Bihar Agricultural University, Sabour

Bhagalpur, Bihar (813210)

List of Ph. D. passed out students from the Department of Agronomy

Sl. No.	Name of Students	Title of thesis	Name of Supervisor	Name of external examiner
1	Mr. Akhilesh Sah	Studies on long term effect of integrated nutrient management on crop productivity and soil fertility in rice-wheat cropping system.	Dr. R. P. Sharma	Dr. Vinod Kumar, Professor, R P.C.A.U, Pusa
2	Mr. Santosh Kumar Dubey	Effect of integrated weed management on direct seeded rice.	Dr. Arun Kumar	Dr. K. N. Tiwari, Ex-Dean, CSUAT,, Kanpur
3	Mr. Sunil Kumar Mishra	Effect of tillage and crop establishment practices on productivity, profitability and sustainability of maize based cropping system.	Dr. S. K. Pathak	Dr. Sanjiv Kumar, Pricipal Scientist, ICAR-RCER, Patna
4	Mr. Tej Pratap	Performance of wheat under need based nitrogen management strategies and tillage options using active crop canopy sensor.	Dr. M. Haque	Dr. S. K. Mukhopadhyay, BCKV, Kalyani, W.B.
5	Mr. N. A. Hanuman	Studies on diversification and intensification of rice-wheat cropping system under irrigated condition of Bihar.	Dr. R.P. Sharma	Dr. R. Thakur, Professor,, BAU, Ranchi
6	Ms. Shruti Suman	Impact of chlorophyll meter based nitrogen application in rice (*Oryza sativa*) under different establishment methods.	Dr. Sanjay Kumar	Dr. J.P. Singh, Professor, BHU, Varanasi
7	Mr. Vinod Kumar	Response of mustar (Brassica juncea L.) to tillage practices, doses of sulphur and boron.	Dr. S. Tyagi	Dr. J.P. Singh, Professor, BHU, Varanasi
8	Mr. Asheesh Chaurasiya	Effect of establishment methods and deficit irrigation on productivity of rice cultivars.	Dr. A. K. Singh	Dr. J. S. Mishra, Pricipal Scientist, ICAR-RCER, Patna
9	Mr. Durgesh Singh	Studies of diversification and intensification of traditional rice-wheat cropping system under irrigated condition.	Dr. S. K. Pathak	Dr. I. B. Pandey, Dr. RPCAU, Pusa

Abstract of the above submitted thesis form the department of Agronomy

Title of Thesis	: "Study on long term effect of Integrated Nutrient Management on crop productivity and soil fertility in Rice (*Oryza sativa* L.)-Wheat (*Triticumaestivum* L.) cropping System"
Name of Student	: AKHILESH SAH
Registration No.	: D/Agron/38/BAC/2014-15
Major Advisor	: Dr. R.P.Sharma

ABSTRACT

Rice(*Oryza sativa* L.)– wheat(*Triticumaestivum* L.) cropping system plays a significant role in food security, contributing 76% of total food grain production of India.About 33% of India's rice and 42% of wheat is grown in this rotation.This system is the principal cropping system occupying 24 m ha of cultivated land in the Asian subtropics. In south Asian countries, this system is prevalent in 13.5 m ha in the Indo-Gangetic plain of which 10 m ha lies in India. However, application of imbalanced chemical fertilizers has led to decline of nutrient use efficiency making fertilizer consumption uneconomical and producing adverse effects on environment. Prolonged use of chemical fertilizer hampers the sustainability of crop production and soil fertility. Imbalance use of chemical fertilizer alone tends to decline yield over a period of years with given input. All these factors led to search for alternative sources of plant nutrients.In this circumstances, nutrient recycling in the soil-plant ecosystem through judicious and efficient use of fertilizers and organic manures may play a vital role towards sustainable productive agricultural enterprise.

Thus, keeping in view the above consideration present study was formulated to find out the effectiveness of organic manure i.e. farm yard manure, wheat straw and green manuring with *Sesbaniaaculeata*and their integration with chemical fertilizers on growth and yield of rice, their residual effects on succeeding wheat crop and fertility status of soil.

The experiment entitled "Study on long term effect of Integrated Nutrient Management on crop productivity and soil fertility in Rice (*Oryza sativa* L.)-Wheat (*Triticumaestivum* L.) cropping system" was conducted during *kharif*and*rabi* seasons of 2014-15 and 2015-16 on permanent plot (started in 1984) at Bihar Agricultural College Farm, Sabour.The experiment was conducted in randomized block design with four replications. Treatmentscomprised T_1 : Control *i.e.*no application of any manure/fertilizer to both crops; T_2 : 50% RDF to both crops; T_3 : 50 % RDF to rice followed by 100% RDF to wheat; T_4 : 75% RDF to both crops; T_5 : 100% RDF to both crops; T_6 : 50%N through FYM+50% RDF to rice followed by 100% RDF to wheat; T_7

:25%N through FYM+75% RDF to ricefollowed by 75% RDF to wheat; T_8 : 50%N through wheat straw+50% RDF to rice followed by 100% RDF to wheat; T_9 : 25%N through wheat straw+75% RDF to rice followed by 75% RDF; T_{10} : 50%N through green manure(*Sesbaniaaculeata*)+50% RDF to rice followed by 100% RDF to wheat; T_{11} : 25%N through green manure(*Sesbaniaaculeata*)+75% RDF to rice followed by 75% RDF to wheat and T_{12}: Farmers' practice ($N_{70}P_{30}K_{10}$) to rice followed by ($N_{80}P_{30}K_{15}$) to wheat. The recommended dose of fertilizer for rice was 80 kg N+40 kg P_2O_5+20 kg K_20 ha^{-1} while it was 120 kg N+40 kg P_2O_5+40 kg K_20 $ha^{-1}$for wheat.Rice variety 'Sita' was transplanted at spacing of 15 cm × 15cm using seed rate of 40 kg/hawhereas, wheat variety 'PBW343' was sown 20 cm apart using a seed rate of 100 kg/ha. The soil of the experimental plot at the inception of the experiment during 1984 was well drained, sandy loam in texture, neutral in reaction, low in organic carbon and nitrogen and medium in phosphorus and potassium.

Results revealed that all the growth characters (plant height, number of tillers/m^2, leaf area index, dry matter accumulation, crop growth rate, net assimilation rate, days to 50% flowering, days to maturity) and yield attributes (number of effective tillers/m^2, number of filled grains per panicle/earhead, length of panicle/earhead, weight of panicle/earhead, 1000-grain weight) of both rice and wheat crops were highestunder the treatment T_6(50%N through FYM+50% RDF to rice followed by 100% RDF to wheat). This treatment also gave the highest grainyield of rice (5562 kg/ha) and wheat (4377 kg/ha) as well as net returns (Rs.36,735/ha)and B:C ratio (1.02) in rice and Rs.49,951/haand 1.62 in wheat. The highest rice equivalent yield (12185 kg/ha) and net returns of Rs.86,686/ha was observed in treatment T_6, which was at par with treatment T_8(50%N through wheat straw+50% RDF to rice followed by 100% RDF to wheat) and T_{10} (50%N through green manure(*Sesbaniaaculeata*)+50% RDF to rice followed by 100% RDF to wheat) in terms of all parameters.

Both the crops as well as system removed higher quantity of NPKS, when fertilized with 50% N through FYM+ 50% RDF through inorganic fertilizers in rice followed by 100% RDF in wheat (T_6) but the effect was statistically at par with T_8 and T_{10}.

So far the soil fertility is concerned, considerable improvement was observed. The maximum build-up of soil organic carbon, bulk density, soil aggregation, available NPKS, micronutrients (Fe, Zn, Mn and Cu) and soil microbial count (Bacteria, fungi and actinomycetes) as well as dehydrogenase activitieswere observed in the plots receiving 50% N through FYM+ 50% RDF through fertilizers in rice followed by 100% RDF in wheat.

The 50% substitution of organic manures in rice established its superiority over 25% substitution. Even substitution of 25% N by FYM in rice+75% RDF through

inorganic fertilizers followed by only 75% RDF in wheat performed better than 100% chemical fertilizers applied to both rice and wheat crop.

Based on the findings of the investigation, it may be concluded that farmers may adopt substitution of 50% N either through FYM or wheat straw or green manuring with*Sesbaniaaculeata*+50% RDF through inorganic fertilizer in rice followed by 100% RDF through fertilizers in wheat for improving crop productivity, profitability and maintaining soil fertility of rice-wheat system.

ABSTRACT

Name of the student	**:**	**Santosh kumar Dubey**
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Chairman Advisor Committee	:	Dr. Arun Kumar
Degree Programme	:	Ph.D (Ag.)
Major Subject	:	Agronomy
Minor Subject	:	Soil Science & Agriculture Chemistry
Year	:	2018
Name of the University	:	Bihar Agricultural University, Sabour, Bhagalpur
Title of the thesis	**:**	**Effect of integrated weed management on direct seeded rice (*Oryza sativa* L.)**

A field experiment was carried out during *Kharif* season 2016 and 2017 at Bihar Agricultural College farm, Sabour under the Bihar Agricultural University, Sabour, Bhagalpur to assess the effect of integrated weed management on direct seeded rice (*Oryza sativa* L.). The soil texture of the experimental site was silt loam and was low in available nitrogen (188.61 kg ha^{-1}), and medium in available phosphorus (21.65 kg ha^{-1}) and potassium (194.88 kg ha^{-1}). The experiment was conducted in a randomized block design with fourteen weed management treatments involving various herbicides (Pendimethalin 1000 g a.i. ha^{-1} (PE), Pendimethalin 500 g a.i ha^{-1} (PE) *fb* 1 HW 40 DAS, Almix 4 g ha^{-1} (PoE), Almix 2 g a.i ha^{-1} (PoE) *fb* 1 HW 40 DAS, Ethoxysulfuron 15 g a.i ha^{-1} (PoE), Ethoxysulfuron 7.5 g a.i ha^{-1} (PoE) *fb* 1 HW 40 DAS, Pyrazosulfuran 25 g a.i ha^{-1} (PE), Pyrazosulfuran 12.5 g a.i ha^{-1} (PE) *fb* 1 HW 40 DAS, Bispyribac-Na 30 g a.i ha^{-1} (PoE) , Bispyribac-Na 15 g a.i ha^{-1} *fb* 1 HW 40 DAS (PoE), Azimsulfuron 35 g a.i ha^{-1} (PoE), Azimsulfuron 17.5 g a.i ha^{-1} *fb* 1 HW 40 DAS (PoE), weedy and weed free with three replications.

The crop was infested with divergent type of weed flora e.g. sedges, grassy and broad leaved weeds group. However, dominancy of *Cyperus rotundus*, *Echinochloa colona*, *Echinochloa crusgalli*, *Cynodon dactylon* , *Caesulia axillaries* and *Commellina benghalensis, Eclipta*

alba, Euphorbia hirta and *Phyllanthus niruri* were very less, so they were grouped as other weeds.

Sedges and broad leaved weeds *e.g. Cyperus rotundus*, *Cyperus iria* and *Cyperus difformis* were controlled very effectively by the Ethoxysulfuron and Azimsulfuron as post-emergence and however, Sedges, Grassy weeds and Broad leaved weeds *e.g. Cyperus rotundus*, *Cyperus iria* and *Cyperus difformis* , *Echinochloa colona*, *Echinochloa crusgalli Caesulia axillaries* were controlled very effectively by the Bispyribac-Na as post-emergence. Only Grassy weeds *Echinochloa colona*, *Echinochloa crusgalli* were controlled very effectively by Pendimethalin as pre-emergence.

At 30 days after sowing, Bispyribac-Na 30 g *a.i.* ha^{-1} (T_9) and Azimsulfuron 35 g *a.i.* ha^{-1}(T_{11}) applied as post-emergence being at par, recorded significantly lower density (21.85 and 35.10 m^{-2}) and dry weight (18.02 and 29.42 g m^{-2}) of weeds over rest of the treatments.

At 60 and 90 days after sowing, Bispyribac-Na 15 g *a.i.* ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{10}) and Azimsulfuron 17.5 g *a.i.* ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{12}) each applied as post-emergence with hand weeding at 40 days after sowing being at par, recorded significantly lower population (24.94, 29.72 and 18.91, 22.55 m^{-2}) and dry weight (38.79, 46.24 and 29.12 , 34.72 g m^{-2}) of weeds over the rest of the treatments. While, application of Pendimethalin 1000 g *a.i.* ha^{-1} (T_1) and Pyrazosulfuron 25 g a.i. ha^{-1} (T_7) recorded maximum weed population and dry weight which was at par with each other.

