medium. Inoculated petri dishes were incubated at 25$\pm$ 1^{o}C in a BOD incubator. Colony

Table 1 : Percent inhibition of colony of *Fusarium oxysporum* f. sp. *lini* at different concentrations of water extracts evaluated by food poisoned technique(Y.L. Nene and P.N. Thaplial 1993) *in vitro.*

S.N.	Name of the Plants	Plant 's Parts used for extracts	Percent inhibition of colony of *fusarium oxysporum* f. sp. *lini* at different concentrations of water extracts		
			5%	10%	20%
1	*Agave american*	Leaves	30	40	60
2	*Eucalyptus globulus*	Young twig with flower	40	48	70
3	*Parthenium hysterophorus*	Whole plant arial	29	37	54
4	*Phyllanthus nurai*	Whole plant arial	45	64	90
5	*Vernonia Cinerea*	Whole plant arial	32	45	58

diameter (two diagonals) was measured after 7days of incubation proper control were maintained using plain distilled water instead of leaf extracts. Each experiment was replicated thrice. Percent mycelia inhibition was calculated as per formula (Kaushik and Arora 2002).

$$\text{Percent mycelia inhibition} = \frac{(dc-dt)}{dc} \times 100$$

Where,

dc = mean colony diameter of control set,

dt = mean colony diameter of treatment set.

RESULTS AND DISCUSSION

The perusal of data (Table -1) indicated that all the plant extracts were able to check the growth of wilt pathogens from 54 to 90% at 20% concentration. The percentage of inhibition was directly proportional to the concentration of the aqueous leaf extracts. *Eucalyptus globulus* and *Phyllanthus nurai* exhibited better controlling property than *Agave americana* (AA) *Vernonia cinerea* (VC) and *Parthenium hysterophorus* (PH). Maximum (70 %) growth of the pathogen mycelia growth was checked by E*ucalyptus globulus* (at 20% concentration of extract). *Phyllanthus nurai* inhibited *the* growth of wilt pathogen mycelium at 10% concentration of extracts but it showed 90% of mycelia inhibition at 20% concentration of extract. Similar results were obtained by Gupta et al. (2014). *Agave americana* (AA), *Vernonia cinerea* (VC) and *Parthenium hysterophorus* (PH) controlled 60, 58 and 54 % at 20% concentration of extracts. Somewhat similar results were reported by Sahani and Saxena (2009) in other selected plant extracts. Yadav et al. (2009) reported that F. *oxysporum* f.sp *lini* can be controlled by water extracts of selected botanicals. From the present findings it may be summarized that there existed correlation between the inhibition of fungal growth and the water extract of botanicals. All the extracts which have more than 70% inhibition could be used under field condition. Thus, *Eucalyptus globulus* and *Phyllanthus nurai* could be effective and safe fungitoxicant for pathogen studied. In present investigation all the five plant species experimented against wilt disease of linseed were new records.

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