The maximum weed control efficiency was recorded (88.14%) under Bispyribac-Na 15 g a.i. ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{10}) and (85.82%) under Azimsulfuron 17.5 g a.i. ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{12}).

Among herbicides, minimum weed index (1.91%) was recorded under Bispyribac-Na 15 g a.i. ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{10}) and (6.99%) under Azimsulfuron 17.5 g a.i. ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{12}). Whereas, maximum weed index (40.79%) was recorded under Pendimethalin 1000 g a.i. ha^{-1}(T_1) and (34.37%) under Pyrazosulfuran 25 g *a.i.* ha^{-1} (T_7).

Among weed management practices, maximum growth attributes, yield attributes and N, P and K uptake by grain and straw were recorded under Bispyribac-Na 15 g a.i. ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{10}) followed by Azimsulfuron 17.5 g a.i. ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{12}) which was comparable to weed free, but was significantly superior over rest of the treatments. Application of Pendimethalin 1000 g *a.i.* ha^{-1}(T_1) followed by Pyrazosulfuran 25 g *a.i.* ha^{-1} (T_7) was least effective and recorded minimum number of tillers, dry matter accumulation, number of panicles m^{-2}, panicle length, number of grains $panicle^{-1}$, grain and straw yield as compared to other treatments. However, all the herbicidal treatments were found significantly superior over weedy in respect of crop growth, yield attributes, grain and straw yield and N, P, K uptake by grain and straw.

In weed management treatments, higher value of net return (Rs. 85728 and Rs. 79565) and benefit: cost ratio (Rs. 2.67 and Rs. 2.49) was obtained in Bispyribac-Na 15 g a.i. ha^{-1} fb

one hand weeding at 40 days after sowing (T_{10}) and Azimsulfuron 17.5 g a.i. ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{12}), respectively. While weedy (T_{14}) gave the lowest net return (Rs. 28753).and benefit: cost ratio (Rs.0.99).

On the basis of pooled data of the experiment during *kharif* 2016 and 2017, it may be concluded that post-emergence application of Bispyribac-Na 15 g a.i. ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{10}) proved superior over rest of the treatments with respect to weed control efficiency, grain yield and economics of direct seeded rice followed by post-emergence application of Azimsulfuron 17.5 g a.i. ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{12}).

On the basis of conclusion, it may be recommended that post-emergence application of Bispyribac-Na 15 g a.i. ha^{-1} *fb* one hand weeding at 40 days after sowing (T_{10}) in direct seeded rice should be practiced for minimizing weed growth and maximizing economic, yield and net return.

ABSTRACT

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Chairman,advisorycommittee	:	Dr. Sushil Kumar Pathak
Degree Program	:	Ph.D
Major subject	:	Agronomy
Minor subject	:	Soil Science and Agricultural Chemistry
Year	:	2018
Name of the University	:	Bihar Agricultural University, Sabour
Title of the research problem	**:**	**Effect of tillage and crop establishment practices on productivity, profitability and sustainability of maize based cropping systems.**

A field experiment was conducted on Bihar Agricultural College Research Farm, Sabour, Bhagalpur during the *kharif* and *rabi* seasons of 2012-13 and 2013-14. The experiment was laid out in a split plot design with three replications. The treatments comprised of three tillage systems *viz.*conventional tillage, zero tillage and permanent raised bed system in the main plots and six cropping systems *viz.*maize+soybean-wheat, maize-wheat, maize-maize, maize-rapeseed, maize-chickpea and soybean-maizein sub plots. The soil of experimental plots was silty

loam in texture, neutral in reaction, low in organic carbon & nitrogen, medium in available phosphate and potash. Field observations were taken in all crops *viz.kharif* maize, soybean, *rabi* maize, wheat, rapeseed and chickpea in two heads, growth andyield and yield attributes.The observations with similar dimensions were pooled for analysis over the environments of the two cropping seasons. However, the data with varying dimensions over various cropping systems has been interpreted from the mean of two years.

All growth parameters of *kharif*and *rabi* crops *viz.* plant height, dry matter accumulation, leaf area index (LAI) and crop growth rate (CGR) were affected by tillage. Similarly, yield attributes of *kharif* maize, soybean, *rabi*maize, wheat, rapeseed and chickpea were affected by tillage. Total number of weed flora and weed dry matter was found significantly lowerin permanent raised bed and zero tillage over conventional tillage at both 30 and 60 DAS. Significantly higher maize equivalent yield, gross returns, net returns and B:Cratio was recorded in zero tillage and permanent raised bed in comparisonto conventional tillage. Among cropping systems tested,maize-maize cropping system recorded significantly highest gross return and net return while B: C ratio was recorded to be maximum in maize-chickpea cropping system. Significantly highest system energy output, net energy and energy use efficiency were found in permanent raised bed and zero tillage than conventional tillage. Maximum total nutrient uptake of N, P and K was found in, which was significantly higher over the conventional tillage. Among cropping systems, the nutrient uptake was found highest in maize-maize system. So far as fertility status of soil was concerned, there was more build-up of available soil N, P and K in permanent raised bed and zero tillage than conventional tillage.However in cropping systems, maize- chickpea cropping system noted maximumbuild-up of available N, P and K.

On the basis of results of net return, B:C ratio and energy use efficiency obtained during two years of experimentation it can be concluded that,among different tillage systems,permanent raised bed and zero tillage may be advocated over conventional tillage whereas among cropping systems, maize-maize system for maximum system productivity (MEY)& net returnsandmaize - chickpea cropping system for maximum B:C ratio may be preferred. With respect to soil fertility, permanent raised bed and zero tillage may be better option overconventional tillage.

ABSTRACT

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Chairman, Advisory Committee	:	**Dr. Md. Mizanul Haque**
Degree Program	:	Ph.D
Major Subject	:	Agronomy
Minor Subject	:	Soil Science & Agricultural Chemistry
Year	:	2019
Name of the University	:	Bihar Agricultural University, Sabour
Title of the Thesis	:	"**Performance of wheat (*Triticum aestivum* L.) under need based nitrogen management strategies and tillage options using active crop canopy sensor**"

Wheat (*Triticum aestivum* L.) is one of the most important grain crops and is the backbone of the national food security system. The country has witnessed a dramatic increase in wheat production from a mere 2.9 mt in 1964 to all time record 98.38 mt (2016-17). This increase production has mainly come through a net gain in productivity per unit area. In Bihar wheat is growing in an around 2.2 mha and produced 5.5 mt with a productivity of 28 q/ha. The productivity of wheat in Bihar is below the national wheat productivity which creates an opportunity for improving productivity. In order to meet the food demand of the growing population which is expected to reach 1.3 billion by 2020 AD, it is essential to sustain the productivity at a much higher level. The projected demand for wheat by 2020 is 105.0 mt and to achieve is new and innovative production technological approaches are to be explored.

Resource degradation problems are being manifested is several ways like soil health degradation and adverse environmental effect due to global climate change. Decline soil carbon and fertility are affecting soil biodiversity resulting in multiple nutrient deficiencies and above all a decline in factor productivity. Therefore, there is an urgent need for promoting conservation agricultural practices and adoption of precision technologies that can reverse the process of resource degradation. Hence, increased production efficiency and resilience in agriculture is what the need at the current juncture.

In-efficient input (fertilizers) use is a key factor pushing the cost of cultivation and pulling down the profitability in wheat farming. Hence, we must ensure synergy for better synchronization of the demand of crop with nutrients inputs to achieve maximum benefit interms of higher production and input-use-efficiency.

Site specific nutrient management practices (SSNMP) are adopted with due consideration to spatial and temporal variability in order to maximizeproduction and minimize cost of production and environmental damage. Among different management variability, SSNM and soil management are two major concerns.

Nitrogenous fertilizers being basic and widely used nutrients in crop production needs special attention for precision management practices for improving N-use efficiency reducing N losses and environmental pollution.For improving N-use efficiency, reducing N lossesand environmental pollution Precision tools, viz. active canopy sensor and SPAD meter may prove to be beneficial in ecologically sound and economically viable options of wheat production.

Keeping the above facts in consideration, a field experiment entitled "performance of wheat under need based nitrogen managementstrategy and tillage options using active crop canopy sensor." Was carried out with three replications during the year rabi 2014-15 and 2015-16 in BAC, Research Farm Sabour. Two different tillage options (conventional tillage, CT and Zero tillage, ZT) were kept in main –plots and six different nutrient management practices [viz.N_1-Recommended dose of nutrients (150:60:40 kg NPK/ha, full P & K and ½ N at basal +1/2 N in two splitting at 1st & 2nd irrigation- Top dressing after irrigation, N_2-Recommended dose of nutrients (150:60:40 kg NPK/ ha, full P & K and ½ N at basal + ½ N in two splitting at 1st & 2nd irrigation-Top dressing before irrigation, N_3-SSNM Based on Nutrient Expert (NE), N_4-70% N of SSNM based on NE+ remaining N as guided by Green Seeker, N_5 Nitrogen enriched plots (225:60:40 Kg. NPK/ha.) and N_6- SPAD based nutrient management, (75 Kg. N as basal + 25 Kg. N as 1st top dress + 25 Kg. N at 42 SPAD reading) were evaluated in sub plots.

The experimental results revealed that different tillage option could not affect the growth & yield attributes of wheat crops where as, different nutrients management practices significantly influences the several growth and yield attributing characters. Yield opened under conventional tillage practice (43.4 q/ ha. & 45.0 q/ha. During both years) zero tillage practices (41.5 q/ha. & 44.3 q/ha.) were statically alike

Different nutrients management practice and positive influence on growth, yield attributing characters and yield of wheat crops. SSNM based on nutrients expert (70 % N) + remaining N as guided by green-Seeker recorded higher mean wheat grain yield of 45.5 q/ha. and 49.4 q/ha during both years of experimental and was statically at par with the mean grain yield recorded under N_3, N_6 and N1-level of nutrients management. Similarly other growth and yield attributing characters like dry matter at different growth stages, LAI, CGR, effective tillers, spike length, number of grains per spike, HI and test weight followed the same trend. Maximum uptake of N, P and K were recorded under N4 level of nutrients management. Based on N applied in various nutrients management option and observed that the agronomic nutrients management use efficiency was higher (43.33 & 47.03) in the treatments N_4 so far the B:C ratio is concerned the maximum value (2.82 &3.02) is recorded under N_4 treatments and was statistically at par with the B:C ratio under the treatment N_6. Based on the result obtained during both years of experimentation,

it may be concluded that performance of timely sown irrigated wheat crop under conventional and zero tillage condition were found to be statically alike in obtained grain yield of wheat but for economic point of view cultivation of wheat under zero tillage condition was found to be the most economic method of wheat cultivation. Among the different nutrients management practices the 70% N of SSNM based on NE along with Green-Seeker guided N application may prove to be the effective and efficient management practices for resource efficient and cost efficient production of wheat. The result of the present study are promising to suggest that precision N management based on Nutrient Expert tool and Green-Seeker guided N management can potentially improve agronomic economic return from irrigated wheat production system.

ABSTRACT

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Chairman Advisory Committee	:	**Dr. R. P. Sharma**
Degree Program	:	Ph.D.
Major Subject	:	Agronomy
Minor Subject	:	Soil Science & Agricultural Chemistry
Year	:	2019
Name of the University	:	Bihar Agricultural University, Sabour
Title of the Thesis	:	"**Studies on diversification and intensification of rice-wheat cropping system under irrigated condition of Bihar**"

A field experiment entitled "Studies on diversification and intensification of rice-wheat cropping system under irrigated condition of Bihar" was conducted at Bihar Agricultural College, Farm. Sabour**,** Bhagalpur (Bihar) during *Kharif, rabi* and *summer* seasons of 2013-14 and 2014-15. Soil of the experimental field was sandy loam in texture, soil was saline-alkali in reaction (pH 7.48), low organic carbon content (0.53 %), with low available N and medium P_2O_5, K_2O and S (213.25, 23.59, 226.02 and 12.2 kg/ha, respectively). The experiment was laid out in Randomized Block Design with three replications. Total twelve cropping sequences were taken to constitute treatments for different intensification of rice-based cropping system *viz.* Rice –wheat – fallow, rice – maize + potato - maize + cowpea, rice -wheat + fenugreek - mung bean, rice - potato + radish - onion + maize, rice - cabbage + radish - ladyfinger + mung bean, rice – maize + potato - sorghum + cowpea, rice - maize +

rajmash - maize + cowpea, rice - garlic + coriander - maize (grain) + cowpea, rice - wheat (Z.T.) - mung bean (Z.T.), rice - maize (Z.T.) - cluster bean, rice - oat (multi-cut)- pearl millet + rice bean and rice - chick pea + coriander - maize + cowpea. Individual plot was thoroughly prepared in each season to avoid mixing of soil. Cultivation practices were followed as per recommendation. The practice of weeding was applied after recording data on weed population.

The cropping systems followed during the *kharif, rabi* and summer season had significant effect on grain yield of rice, *rabi* and *summer* crops (including intercrops). The highest rice - equivalent yield of 271.09 q ha^{-1}, net return of Rs 1, 28,142 ha^{-1} and additional net return of Rs 48,677 ha^{-1}, was recorded with (T_6) rice (Hybrid JKRH-401) – maize + potato - sorghum + cowpea, closely followed by (T_4) rice (R.Suwasini) - potato + radish - onion + maize, produced rice - equivalent yield of (252.54 q ha^{-1}), net return of (Rs 1, 27,248 ha^{-1}) and additional net return of (Rs 47,783 ha^{-1}). These sequences were significantly superior to all the treatments and generated almost 61.25% and 60.13%, respectively more profit over (T_1) rice – wheat system.

The system productivity of 75.12 rice kg/ha/day and system profitability of Rs. 351.07 ha^{-1}/day) was distinctly highest under the (T_6) rice (Hybrid JKRH-401) – maize + potato - sorghum + cowpea cropping system. Further, this system coupled with higher monetary returns provided more employment to labourers (442 man days ha^{-1} $year^{-1}$) and generated employment by101.66% more than (T_1) rice-wheat cropping system. On the other hand, highest irrigation water use efficiency (45.63 kg/mm), carbohydrate (equivalent) yield (21908 kg/ha) and highest energy output (365555MJ/ha) was recorded under (T_6) rice (Hybrid JKRH-401) – maize + potato - sorghum + cowpea, while, highest energy productivity of 337 g/MJ was obtained in (T_8) rice - garlic + coriander – maize (grain) + cowpea, due to less amount of input energy required. The lowest weed population of 15.52 /m^2, dry matter production of 12.48g/m^2 and highest weed smothering effect of 37.05 % was recorded in (T_6) rice (Hybrid JKRH-401) – maize + potato - sorghum + cowpea, at 60 DAT, which was at par with (T_7) rice (Hybrid JKRH-401) - maize + rajmash - maize + cowpea.

As regards the status of organic carbon, intensification involving green gram as summer crops resulted in marked improvement in soil organic carbon and soil pH from the initial level. Maximum available soil N (219.33kg/ha) and available P_2O_5 (32.90 kg/ha) was recorded under (T_9) rice (R.Mahsuri) -wheat (Z.T.) - mung bean (Z.T.), whereas, highest K_2O (178.60 kg/ha) was recorded in (T_3) rice - wheat + fenugreek - mung bean. Significantly higher total N, P, K uptake was obtained in (T_6) rice (Hybrid JKRH-401) - maize+ potato - sorghum + cowpea, (937.64 kg/ha). The highest net gain of N (7.32 kg/ha) and P_2O_5(10 kg/ha) after two years was observed

in (T_9) rice -wheat (Z.T.) - mung bean (Z.T.) and minimum deficit of K (47.99 kg/ha) was observed with (T_3) rice -wheat + fenugreek - mung bean.

On the basis of the results obtained it may be concluded that farmer with adequate resources can diversify the existing rice – wheat system with (T_6) Rice (Hybrid JKRH-401)- maize + potato - sorghum + cowpea and (T_4) Rice (R.Suwasini) - potato + radish - onion + maize, cropping systems for getting higher productivity, profitability and sustainability.

ABSTRACT

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Degree Programme	:	Ph.D. (Agronomy)
Major Subject	:	Agronomy
Minor Subject	:	Soil Science & Agriculture Chemistry
Year	:	2020
Name of the University	:	Bihar Agricultural University, Sabour
Title of the thesis	**:**	**Impact of chlorophyll meter based nitrogen application in rice (*Oryzasativa* L.) under different establishment methods**

Nitrogen is one of the most limiting fertilizer nutrient for achieving high yield of rice.Urea is the widely used source of fertilizer N for rice crop production in India. The inefficient splitting of N doses and improper application lowers the N use efficiency (NUE)and the crop recovers only 30-40% of applied N. Results from multi location trials have revealed that proper N management may or may not improve the crop yield when compared with farmers' practice but can reduce the N application rate by about 20-25% and hence increases the NUE. Need based N management using SPAD meter not only increases the NUE and yield of rice but also help in maintaining environmental sustainability. With this in view, the present investigation**"Impact of chlorophyll meter based nitrogen application in rice(*Oryzasativa* L.)under different establishment methods"** was carried out during *kharif* seasons of 2016 and 2017 at the research farm of Bihar Agricultural University, Sabour. The experiment with twenty four treatment combinations was laid out in split plot design and replicated thrice. The crop was sown according to the establishment methods i.e. puddled transplanted rice (PTR), unpuddled transplanted rice (UPTR) and direct seeded rice (DSR) in main plots. However, in sub plots, there were five treatments using SPAD thresholds (35.0, 36.5, 38.0, 39.5 and 41.0) as real time N management(RTNM), one fixed time N management (FTNM), one

adjustable dose of nitrogen management (ADNM) using and one control (no fertilizer).Thus there were three main plot and eight subplots.

Results revealed that the direct seeded rice gave better economic yield of rice over the years, among crop establishment methods.The average grain yield over the years under DSR was 10.3% higher than the average grain yield obtained under transplanted rice (PTR and UPTR) and it might be due to the higher fertilizer dose (158 kg ha^{-1}) and good crop establishment in DSR over traditional transplanted system. Among the RTNM, the SPAD 39.5 recorded the maximum grain yield of 57.53 q ha^{-1} (averaged over the years) against the N fertilizer dose of 127.5 kg ha^{-1} (averaged over the years).However it was noted that the treatment SPAD 38.0 recorded the statistically similar grain yield of 53.70 q ha^{-1} and 54.17 q ha^{-1} in the year 2016 and 2017, respectively with SPAD 39.5. The treatment SPAD 38.0 consumed the N fertilizer @ 100 kg N ha^{-1}(averaged over the years) which was 17%, 22% and 33% (averaged over the years) lower than the treatment of FTNM, SPAD 39.5 and SPAD 41.0 respectively. All these above mentioned treatments recorded statistically similar grain yield with SPAD 38.0 in both the years. Although the grain yield recorded under SPAD 39.5 was found maximum, but SPAD 38.0 can be recommended due to lesser consumption of fertilizer in it. It was also noted that the grain yield under FTNM remained at par with SPAD 38.0 in both of the years and SPAD 38.0 saved the fertilizer N by 13.9% and 19.4% in 2016 and 2017, respectively. Hence the RTNM based treatment i.e. SPAD 38.0 performed better than FTNM (the state recommendation using by the farmers was used as FTNM in the study).The N use efficiencies like agronomic N use efficiency (AE_N), partial factor productivity of applied N(PFP_N) and N recovery efficiency (RE_N) varied under the need based N management practices using SPAD meter in both of the years during study. The SPAD 38.0 recorded the highest AE_N in both of the years under RTNM and ADNM treatment where SPAD 38.0 was used as benchmark; also recorded the similar AE_N. Treatments like SPAD 38.0, 39.5, 41.0, FTNM and ADNM maintained good economic yield under different N applications and among these treatments the SPAD 38.0 recorded the highest PFP_N and RE_N during the study. The DSR recorded maximum monetary returns and return/Rs. invested due to higher grain and straw yields of rice crop in both the years as well as lower cost involvement in DSR. The SPAD 39.5 recorded the maximum gross return (Rs.90,808 ha^{-1} and Rs.92,196 ha^{-1} in 2016 and 2017, respectively) which was statistically similar with the SPAD 38.0 having 26% less consumption of N fertilizer over SPAD 39.5 during the study. Hence it can be concluded that SPAD 38.0 may be considered as the optimum SPAD index for long duration high yielding rice cultivar under PTR/DSR in alluvial soil of Indo-Gangetic belt in India.

ABSTRACT

Name of the Student : **Vinod Kumar**

Registration Number : **D/AGRO/42/BAC/2015-16**

Major Advisor	**:**	**Dr. Shashank Tyagi**
Degree Programme	:	Ph.D.
Major Subject	:	Agronomy
Minor Subject	:	Soil Science and Agricultural chemistry
Year	:	2019
Name of the University	:	Bihar Agricultural University, Sabour
Title of Thesis	**:**	**"Response of mustard (*Brassica juncea* L.) to tillage practices, doses of sulphur and boron"**

A field experiment was conducted during *rabi* season of the years 2016-17 and 2017-18 at research farm of Bihar Agricultural College, Sabour, Bhagalpur to assess the response of mustard (*Brassica juncea* L.) to tillage practices, doses of sulphur and boron.

The soil texture of the experimental plot was sandy loam and was low in available nitrogen (230.35 kg ha^{-1}) and phosphorus (23.9 kg ha^{-1}) and medium in available potassium (143.4 kg ha^{-1}), medium in available sulphur (13.26 ppm) and low in available boron (0.44 ppm). The experiment consisted of twenty seven treatment combinations comprising three tillage practices *viz.*, conventional tillage, zero tillage and reduced tillage, whereas three doses of sulphur i.e. 0, 20 and 40 kg ha^{-1} and three doses of boron i.e. 0, 1.0 and 2.0 kg ha^{-1}. The experiment was laid out in split split plot design with three replications.

Growth parameters like plant height, leaf area index and dry matter production per plant was observed highest with conventional tillage except LAI which recorded maximum value with zero tillage and these parameters except LAI increased with increasing S and B doses up to 40 kg ha^{-1} and 1.0 kg ha^{-1}, respectively during both the years.

Yield attributing characters like number of siliqua per plant, length of siliqua, 1000-grain weight and number of seeds per siliqua were found maximum in conventional tillage. Tillage practices did not cause significant variation in 1000-grain weight. These attributes increased with increasing S and B doses up to 40 kg ha^{-1} and 1.0 kg ha^{-1}, respectively. Doses of sulphur did not cause significant variation in number of seeds per siliqua.

Conventional tillage gave significantly higher seed yield over zero tillage during both the years. Reduced tillage was significantly superior over zero tillage during 2017-18.

Highest seed yield (10.42 and 9.61 q ha^{-1}) was recorded with conventional tillage during 2016-17 and 2017-18, respectively. Significantly highest seed yield (10.65 and 9.85 q ha^{-1}) was recorded with 40 kg S ha^{-1} over control and was at par with 20 kg S ha^{-1} (10.45 and 9.51 q ha^{-1}) during 2016-17 and 2017-18, respectively. Significantly highest seed yield (10.59 and 9.75 q ha^{-1}) was recorded with 1.0 kg B ha^{-1} over control and was at par with 2.0 kg B ha^{-1} (10.40 and 9.44 q ha^{-1}) during 2016-17 and 2017-18, respectively. Interaction between tillage and

sulphur (T×S) was significant during both the years. Treatment combination of T_1S_3 was found the best in terms of highest seed yield (11.71 and 11.25 q ha^{-1}) during 2016-17 and 2017-18, respectively. Highest stover yield (27.42 and 26.25 q ha^{-1}) was registered with conventional tillage during 2016-17 and 2017-18, respectively. However, the difference between conventional tillage and reduced tillage was statistically at par. Significantly highest stover yield (28.47 and 27.29 q ha^{-1}) was recorded with 40 kg S ha^{-1} over control and was at par with 20 kg S ha^{-1} (27.54 and 26.59 q ha^{-1}) during 2016-17 and 2017-18, respectively. Significantly highest stover yield (27.86 and 26.76 q ha^{-1}) was recorded with 1.0 kg B ha^{-1} over control and was at par with 2.0 kg B ha^{-1} (27.63 and 26.16 q ha^{-1}) during 2016-17 and 2017-18, respectively. Only interaction between tillage and sulphur (T×S) was found significant for stover yield during both the years. Treatment combination of T_1S_3 was the best in terms of highest stover yield (32.79 and 31.62 q ha^{-1}) during 2016-17 and 2017-18, respectively.

Effect of tillage practices on oil content in seed was found non-significant. Maximum oil content in seed (40.66 and 40.15 %) was noted with conventional tillage during 2016-17 and 2017-18, respectively. Oil content in seed increased with increasing S dose upto 40 kg ha^{-1} during 2016-17 (41.59 %) and 2017-18 (41.12 %). While it increased with increasing B dose upto 1.0 kg ha^{-1} during 2016-17 (41.88 %) and 2017-18 (41.37 %).

Maximum cost of cultivation (₹ 17647 and 18855 ha^{-1}) was incurred with conventional tillage during 2016-17 and 2017-18, respectively. It increased with corresponding increase in sulphur and boron dose. Conventional tillage achieved highest net returns (₹ 25383 and 23564 ha^{-1}) during 2016-17 and 2017-18, respectively. It increased correspondingly up to 40 kg S ha^{-1} (₹ 25931 and 24216 ha^{-1}) and 1.0 kg B ha^{-1} (₹ 26743 and 25025 ha^{-1}) during 2016-17 and 2017-18, respectively. Highest B: C ratio (1.42 and 1.23) was noted with conventional tillage which was significantly superior over rest of the tillage practices during 2016-17 and 2017-18, respectively. Maximum B: C ratio (1.53 and 1.32) was found at 20 kg S ha^{-1} which was significantly superior over control and was at par with 40 kg S ha^{-1} during 2016-17 and 2017-18, respectively. Similarly, the highest B: C ratio (1.58 and 1.38) was obtained with 1.0 kg B ha^{-1} during 2016-17 and 2017-18, respectively which was significantly superior over remaining B levels.

Conventional tillage exhibited maximum water productivity (11.69 and 16.21 kg ha^{-1}-mm) during 2016-17 and 2017-18, respectively. However, it was enhanced with increasing S and B dose up to 40 kg ha^{-1} and 1.0 kg ha^{-1} during 2016-17 and 2017-18, respectively.

Soil pH, EC and organic carbon did not vary significantly due to tillage practices and dose of sulphur and boron.

Tillage practices caused significant improvement in available nitrogen, phosphorus, potassium, sulphur and boron content of soil indicating higher value with zero tillage. Their respective content in soil was found towards increasing trend up to 40 kg S ha^{-1} and 2.0 kg B ha^{-1} during both the years and observed remarkable improvement over initial status.

Sulphur and boron uptake was recorded highest with conventional tillage significantly during both the years. S and B uptake was found maximum value at 40 kg S ha^{-1} and 2.0 kg B ha^{-1}, respectively.

Nutrient use efficiency was decreased with increasing doses of sulphur and boron. The optimum nutrient use efficiency was computed with 20 kg S ha^{-1} and 1.0 kg B ha^{-1} during both the years.

Hence, it can be concluded that application of 40 kg S ha^{-1} under conventional tillage practice recorded highest seed yield, stover yield, oil content and water productivity of mustard and available phosphorus in soil. Interaction effect of sulphur and boron was found significant in improving nitrogen and boron availability in soil and uptake of sulphur by mustard.

ABSTRACT

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Registration No.	:	D/AGRO/69/BAC/2016-17
Chairman, Advisory Committee		**Dr. Ajoy Kumar Singh**
Degree Programme	:	Ph. D (Agronomy)
Major Subject	:	Agronomy
Minor Subject	:	Soil Science and Agricultural Chemistry
Year	:	2020
Name of University	:	Bihar Agricultural University, Sabour
Title of the Thesis	:	**Effect of establishment methods and deficit irrigation on productivity of rice cultivars**

Rice is the staple food for half of India as well for Bihar's population. It is thelargest user of water in agriculture which occupies 30 percent of the world's irrigated cropland. It is grown with flooded water for most of the crop season so irrigated rice receives about 40 percent of the water diverted for irrigation. Over the past 2 decades, efforts have been made to develop ways to reduce water use in rice production and/or increase rice water productivity because reducing water use for rice by a small percentage could free up large volumes of this vital resource for alternative uses. To cope with scarce supplies, deficit irrigation system can play an important role to achieve the goal of reducing irrigation water use with alternate wetting and drying (AWD). For proper guidance and implementation of AWD and deficit irrigation system, a very simple and low cost, farmer-friendly tool a perforated "field water tube" was adopted. The main aim of this water saving-technology is to decrease losses of water due to seepage, percolation and runoff,

thereby increasing the productivity of total water inputs from rainfall and irrigation under different establishment methods of rice cultivation.

Present experiment was conducted at research farm of Bihar Agricultural University, Sabour during *Kharif*season of 2017 and 2018. In this research the effects of various cultivars (i.e. Rajendra Mahsuri and Arize 6444) with different establishment methods i.e. puddle transplanted rice (PTR) and direct seeded rice (DSR), deficit irrigation (AWD) in different rice cultivars were evaluated in a split - split plot design. In main plot, two establishment methods PTR (T_1) and DSR (T_2), in sub plots two varieties, Arize 6444 (Hybrid) (V_1) a medium duration and Rajendra Mahsuri (V_2) a long duration variety, and in sub-sub plots irrigation water with AWD treatments at different threshold levels were allocated. Irrigation was applied when the perched water table dropped below AWD 0 cm, AWD 10 cm, AWD 15 cm, AWD 20 cm and AWD 25 cm respectively. In the AWD treatments, timing of irrigation was based on the water depth in the field water tube installed in each plot. Irrigation time thus varied slightly across replicates. The tubes were installed in the field to depths of 10, 15, 20 and 25 cm (to correspond with AWD treatments). When there was no visible water in the tube, irrigation was applied until the depth above the soil surface reached 5-10 cm. The AWD was stopped until 10-12 days before the expected time of harvest in all water treatments.

In terms of growth and productivity of rice, among establishment methods DSR and among varieties Arize 6444 recorded higher values for plant height, LAI, number of tillers, and dry matter accumulation as compared to PTR and Rajendra Mahsuri respectively. Among the irrigation treatments, AWD 0 cm recorded higher growth attributes which was at par with AWD 10 cm and AWD 15 cm. Maximum yield was recorded in PTR (5651 kg/ha) because of higher number of filled grains per panical which was 4 percent higher over DSR. Among varieties, Arize 6444 recorded 3 percent higher yield (5610 kg/ha) over Rajendra Mahsuri while AWD 0 cm recorded the highest yield of 5902 kg/ha over rest of the irrigation treatments. Among establishment methods, DSR required 22 percent less water as compared to PTR while Arize 6444 recorded irrigation water savings of 4 percent with no significant changes to crop management. With increasing AWD treatments, the water savings recorded increase of 20, 32, 41 and 48 percent in AWD 10 cm, 15 cm, 20 cm and 25 cm respectively, over AWD 0 cm while, yield reduction were 2, 6, 10 and 13 percent for the respective AWD treatments. Irrigation water productivity was higher in DSR (1.24 kg m^{-3}) over PTR while input water productivity was higher in PTR (0.44 kg m^{-3}) over DSR (0.42 kg m^{-3}). Among the irrigation treatments the highest input water productivity was recorded in AWD 25 cm (0.48kg m^{-3}) while the lowest water productivity was recorded in AWD 0cm (0.41 kg m^{-3}). The water stress indicators like chlorophyll content and relative water content decreased gradually upto anthesis while proline content, electrolytic leakage increased with age of crop

and increasing AWD depths. At milking stage chlorophyll content and relative water content was significantly reduced while proline content and electrolytic leakage was significantly increased due to water stress. Highest cost of cultivation was recorded in PTR (Rs. 53558 / ha) which was 15 per cent higher over DSR, however, 9 percent higher net returns and 13 percent higher benefit cost ratio was obtained in DSR (net returns - Rs. 59694/ ha and B:C ratio - 2.31). Cost of cultivation was maximum in Arize 6444 while net returns was at par to Rajendra Mahsuri. However, Rajendra Mahsuri recorded 3.3 per cent higher benefit: cost ratio over Arize 6444. Among the different irrigation treatments AWD 0 cm recorded the highest cost of cultivation, gross returns and net returns, however, maximum benefit cost ratio was recorded in AWD 10 cm which was at par with AWD 15 cm and AWD 0 cm treatment.

On the basis of two years' data it may be concluded that adoption of AWD irrigation strategy may provide water savings along with positive economic effects for rice farmers. Deficit irrigation based on AWD regime, can aid in coping with situations where supply is restricted. In rice, a well-designed restricted irrigation regime can optimize water productivity over an area when full irrigation is not possible. The large variability in results was due to differences in the number of days of soil drying between irrigations, and the soil and hydrological conditions. Novel irrigation water-saving technologies (AWD) can also help many rice farmers around the world to cope with water scarcity, thus safeguarding their livelihoods. However, high yields of rice can be obtained only by eliminating moisture stress through assured irrigation and better utilization of rain water.

ABSTRACT

Name of the Student	**:**	**Durgesh Singh**
Registration No.	**:**	**D/AGRO/62/BAC/2016-17**
Chairman, Advisory Committee	**:**	Dr. Sushil Kumar Pathak
Degree Programme	**:**	Ph.D. (Agronomy)
Major Subject	**:**	Agronomy
Minor Subject	**:**	Soil Science and Agricultural Chemistry
Year	**:**	2020
Name of University	**:**	Bihar Agricultural University, Sabour
Title of the Thesis	**:**	**Studies on diversification and intensification of traditional rice-wheat cropping system under irrigated condition**

A field experiment entitled **"Studies on diversification and intensification of traditional rice-wheat cropping system under irrigated condition"** was studied in an ongoing trial of AICRP at Bihar Agricultural College, Farm, Sabour during 2017-18 and 2018-19.Bihar Agricultural College, Sabour is situated at sub-urban area of Bhagalpur city on latitude of 25° 50′ N and longitude 87° 19′ E with an altitude of 37.19 meters above the mean sea level under Gangetic plains of India. The centre is situated under Agro-Climatic Zone III-A (NARP Zone of the State) having diverged type of topographic features, soils, climate, flora and fauna. Sabour, Bhagalpur has a sub - tropical climate characterized with dry summer, comparatively cool rainy season followed by moderate winter. The average annual rainfall of the locality is around 1250 mm of which 75-80 per cent is received during monsoon months (June to October).

Soil of the experimental field was loam in texture, soil is slightly saline in reaction (pH 7.61), low organic carbon (0.45%), with low available N, medium P_2O_5 and K_2O (237, 24.46 and 226.02 kg ha^{-1}, respectively). The experiment was laid out in Randomized Block Design with three replications. Total nine cropping sequences were taken to constitute treatments for different intensification of rice-based cropping system *viz.,* Rice -wheat - fallow, rice - wheat (ZT) - mungbean (ZT), rice - maize + vegetable pea (ZT) - sorghum + cowpea (F), rice - potato + radish -mungbean (G+R), rice - cabbage + coriander leaf - sesamum, rice -fababean (ZT)- okra, rice - berseem - maize + cowpea (F), rice - mustard - mungbean (G+R) and rice -chickpea + linseed (ZT) - maize (green cob & F). With a view to avoid mixing of soil, individual plot was thoroughly prepared in each season. Cultivation practices were followed as per recommendation. The practice of weeding was applied after recording data on weed population.

Impact of different cropping systems followed during the *kharif, rabi* and*zaid* season was foundnon-significant on growth and yield of rice, however,*rabi* and *zaid*crops (including intercrops) are significantly affected by them. Significantly highest rice equivalent yield of 23.34t ha^{-1}wasproduced by rice- potato + radish-mungbean (G+R)system.This system also provideshighest net return ofRs.2,82,835 ha^{-1} and additional net return of Rs. 1,45,457 $ha^{-1}$with 300% cropping intensity over rice-wheat system. Being at par with rice - cabbage + coriander leaf -sesamumcropping system, this system was found significantly superior and generated almost 105% more profit over rice - wheat system.

Production efficiency, economic efficiency and employment generation efficiency of any diversified system is a direct measure of its prefer ability in any area as these indicate the employment for farming community for a given period of time. The system productivity (63.95 kg$ha^{-1}day^{-1}$) and system profitability (774.89Rs$ha^{-1}day^{-1}$) was distinctly highest under the rice - potato + radish-mungbean (G+R) cropping system. However, system profitability of rice - cabbage + coriander leaf -sesamumand rice - maize + vegetable pea - sorghum + cowpea (F) system was also found at par. Rice - potato +

radish-mungbean (G+R) cropping system was observed significantly higher in relative production efficiency (129.64 %) and relative economic efficiency (106.65 %) while, rice - maize + vegetable pea - sorghum + cowpea and rice - cabbage + coriander leaf -sesamum system was found at par in terms of relative economic efficiency. Further, this system with higher monetary returns provided more employment to labourers (335 mandays $ha^{-1}year^{-1}$) and generated 55.10 % more employment than that of traditional rice-wheat cropping system. Significantly higher energy productivity of 407.04 $gMJ^{-1}$was also recorded in rice - cabbage + coriander leaf -sesamum system. Hence, on the basis of two years' data it may be concluded that intensification and diversification of rice -wheat system by rice - potato + radish-mungbean (G+R)system (B:C ratio-2.02)at 300% cropping intensity considered as the economic viable option for resource rich farmers while, rice - maize + vegetable pea - sorghum + cowpea (B:C ratio- 2.39) and rice - cabbage + coriander leaf - sesamum(B:C ratio- 2.23) for resource poor farmers.

List of Ph. D. passed out students from the Department of Extension Education

Sl. No.	**Name of the Researcher (Name of Ph.D. Scholar)**	**Name of Major Advisor**	**Name of External Examiner/Expert**	**Title of Thesis/ Research work**	**Published Paper**
01.	Neeraj Kumar (D/EXTN/039/BAC/2014-15)	Dr. S. R. Singh	**Dr. R. P. Singh 'Ratan'** (Former Director Extension Education)	Study the Challenges and Opportunities of Agricultural Development in a Village: A case Study	
02.	Neha	Dr. S. R.		Farmers Perception	1. Farmers' Perception

	Pandey (BAC/D /EXTN/ 002/2015 -16)	Singh	BAU, Ranchi, Jharkhand.	towards Climate Change and Adaptation Strategies in Bihar: A Gender Perspective.	on Climate Change and its Impact on Agriculture in Bihar. 2. Perception of Farmers on Climate change and its Impact on Agriculture in India: A Review

ABSTRACT

Name of the student	**:**	Neeraj Kumar
Registration Number	**:**	D/EXTN/39/BAC/2014-15
Degree Programme	**:**	Ph.D. (Ag.)
Major Subject	**:**	Extension Education
Minor Subject	**:**	Agronomy
Year	**:**	2019
Chairman of Advisory Committee	**:**	Dr. S.R. Singh
Department	**:**	Deptt. of Extension Education
Thesis title	**:**	**"Study the Challenges and Opportunities of Agricultural Development in a Village: A Case Study"**

India live in villages and the later continue to be the sole basic units of administration in the country since time immemorial. However, quite ironically, the 'village' is often associated with 'backwardness', tradition' or 'conservative attitude'.

Bihar is a state blessed with fertile lands, diverse climatic situations and large human as well as natural agricultural resources. But it is also a state which faces the persistent problems like fragmented land holdings, poor farm infrastructure, poor access to extension services and high population density and resultant poverty.

The low average yields of most commodities, the huge gaps between the demonstrated and generally realized yields, the low farmers' income and widespread rural poverty despite the blessed richness of the natural resources needs a holistic system based approach to simultaneously enhance productivity, profitability, equity and environmental sustainability through synergistically integrating crops including horticultural and other cash crops, livestock, fisheries,

agro forestry, watershed-based soil and water management, social capital formation, agro-processing and marketing in an end-to end mode.

In order to understand as to how to address the constraints and problems in agriculture to lead to overall development, an in-depth study of one village needed to be undertaken and on the basis of the database, a development programme needed to be undertaken. Only such an experience of working in a village could provide an insight for future village development programmes on large scale. Keeping this in aim in view, this research study entitled "Study the Challenges and Opportunities of Agricultural Development in a Village: A Case Study" was conceptualized with the following specific objectives: 1 To study the situational profile of the farmers and the village. 2 To assess the livelihood diversification pattern among the farmers. 3 To identify the opportunities of agricultural development in the selected Village. 4 To determine the challenges and constraints of the agricultural development in the selected village.

Twin villages, Birnaudha and Barhari of Goradih block in Bhagalpur district of Bihar state which were already selected under FARMER FIRST Programme of ICAR by Bihar Agricultural University, Sabour (BAU, Sabour) were selected purposively for this investigation. This study aimed to build valuable data base for this all-inclusive development programme so that planning and execution of the programme could have a data support and could provide a benchmark for evaluation of achievements of the efforts made under the programme. But total households in these villages numbered more than 1,300. Considering the limitation of a Student's study with respect to time and resources, only 400 farm families were randomly selected for this investigation. The variables of the study were selected through a lot of discussion with the scientists working in the Farmer First Project, progressive farmers of the villages and other scientists of the University who enjoined wide field experience. These variables were operationally defined and measures were decided objectively and scientifically. For measuring some variables like Socio-economic status, gender participation and marketing behavior of the respondents, well established scales were used and for other variables, schedules were developed. The entire schedule was pre-tested for its reliability and validity. The data collected with the help of schedule was subjected to suitable statistical analysis and results were discussed in the light of literature available in the subject area of the study.

The majority of the respondents (68.75%) were in the age of 36-50 years, belonged to BC II Category (65.0 %), about 47.0 per cent respondents possessed high school and above qualification, while 14.25 per cent were illiterate. Further, the majority of them (86.25%) had nuclear families and family size of 57.50 percent was medium. About 70.00 percent respondents were marginal farmers, 45.0 percent possessed Pucca houses 35.0 percent had mixed type of houses.

Agriculture was the sole occupation of 32.50 percent respondents only. There were 28.75 percent respondents doing the work of labour along with farming. About half of the respondents (52.75%) had an annual income in the range of Rs. 50.001 to 75,000 and income above Rs. 1.0 lakh was of 7.25 percent respondents only. About 54.25 percent had medium level of material possession followed by low (27.25%) and high level (18.50%). Under the above background, the majority of respondents (75.0%) had received some training in agriculture, from one day to more than 10-days duration. But still 53.75 percent respondents had medium level of knowledge followed by 36.25 percent having low level of knowledge of important farm technologies. So, large adoption gap (67.0%) exists with respect to improved technology of commonly cultivated crops. Component-wise, maximum gap was found with respect to Plant protection measures (91.0%). It was followed by seed treatment (90.0%). The adoption gaps were also very large with respect to improved varieties and seed materials (75.0%), intercultural operation (70.0%), water management (66.0%), fertilizer management (63.0%) and sowing methods and time of planting (51.0%). Out of six personalized sources of information, neighbours were used regularly by maximum number of respondents (44.50%) followed by relatives (41.0%). Among mass contact sources, Kisan Diary was most regularly used source of technical information (45.0%), other sources played marginal role.

The majority of the growers (61.12 %) sold their produce immediately after the harvest. The majority of the growers (88.88%) used Tempo/Jeep for transportation of their agricultural produce to the market. Livelihood diversification was found with 48.50 percent respondents at medium level and 27.25 percent at high level.

The Index Value of the financial capitals was highest (62.14) whereas of Human capitals was the lowest (48.92). The associations of Extension contact and mass media contacts with all the five livelihood capitals and the overall security were positive and highly significant. The fertile soil for cultivation was perceived by the respondents to be the most important factor for agricultural development.

Major crops grown in this villages are rice, wheat, maize, potato & other vegetables. However, the agricultural sector in the village is plagued with numerous, and well known, constraints and problems. The present study discusses the issues plaguing the agricultural sector in the village, Bihar and talks about the possible opportunities interventions to make the best use of available resources adopting a multi-pronged strategy of development. It also talks about the village specific problems and suggests ways and means to tackle them.

ABSTRACT

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Chairman, Advisory Committee	:	Dr. S.R.Singh
Degree program	:	Ph.D. (Ag.)
Major subject	:	Extension Education
Minor subject	:	Agricultural Economics
Year	:	2018
Name of the University	:	Bihar Agricultural University, Sabour
Title of the Thesis	:	Farmers' perception towards climate change and Adaptation in Bihar: A gender perspective.

The present study was an attempt to understand the perception of farmers about climate change and document the adaptation strategies to climate change in Bihar. The constraints faced by the farmers in adaptation were also examined. A comparable vulnerability index of both men and women farmers was calculated. This investigation was carried out in four purposively selected districts of Bihar state. This investigation was carried out in four purposively selected districts of Bihar state .A total of 240 respondents, 120 being male and 120 being female were selected as the sample size. The study was conducted in 8 villages selected both purposively and randomly. A multi stage sampling design was adopted to select the sample size.

The major findings of the study revealed that Majority (50.00 per cent) of the men farmers and 45.83 per cent of the women farmers were of the middle age group. Majority of the women farmers and 30.00 per cent of the men farmers were illiterate. Majority of the men and women farmers were of OBC category. Majority (60.00 per cent and 76.67 per cent) of the men and women farmers were of the joint family type. Majority of the respondents were having family size greater than 5 members. Majority of the men and women respondents were having medium farming experience. About social participation, very few respondents were member of milk federation, school and few women were member of self help group in their village. Majority (70.83 per cent) of the farmers were marginal land holders while 16.67 per cent of the farmers were small land holders, and only 6.67 per cent of the farmers were big land holders. Majority of the men and women farmers were of medium annual income. Only

18.33 per cent of men farmers and 37.50 per cent of the women farmers had acquisition of credit. Majority (70.80 per cent and 80.00 per cent) of the men and women farmers were having one to four of the farm implements. Majority of the farmers had to face the problem of market availability which was around 3 to 5 km distance away from their villages. Majority (60.00 percent and 40.83 per cent) of the women and men farmers had medium level of contact with the extension person. Majority (56.67 per cent and 51.67 per cent) of the men and women farmers had medium participation in extension activities. Majority of the respondents (54.17 per cent and 44.17 per cent) had medium extent of use of mass media.

Access to weather forecast was available only to 49.17 per cent and 22.50 per cent of the men and women farmers respectively. Majority of the men and women farmers had medium level of risk orientation, innovativeness and decision making pattern.

While the men farmers were more aware of the indicator that climate is getting warmer day by day, the women farmers were more aware of the increase in pollution level of the environment. Majority of the men respondents perceived that in monsoon season onset of monsoon has been delayed, end of monsoon has been early, frequency of dry spell has increased, uneven distribution of rainfall has increased and uncertainty of rainfall has increased. In winter season, onset of winter season has been delayed; duration of winter season has decreased and no of days of severe cold has decreased. In summer season minimum and maximum temperature has increased, onset of summer season was early and end of summer season was delayed, month with intense hot days was increased and rainfall in summer season was also increased. For the same season wise climate change indicators, the women farmers perceived differently as for them, the frequency of dry spell was unchanged; duration of monsoon season was decreased. In winter season intensity of cold wave was increased, no of days of severe cold was increased and duration of winter season was decreased. In summer season end of summer season was delayed, number of intense hot days has increased and intensity of heat wave has increased.

To avoid the climate change extremities, the farmers adopted certain adaptation strategies which was further divided into short term and long term adaptation strategies. Early sowing, crop insurance, mixed cropping, increased seed rate, flood tolerant variety, strengthening of bunds, drought tolerant variety, early maturing variety, low water requirement crops, deep rooted crops, increased irrigation, application of potash and urea, thinning, use of farm implements and pest resistant variety are some of the short duration strategies. Crop diversification, tubewell, ponds, renovation of ponds and wells, polyhouse, checkdam, sprinkler irrigation, INM in crops, backyard poultry and duck farming are some of the long term strategies adopted mainly by the men farmers. The men and women farmers were exposed to same type of climate extremities but it was the coping mechanism which makes the difference in vulnerabilities faced by both the social groups. To overcome these problems, climate change and related issues should be seen from a gender lens and the policy implications must be more gender just.

List of Ph. D. passed out students from the Department of Horticulture (Fruit & Fruit Technology),

S. No	Name of Student	Registration No.	Year of Degree	Title of Thesis	Major Adviser	External Adviser

1	Bibha Kumari	D/Hort./01 /BAC/2011-12	2015	Effect of Nitrogen and Boron on Guava (Psidium Guajava L.) CV. Allahabad Safeda.	Dr. U.S. Jaiswal	Dr. C.P.Suresh
2	Dhiru Kumar Tiwari	D/Hort./09 /BAC/2012-13	2015	Phino-Physicalogical Studies on Baramasi Regular and Biennial Bearing Mango.	Dr. V. B. Patel	Dr. M.N.Hoda
3	Piyush Shrivastava	D/Hort./18 /BAC/2013-14	2016	Evaluation of different Banana Genotypes for Pomological characters and Resistance against fuzarium wilt using Molecular Marker.	Dr. M. Feza Ahmad	Dr. M.N.Hoda
4	Md. Abu Nayyer	D/Hort./05 /BAC/2012-13	2017	Nutritional studuies in Banana for Alluvial Soil of Bihar.	Dr. M. Feza Ahmad	Dr. M.N.Hoda
5	Praveen Kumar Mishra	D/Hort./17 /BAC/2013-14	2018	Effect of Fertigation and Mulch in Guava (Psidium Guajava L.) CV. Allahabad Safeda under high density planting.	Dr. Sanjay Sahay	Dr. A.K.Mehta
6	Ravindra Kumar Singh	D/Hort./27 /BAC/2014-15	2018	Studies on boron nutrition in relation to yield and quality attributes of banana CV. Grand Naine.	Dr. M. Feza Ahmad	Dr. K.K.Shrivastava
7	Vimlesh Kumar Maurya	D/Hort./16 /BAC/2013-14	2018	Influence of Nitrogen Levels, Vermicompost and Azotobactor on Phenology Yield and quality attributes of Mango (Mangifera indica L.) CV. Amrapali under High density planting.	Dr. R. R. Singh	Dr. V.B.Patel
8	Kanchan Bhamini	D/Hort./28 /BAC/2014-15	2018	Estimation of morphological and genetic variation in some Mango (Mangifera indica L.) varieties using DUS testing's norms.	Dr. U. S. Jaiswal	Dr. Vishal Nath
9	Deen Dayal Singh	D/Hort./04 /BAC/2012-13	2018	Studies on the effect of GA3 application on Physiological Regulation of flowering and maturity in mango (Magifera Indica L.) C..V Langra.	Dr. R. R. Singh	Dr. B.K.Singh

10	Rajni Sinha	D/Hort./46 /BAC/2015-16	2019	Effect of Fertigation of Physico-chemical, Physiological and Antioxidents attributes linked to Fruit quality and Granulation in Kinnow Mandarin.	Dr. Kumari Karuna	Dr. S.K.Singh
11	Vikash Kumar	D/Hort./48 /BAC/2015-16	2019	Runner production of strawberry and its survivalility in subtropical condition of Estern India.	Dr. Sanjay Sahay	Dr. Devendra Pandey
12	Suparna Sinha	D/Hort./47 /BAC/2015-16	2019	Pre and Post harvest approaches to improve quality of mango (Mangifera indica L.) C.V. Zardalu.	Dr. R. R. Singh	Dr Amarendra Kumar
13	Pushpa Kumari	D/Hort./46 /BAC/2015-16	2019	Mineral Nutrient studies in Papaya (Carica Papaya L.) Red Lady under Alluvial Soil of Bihar.	Dr. M. Feza Ahmad	
14	Abha Kumari	D/Hort./87 /BAC/2016-17	2020	Impact of bio inoculants on growth and Establishmernt of litchi (Litchi chineensis Sonn.)plants	Dr Ruby Rani	Dr. K.K.Jhaa

Title of the Research work : "Effect of Nitrogen and Boron on Guava (*Psidium guajava* L.) cv. Allahabad Safeda"

Name of the Student : Bibha Kumari

Registration No. : D/Hort./01/BAC/2011-12.

Degree Programme : Ph.D. Horticulture (Fruit Science)

Major Subject : Horticulture (Fruit)

Minor Subject : Olericulture

Major Advisor : Dr. U. S. Jaiswal

Year : 2014

Name of the University : Bihar Agricultural University, Sabour (Bhagalpur), Bihar

ABSTRACT

Guava is an important, highly productive, delicious and nutritious fruit of tropical and sub-tropical region and said to be the apple of tropics. Plant fertilization is dominated by the N, P and K which promote plant development and increase the production. Boron application influences the flowering, fruiting and other physiological activity of the plant. Very little information is available with special reference to nitrogen and boron application on guava production. Hence, an experiment entitled "**Effect of Nitrogen and Boron on Guava** *(Psidium guajava L.)* **cv. Allahabad Safeda**" was under taken during 2012 to 2013 to study the effect of sources of nitrogen and boron on growth, yield, quality and post-harvest life of winter guava fruit.

The vegetative parameters increased with increasing doses of nitrogen and the maximum percent increase in plant height (17.54 %), shoot length (66.08 cm), tree girth (7.29 %), plant spread (15.19 %) and leaf area (132.59 cm^2) were recorded when nitrogen applied @ 800 g/plant. The effect of boron did not show significant variation on vegetative parameters. The flowering characteristics, fruit set and fruit drop had a positive effect with the various doses of nitrogen. The boron applied @ 50 g/plant took minimum days for flowering (81.64 days), maximum fruit set (74.67 %), minimum fruit drop (35.05%) and days of harvesting (98.86 days). The flowering to harvesting was decreased by 17 days with application of boron at 50 g/tree. The maximum fruit yield and fruit yield efficiency was recorded 54.37 kg/tree and 6.04 kg/tree respectively, when CAN was applied @ 600 g/plant. The maximum fruit weight (330.22 g) was obtained when CAN was applied @ 600 g/plant. Whereas, boron applied @ 50 g/plant was recorded fruit weight of 307.30 g. The maximum TSS content (11.64^{0}B) was recorded with CAN applied @ 600 g/plant, while as maximum acidity ((0.376%) was recorded when CAN applied @ 800 g/plant. The application of boron @ 50 g/plant recorded 0.357 % titrable acidity which was statically at par when boron applied @ 75 g/plant. The ascorbic acid content (267.52 mg/100 g of pulp) was obtained with CAN applied @ 600 g/plant. However, highest total sugar (7.74%) was found with application of CAN @ 600 g/plant. the interaction effect of CAN

@ 600 g/plant in combination with Boron @ 50 g recorded best treatment in term of qualitative and quantities characters of guava.

Title of Research work	:	**"Pheno-Physiological studies on *Baramasi*, regular and biennial bearing mango"**
Name of the Student	:	**Dhiru Kumar Tiwari**
Registration No.	:	D/Hort.09/BAC/2012-13
Degree Programme	:	Ph.D. Horticulture (Pomology)
Major Subject	:	Horticulture (Pomology)
Minor Subject	:	Horticulture (Olericulture)
Major Advisor & Chairman	:	**Dr. V.B. Patel**
Year	:	2015
Name of the University	:	Bihar Agricultural University, Sabour (Bhagalpur), Bihar

ABSTRACT

Flowering in mango (*Mangifera indica* L.) is a very complex physiological phenomenon. The potentiality to form flower buds depends on the florious condition of the tree that depends on many factors such as genotypes, climatic factors, physiological behavior, agro-techniques, pests and disease management etc. Very less information is reported on the above subject. Hence, a study was carried out at AICRP (Fruit) experimental farm of the Department of Horticulture (Fruit & Fruit Technology), Bihar Agricultural College, Sabour, Bhagalpur, Bihar during 2012-13 and 2013-14 to know the phenological behavior as well as to understand the physiological and biochemical activities during different stages. This experiment was laid out with four mango cultivars *Baramasi*, regular bearing (Amrapali) and biennial bearing (Langra and Alphonso) in RBD. The highest flowering intensity was produced by Langra (4295.50 flowers/sq. ft.) whereas Alphonso had longest panicle (32.86 cm), minimum flowering intensity (2621.00 flowers/sq. ft.) and panicle length in *Baramasi* (25.16). Results also indicated that flowering inhibit the photosynthesis

(Pn) (6.22-12.11 µmol/m^2/sec), stomatal conductance (gs) (0.131-0.229 µmol/m^2/sec) and transpiration (E) (4.35-5.33 µmol/m^2/sec) rates, these were higher during the post flowering stage however the lower values were recorded at flowering stage. The higher rate of photosynthesis was not due to variation in the water status of the leaves, since relative water content (RWC) was significantly lower in leaves of Langra. Chlorophyll has significant role in the photosynthesis. The highest chlorophyll content (2.45-4.00 mg/g) was estimated during the post flowering stage. Results also underlined the significance of chlorophyll fluorescence (Fv/Fm) system in flowering of mango. Increased accumulation of carbohydrates was also estimated during flowering stage compared to other stages in all cultivars but *Baramasi* exhibited almost similar level during all stages in terms of carbohydrate (88.44-89.2 8 mg/100g) as well as nitrogen content, flavonoids and total antioxidants capacity. Time of 50% flowering, panicle length, No. of flowers, No. of panicles, and hermaphrodite flowers were found to be positively correlated with Pn, gs, E, Fv/Fm while leaf area index (LAI) was positively correlated with total chlorophyll, phenolics, carbohydrates and nitrogen however, No. of flowers was correlated with carbohydrates and total chlorophyll, Pn, gs, E, Fv/Fm, total chlorophyll, temperature, RH and rainfall were positively correlated to each other whereas negatively correlated with internal CO_2 concentration of leaf (Ci), relative water content (RWC), specific leaf weight (SLW), carbohydrates, phenolics and nitrogen content. Although, results are not clearly showing the actual factors involved in flowering, however this study is helpful to understand the relationship of physiology and biochemical attributes towards flowering of *Baramasi,* regular and irregular bearing mango. *Baramasi* bears five times flowers as well as more flushes in a year than other cultivars. Leaf area index observed significantly maximum in *Baramasi*. Higher chlorophyll content, electron transport rate, specific leaf weight and relative water content during all stages were observed in *Baramasi*. In the data, it was observed that *Baramasi* has exhibited much fluctuating carbohydrate reserve due to staggered flowering pattern during flowering process. During flowering increased level of carbohydrate reserve, indicating their decisive role in the flowering. Further works at molecular level (gene expression) are needed to understand the mango flowering. This information could be used for breeding programs to improve mango productivity by producing fruits throughout the year.

Department of Horticulture (Fruit and Fruit Technology)

Thesis title: "Evaluation of different banana genotypes for pomological characters and resistance against Fusarium wilt using molecular marker."

Abstract

This experiment has been conducted to study the genetic variability based on morphological and pomological characteristics of banana and phylogenetic analysis of various banana genotypes based on molecular markers against the Fusarium wilt during the year 2014-2016. As many as 28 genotypes *viz.* FHIA-23, Dwarf Cavendish, Gandevi Selection, Grand Naine, Jahaji, Lalkel, Robusta,

Alpan, Bareli Chinia, Chinia, ChiniaRatwara, Doodhsagar, Kalibel, Marthman, MarthmanNemopur, MarthmanSimra, MalbhogBarhari, Panchanan, Poovan, Rasthali, Bersain, Kanchkel, Kanthali, Kothia, Lambee, PanchabanthaBattisa, Udhayam and Saba-8 were collected from R.A.U., Pusa for this study.

Wide variation was found among different morphological as well as biochemical parameters like plant height (186.33-335.78 cm), girth (46.67-70.67 cm), number of leaves at shooting (9.67-16.76), leaf area (7.47-17.78 m^2), duration from planting to shooting (266.17-343.0 days), duration from shooting to harvesting (109.60-135.16 days), bunch weight (8.75 - 21.25 kg), number of fingers per hand (9.16-15.33), number of fingers per bunch (80.78 – 147.03), fruit length (7.83-16.0 cm), fruit width (3.56-6.60 cm), fruit weight (72.35 - 214.17 g), peel thickness (1.07-3.58 mm), pulp: peel ratio (2.05 – 3.22), TSS (15.71-23.04 ^{o}Brix), acidity (0.339-0.419 %), total sugar (12.75- 18.43 %), starch (4.34-13.59 %), total phenol (13.67 - 36.80mg CE/100g), total flavonoids (0.0.87 – 4.39 mg CE/100 g), total antioxidant (0.76-4.04 micromole TE/g), ascorbic acid (10.3-25.0 mg/100g), Total carotenoids (2.06-4.80 mg/100g), dry matter content (19.49-25.31 %), potassium content (287.67-428.55 ppm) and calcium content (3.58-9.82 ppm).

Significant genetic variability was found among the genotypes with respect to morphological and biochemical characters thus there is an ample scope for selection of promising genotypes. High heritability estimates for plant height, girth, bunch weight, no. of fingers per bunch, fruit length, fruit weight, peel thickness, starch content, total phenol, total flavonoids, ascorbic acid, total carotenoids, total antioxidant, potassium and calcium content which indicates that the traits under study had great scope for genetic improvement.

Under screening of genotypes against Fusarium wilt based on rhizome discoloration index Grande Naine, Bersain, Poovan and Kanchkel were found to be resistant among all studied genotypes. The photosynthesis rate (µmol/m^2/sec), stomatal conductance (µmol/m^2/sec), internal CO_2 concentration of leaf (ppm), transpiration rate (µmol/m^2/sec) and relative water content of leaf showed decline in inoculated plants as compared to non-inoculated plants among most of the susceptible and tolerant genotypes however less decline and in few cases even increase was found in resistance genotypes. Along with this, the phenolics content in roots of resistant plants were also higher as compared to tolerant and susceptible plants.

The genetic similarity coefficients obtained with RAPD markers ranged from 0.474 (between the genotypes Panchanan and Udhyam) to 0.961 (between Grand Naine and Gandevi Selection). Based on this, the obtained dendograme divided all the genotypes in two clusters having 12 and 16 genotypes. Primer OPA3 produced a specific band, which was present in Fusarium wilt susceptible genotypes. Therefore, this primer can be used further in such type of studies to detect genotypes susceptible to Fusarium wilt.

Overall, in this experiment among all genotypes like Grand Naine,

Kanchkel and Bersain were found to be high yielder along with resistance against Fusarium wilt whereas MalbhogBarahari, Chiniya, ChiniyaRatwara were found to be better in terms of biochemical parameters however these were susceptible to Fusarium wilt which shows that under Bihar conditions cultivation of genotypes like Grand Naine, Kanchkel and Bersain may prove much beneficial to growers.

Department of Horticulture (Fruit and Fruit Technology)
Bihar Agricultural College, Sabour, Bhagalpur

Title of Thesis	:	Nutritional Studies in Banana for alluvial soil of Bihar
Name of the student	:	Md. Abu Nayyer
Registration No	:	D/Hort./05/BAC/2012-13
Degree of Programme	:	Ph. D. (Ag.)
Major Subject	:	Fruit and Fruit Tech. (Pomology)
Advisor	:	Prof. M.Feza Ahmad Univ. Prof.-cum- Chief Scientist Bihar Agricultural University, Sabour
Year	:	2017
Name of the University	:	Bihar Agricultural University, Sabour, Bhagalpur, Bihar

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ABSTRACT

Banana is one of the leading fruit crop and considered as the "Apple of Paradise". It is also known as "Adam's fig". Banana (*Musa spp*.) is believed to have originated in

the hot tropical region of South-East Asia and India is believed to be one of the centers of origin. It belongs to the family *Musaceae*. Three experimentswere carried out. In first experiment nutritional survey of banana orchard is carried out in two district of Bihar, second and third experiment was carried out in tooth bagan, Bihar Agriculture college, Sabour to study the effect of nitrogen and potassium on growth, yield, quality and post harvest life of banana during the year 2013-15.

The results of survey of orchard showed that the pH, EC, available N, available P and available K status of soils of Naugachia block of Bhagalpur district varied from 7.54 to 8.35, 0.22 to 0.34, 135.55 to 210.45 Kg/ha, 11.34 to 16.25 Kg/ha and 130.16 to 163.74 Kg/ha respectively, and pH, EC, available N, available P and available K status of soils of Bihpur block ranged from 7.18 to 7.81, 0.18 to 0.29, 171.89 to 215.24 Kg/ha, 10.58 to 16.13 Kg/ha and 136.03 to 163.02 Kg/ha respectively.

The results of field experiment showed that the vegetative parameter such as maximum pseudostem height (188.81 cm), girth (62.31 cm), no of leaves (13.28 cm) were found when plants treated with 300g nitrogen per pseudostem. Minimum number of days taken to flowering, days taken from flowering to maturity and total crop duration (266.25, 96.83 and 363.79 days respectively) were found with 450g potassium per pseudostem. Besides flowering character, yield contributing characters such as number of hands per bunch, weight of finger, and weight of bunch (8.75, 194.67g and 26.35 Kg, respectively) were also increased significantly with potassium @ 450g per pseudostem whereas, maximum number of finger per bunch (138.31) was significantly increased with nitrogen @ 300g per pseudostem. Fruit quality character such as maximum TSS (22.78 ^{0}Brix) was found with potassium @ 450g per pseudostem whereas, no dose of nitrogen and potassium affect significantly on titratable acidity content of banana finger however, maximum acidity (0.31%) was found with nitrogen @ 150g or 300g and potassium @ 250g or 350g per pseudostem treated plants.The wide range of Leaf nutrient status was observed with different doses of nitrogen and potassium. The parameter such as highest nitrogen, phosphorus and magnesium content (2.37, 0.13 and 0.29 % respectively) was recorded with nitrogen @ 300g per pseudostem. Other trait like maximum potassium content (3.37%) was recorded with potassium @ 450g per pseudostem. The traits like nitrogen, phosphorus, zinc and iron content in banana pulp (1.37%, 0.12%, 3.07 ppm and 19.85 ppm) was observed with nitrogen @ 300g per pseudostem however, maximum potassium content (2.35%) in banana pulp was found with potassium @ 450g per pseudostem.The results of post harvest quality of banana showed maximum TSS (19.44 ^{0}Brix) on 9th days of storage with potassium @ 450g per pseudostem, Acidity (0.29 %) was with nitrogen @ 300g per pseudostem during 9th days of storage, maximum Vit-C (11.21 mg/100g) was found with potassium @ 450g per pseudostem during day of storage, whereas, total phenol and total flavonoids content (88.99 and 62.69 mg/100g) was found with potassium @

450g per pseudostem during 3rd days of storage. It is concluded from above results that doses of nitrogen @ 300g per pseudostem increased vegetative growth significantly. Higher doses of potassium *viz* potassium @ 450g per pseudostem significantly improved yield and quality characteristics of banana.

Key words: Nitrogen, Potassium, Banana.

DEPARTMENT OF HORTICULTURE (FRUIT & FRUIT TECHNOLOGY

Bihar Agricultural College, Sabour

Bihar Agricultural University, Sabour, Bhagalpur, Bihar- 813210

Thesis title: "Effect of fertigation and mulch in Guava (*Psidium guajava* L.) cv. Allahabad Safeda under High Density Planting"

Abstract

The investigation was carried out to assess the "Effect of fertigation and mulch on phenol-physiological, yield and quality attributes of their soil and leaf nutrient status in Guava (*Psidium guajava* L.) cv. Allahabad Safeda under High Density Planting" at experimental fruit orchards of Bihar Agricultural College, Bihar Agricultural University, Sabour, Bhagalpur, Bihar. The present experiment was laid out in split plot design with two mulch levels M_0 (Non-mulch) and M_1 (Black polythene mulch) as main plot and four levels of two fertilizers i.e. nitrogen @100g, 200g, 300g & 400g/plant/year and potassium @75g, 150g, 225g & 300g/plant/year with sixteen treatment combinations as sub plot treatment with uniform basal dose of P (200g/plant) in three replications.

The pheno-physiological, yield and quality attributes of guava cv. Allahabad Safeda along with their soil and leaf nutrient status was improved significantly in black polythene mulch as compared to non-mulch with subsequent levels of N, K and NK treatments in the main plot. The pheno-physiological, yield and quality attributes are varied significantly with the application of nitrogen, potassium and its combination. The highest plant height (2.77, 2.69 & 2.81 m), canopy volume (10.40,

9.55 & 10.91 m^3), growth of current season shoot (33.44, 30.99 & 34.48 cm), leaf area (59.06, 55.18 & 61.74 cm^2), leaf area index (5.84, 5.62 & 6.00), photosynthesis rate (8.70, 8.19 & 9.62 µmol/m^2/sec), internal CO_2 concentration (298.56, 284.59 & 312.45 ppm), stomatal conductance (0.34, 0.27 & 0.39 µmol/m_2/sec), total chlorophyll (2.07, 1.74 & 2.15 mg g^{-1}), relative water content (57.71, 53.33 & 58.60 %), specific leaf weight (12.80 & 12.87 mg/cm^{-2}), fruit weight (257.19, 221.09 & 269.25 g), length (7.12, 6.77 & 7.38 cm), width (7.90, 7.66 & 8.21 cm) and pulp: seed ratio (37.91, 35.04 & 39.59), T.S.S. (10.41, 11.11 & 11.52 °B), TSS: Acid ratio (39.69, 37.85 & 45.74), total sugars (8.62, 9.18 & 9.52 %), ascorbic acid (158.60, 153.09 & 160.68 mg/100 g FW), total carotenoid (0.437, 0.462 & 0.495 mg/100 g FW) and the lowest total acidity content (0.26, 0.30 & 0.26 %) were recorded with higher level of nitrogen applied @400g/plant and potassium @ 300g/plant.

The fertigation do not showed any marked effect on reproductive growth as expressed the minimum period of bud break to full bloom, period of 50 % flowering, duration of fruit set to maturity and the maximum number of fruit set per plant, total phenolics, flavonoids, antioxidant activity and yield attributes were gained with N_3 (300gN/plant), K_4 (300gK/plant) and N_3 K_4 (300:300gNK/plant) treatments. However, the little variation was there, it had a definite trend.

The net income was gained significantly higher Rs.8,75,012.63/- per hectare from the $M_1N_3K_4$ (300gN & 300gK under black polythene mulch) followed by Rs.8,24,560.96/- per hectare $M_1N_4K_1$ (400gN & 75gK under black polythene mulch) as compare to other treatments while the maximum benefit: cost ratio (5.77:1) was noted under $M_0N_4K_1$ (400gN & 75gK under without mulch) followed by 5.38:1 in $M_1N_4K_1$ (400gN & 75gK under black polythene mulch). Hence, the balanced fertilizer dose of 300:300 g N and K per plant per year were found economically superior with better quality by the saving of 25 % N fertilizers over other doses of fertilizers.

The available nutrients and enzymatic activity of soil under high density guava orchard with their leaf nutrient status varied significantly among the N, K & NK levels, in this view N_4, K_4 and N_4K_4 treatments were significantly higher in available soil N, P_2O_5, K_2O, DHA, APA and leaf nutrient status of N, P, K, Zn, Cu, Fe and Mn over $N_1K_1$and N_2K_2 treatments.

The variations in above findings with different treatments of fertigation and mulch might be due to the soil and climatic factors as well as changes in metabolic activity of plants due to various nutrient levels. Therefore, above results showed that the guava cv. Allahabad Safeda is highly responsive to fertigation with mulching for growth, yield and quality. Conversely, the additional investigations are also required to validate the above result prior to its recommendation to the guava orchard growers for elevated production and maximum earnings.

Department of Horticulture (Fruit & Fruit Technology)

Bihar Agricultural College, Sabour

Bihar Agricultural University, Sabour, Bhagalpur, Bihar – 813210

Thesis title: "Studies on boron nutrition in relation to yield and quality attributes of banana cv. Grand Naine"

Abstract

The aim of present investigation was to test the efficiency of soil and foliar application of boron in relation to growth, yield and quality of Grand Naine banana in main as well as ratoon crop. Soil application comprised of four boron levels (Control, 2.5, 5 and 7.5kg ha^{-1}) whereas foliar application involved five levels of solubor viz. 0%, 0.1%, 0.2%, 0.3% and 0.4%. All levels of boron and solubor were applied separately in 6^{th}, 7^{th}, 8^{th} and 9^{th} month after planting in main crop while in 4^{th}, 5^{th}, 6^{th} and 7^{th} month after planting in ratoon crop. All data were subjected to RBD factorial analysis which showed significant influence of soil application of 7.5kg ha^{-1} boron on different yield related characters like fingers/hand (20.28), fingers/bunch (145.13), finger weight (178.66g), bunch weight (21.65kg) and yield (54.13ton ha^{-1}) which is attributed to its positive impact on plant characters like number of leaves (13.50), leaf area (0.92m^2), days to maturity (89.58) and total crop duration (366.33days) as well as higher uptake of different nutrients from soil, clearly evident in terms of leaf N (2.57%), P (0.154%), K (3.57%), Mg (0.320%) and B (40.39ppm) content. Similar influence of boron application was observed in ratoon crop also though with 5kg ha^{-1} as a significant reduction in growth and yield was recorded at higher level. Further, application of 7.5kg ha^{-1} boron in 7^{th} month and 5kg ha^{-1} boron in fifth month improved post harvest life and quality of fruits maintaining higher TSS and sugars content, minimum loss in fruit weight, ascorbic acid, total phenols, flavanoids and total chlorophyll content along with faster starch degradation during storage study of nine days in main and ratoon crop, respectively. No significant influence of application time individually or through its interaction with different boron levels was observed on growth, yield or leaf nutrient content.

Foliar application of 0.4% solubor also caused significant improvement in number of green leaves (13.25) and leaf area (0.8m^2) with minimum days

required for fruit maturity (92.46) and crop duration (369.63days) which subsequently resulted in positive yield response (47.72ton ha^{-1}) with

Title of thesis	**:**	**Influence of nitrogen levels, vermicompost and *Azotobacter* on phenology, yield and quality attributes of mango (*Mangifera indica* L.) cv. Amrapali under high density planting**

significant influence on finger weight (170.14g), fingers/hand (18.42), fingers/bunch (130.13) and bunch weight (19.09kg). This yield improvement was also contributed by higher concentration of leaf N (2.49%), P (0.140%), K (3.60%), Mg (0.284%) and B (46.23ppm) caused by foliar application of boron in main crop. Application of 0.4% solubor was most effective in ratoon crop also maintaining higher growth and quality like main crop, influence of application time and its interaction with different levels of solubor yielded no significant response in terms of growth, yield or quality of Grand Naine banana. Besides, application of 0.4% solubor in eight month also maintained higher level of TSS, sugars ascorbic acid, total phenols, flavanoids and total chlorophyll content along with minimum %PLW and titrable acidity and higher starch degradation during storage period of nine days thereby providing quality fruits with better post harvest life in main crop. In ratoon crop by 0.4% solubor applied in sixth month exerted similar response on fruit quality and post harvest life. Finally, as per results of present study soil application of boron @ 7.5kg ha^{-1} in main crop while 5kg ha^{-1} in ratoon crop surpassed foliar application ensuring higher growth, yield, leaf nutrient content as well as fruit quality.

ABSTRACT

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Registration No.	**:**	**D/Hort./016/BAC/2013-14**
Degree of Programme	:	Ph.D.
Major Subject	:	Horticulture (Pomology)
Major Advisor	**:**	**Dr. R.R. Singh**
Year	:	2018
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Mango (*Mangifera indica* L.) of family Anacardiaceae is one of the most popular fruit of the tropical and sub-tropical region. In recent years high density planting is being promoted due to higher income per unit area. The high density planting is achieved by closer planting of 3.0 m X 2.5m in place of traditional planting distance of 10m×10m using dwarf varieties like Amrapali. The closer planting along with other cultural practices enhance the use efficiency of resources like land, water, fertilizer and solar radiation to its maximum potential. Application of vermicompost and bio fertilizer has been found to be beneficial in different fruit crops. Also, application of inorganic fertilizers like N, P and K are need to be standardize under high density planting. Thus, present investigation was undertaken with the objectives to standardize the nitrogen requirement of mango under high-density planting and to study the effect of levels of nitrogen, vermicompost and *Azotobacter* on phenology, yield and quality attributes of mango under high-density planting.

The experiment was laid out in factorial randomized block design with three replications as three factors namely nitrogen, vermicompost and *Azotobacter*. The four levels of nitrogen (60g, 80g, 100g, 120 g/plant), three levels of vermicompost (0 kg/tree, vermicompost @ 4.0 kg/plant and *in-situ* vermicomposting) and two levels of *A*zotobacter (0 g/tree and *A*zotobactor @ 200 g/plant) were taken for the experiment. The maximum fruit set (17.97%) was found with combined application of nitrogen 100 g/tree + vermicompost @ 4.0 kg/tree + *Azotobacter* @ 200 g/tree ($N_3 \times V_1 \times A_1$). The heaviest fruit of 203.85 g was found with combined application of nitrogen @ 120 g/tree + *in-situ* vermicomposting along with *Azotobacter* @ 200 g/tree which was statistically equal with nitrogen @120g/tree + *in-situ* vermicomposting in the absence of *Azotobacter* and nitrogen @120g/tree + vermicomposting @ 4.0 kg/tree in the absence of *Azotobacter*. The highest number of fruits/plant (82.35) was noted with the application of interaction of nitrogen @ 100 g/tree along with vermicompost @ 4.0 kg/tree. The plant supplied with nitrogen @ 100 g/tree along with vermicomposting @ 4.0 kg/tree and *Azotobacter* @ 200g/tree ($N_3 \times V_1 \times A_1$), gave the maximum TSS/acidity ratio (185.12), total carotenoid (18.75 mg/100g pulp) and total sugars (18.31 %). Soil health in terms of organic carbon, pH and nutrient content and microbial population improved with the application of nitrogen @ 120g + *in-situ* vermicomposting along with *Azotobactor* @ 200 g/plant.

DEPARTMENT OF HORTICULTURE (FRUIT & FRUIT TECHNOLOGY)
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Title: "Estimation of morphological and genetical variation in some mango (*Mangifera indica* L.) varieties using DUS testing's norms"

Abstract

The experiment entitled "Estimation of morphological and genetical variation in some mango (*Mangifera indica* L.) varieties using DUS testing's norms" was carried out in Horticulture Garden of Bihar Agricultural College, Sabour during the year 2015-16 and 2016-17 with the main objectives (1) to study the genetic diversity in mango varieties based on morphological and phenotypic characters and (2) to access the genetic diversity of mango accessions through molecular markers focused on analysis of genetic variability and divergence in mango genotypes. As many as 48 varieties were selected for study.

Wide range of variability was observed among various morphological traits like plant height (3.45-5.43 m), plant spread (3.18-4.63 m E-W direction & 3.21-4.68 m N-S direction), crown diameter (3.20-4.66 m), trunk circumference (45.03-67.04 cm.), crown height (0.72-1.34 m), canopy volume (23.09-52.95 m^3), canopy height (2.99-4.09 m), leaf length (12.15-33.40 cm), leaf width (2.55-10.19 cm) and petiole length (1.90-5.75 cm), inflorescence length (10.24-40.73 cm), inflorescence width (5.73-26.56 cm) and hermaphrodite flower per cent (6.25-30.06 %). A wide range of variability was observed in physical parameters of fruit traits also. The maximum fruit length (14.94 cm) was found in Alfazli, fruit diameter (10.59 cm) in Dholikothi Maldah at par with Alfazli (10.43 cm) and Vanraj (10.27 cm) and fruit weight (598.27 g) in Hathi Jhula, while minimum fruit length (4.68 cm), fruit diameter (4.45 cm) & fruit weight (73.29 g) were noted in Gilas. The highest range of variability was found in fruit weight i.e. 73.29 to 598.27 g among all characters of mango varieties. The wide range of variability was also observed in biochemical traits. Variety Sabri recorded highest TSS (23.49%) at par with Nisar Pasand, Bag Bahar, Rani Pasand, Bombai, Prabhashankar, Kala Pahar, Husnara and Neeludin (23.21 %, 23.07 %, 23.05 %, 22.89 %, 22.88 %, 22.74 %, 22.58 % and 22.58 %). The minimum mean value was obtained in Gilas (12.55 per cent) which showed at par with Irwin, Sanha Karbi and Safed Bathua having TSS i.e. 13.26 per cent and 13.31 per cent, respectively. The lowest titratable acidity (0.12 per cent) was obtained in variety Sabri and maximum (0.56 per cent) in Vanraj which was at par with Gilas (0.55 per cent).

At genetic level, more genetic variability was found in fruit weight among all characters in genetic parameters. Seven major clads were observed in dendrogram of morphological data using Euclidean D^2 analysis. Maximum varieties (14) were found in cluster IV that included Husnara, Dalma, Taimuria, Prabhashankar, Mulgoa, Vanraj, Sital Pasand, Sanha Karbi, Rangraj, Safed Bathua, Seso Maldah, Khatma Belkhar, Irwin and Nisar Pasand. Maximum intra cluster distance (1110.02) was noted in Cluster IV and inter cluster distance (8563.81) was noted between Cluster III and Cluster VI. Maximum range of cluster means was found in Cluster IV among overall clusters. Among 19 SSR markers, MiIIHR04c primer showed highest polymorphism having PIC value, 0.87. The number of alleles detected varied from 2 to 5.Two major clads were observed in dendrogram derived based on UPGMA cluster analysis using SSR markers, which was further divided into sub-clusters (2). As per this dendrogram, only one variety Peri Poona was found to be unique variety while others varieties were divided in two main clusters. On the basis of Jaccard's similarity co-efficient values, Menka and Hathi Jhula were found to be most closely related i.e. 0.78 and Peri Poona and Gourjeet genotypes were found to be most distantly related i.e. 0.31, respectively.

As per the above results obtained in present study, it is clear that these 48 genotypes are totally distinct from each other and SSR markers are an excellent genetical tool for the diversity analysis among different mango varieties.

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Topic : Studies on the effect of GA_3 application on physiological regulation of flowering and maturity in mango [*Mangifera indica* L.] cv. Langra".

Name of the Student : Mr. Deen Dayal Singh
Registration No. : D/Hort./04/BAC/2012-13
Major Advisor : Dr. Rewti Raman Singh

ABSTRACT

Mango (*Mangifera indica* L.) is one of the most important fruit crops of many tropical and sub-tropical countries of world which belongs to the family *Anacardiaceae* (Nakasone and Paul 1998 and Purseglove 1972).The experiment was carried out in Horticulture Garden of Bihar Agricultural College, Sabour during Rabi season of 2013 - 2015 with the objectives focused in this direction on the effect of GA_3 application on physiological regulation of flowering and maturity in mango [*Mangifera indica* L.] cv. Langra. A critical analysis of data revealed that wide range

of phonological observation was observed on morphological traits. The traits such as panicle emergence (14.55 Days), days to 50 % flowering (38.45 Days), bud break to full bloom (45.85 Days) and period of full bloom to maturity (110.43 Days) was recorded with gibberellic acid (GA_3) @ 100 ppm, respectively. The other traits like panicles per tree (1044.45) and maximum leaf area (89.73 cm^2) were recorded when application of gibberellic acid @ 200 ppm respectively. The other traits like length of panicles (26.73 cm) was recorded when application of gibberellic acid @ 0 ppm while flowering intensity (67.09 %) was recorded when spray of gibberellic acid @ 100 ppm. A wide range was observed with application of gibberellic acid on Physiological parameters. The trait such as photosynthetic rate (8.71 µmol/m^2/sec) and internal CO_2 concentration (283.80 ppm) was recorded with gibberellic acid @ 200 ppm while Stomatal conductance of leaf (0.163 µmol/m^2/sec) was recorded at the time of stone formation stage. The physical observations fruit set percentage (17.98 %) was recorded with gibberellic acid @ 50 ppm within pea stage and fruit retention percentage (0.67 %) and fruit drop percentage (99.01 %) was recorded with gibberellic acid @ 0 ppm within stone formation stage. The other traits like yield (288.73 Kg/ plant) and length of fruit (97.47 mm) was recorded with spray of gibberellic acid @ 100 ppm respectively. The other traits like pulp weight (210.00 g), edible: non edible ratio (2.69) and Pulp and stone ratio (6.11) was recorded with gibberellic acid @ 50 ppm, however, maximum stone weight (37.95 g) and peal weight (59.91 g) was recorded at the time of 20 days before expected harvest stage. A wide range of Chemical parameter was observed with application of different dose of gibberellic acid. The parameters such as total soluble solids (20.53 ^{0}Brix), acidity percentage (0.364 %), total sugar content (16.24 %) and ascorbic acid content (57.65 mg/ 100 g fruit weight) was recorded with gibberellic acid @ 100 ppm, respectively. The wide range of Leaf nutrient was observed with different dose of gibberellic acid. The parameters such as nitrogen content (1.31 %) and phosphorus content (0.109 %) was recorded with gibberellic acid (GA_3) @ 0 ppm. Other traits like potassium content (0.91 %) and iron content (79.52 ppm) and manganese content (58.86 ppm) and copper content of leaf (32.90 ppm) were recorded with gibberellic acid (GA_3) @ 200 ppm respectively. The traits like leaf calcium content (1.87 %) and magnesium content (0.188 %) was recorded with gibberellic acid (GA_3) @ 100 ppm while as leaf zinc content (19.97 ppm) was recorded with gibberellic acid (GA_3) @ 0 ppm.

ABSTRACT

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Degree programme	:	Ph.D
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Minor subject	:	Soil Science
Year	:	2019
Name of the University	:	Bihar Agricultural University, Sabour
Title of the Research Work	:	**"Effect of fertigation on physico-chemical, physiological and antioxidants attributes linked to fruit quality and granulation in Kinnow mandarin."**

ABSTRACT

A field experiment was conducted on Kinnow mandarin to find out the effect of fertigation on growth, physiological and biochemical parameters, nutrient acquisition by leaf, yield and granulation related changes in Kinnow mandarin at BAU, Sabour during the year 2016 and 2017 under different fertigation levels. There were five treatments comprising of ring and drip irrigation combined with fertilizers application in soil application and through drip system as fertigation. The experiment was conducted on 6-years old plants at Horticulture Garden, Bihar Agricultural College, Sabour. Observations on vegetative, physiological parameters and leaf nutrient status were recorded once in a year and biochemical analysis were done every month starting from September to December. Fertigation had significant effect on vegetative growth parameters of trees and response was good in comparison to soil application. The percent increase in plant height, stem girth and canopy spread was found maximum (87.69 %, 6.23 %, 70.22 % respectively) in treatment receiving 120 % NPK as fertigation (T_1) which was at par with the treatment T_2. The lowest was recorded in treatment with ring irrigation and broadcast methods of fertiliser application (T_5). Fertigation treatments resulted in significant variation in leaf nutrient content in Kinnow.

Higher nitrogen (2.81 %), phosphorus (0.19 %), potassium (1.71 %), iron (72.55 ppm), manganese (63.35 ppm), copper (20.54 ppm) and zinc (60.31 ppm) were recorded with fertigation with 120 % RDF (T_1). Available nutrient distribution in soil had shown a decreasing trend with increasing soil depths (0-15 to 30-60 cm). Physiological parameters like photosynthesis (9.08 µmol/m^2/sec), transpiration (0.82 µmol/m^2/sec), stomatal conductance (0.33 µmol/m^2/sec), leaf area (119.45 cm^2) , chlorophyll a content (2.82 mg g^{-1}), chlorophyll b content (0.43 mg g^{-1}), total chlorophyll content (2.82 mg g^{-1}) and total carotenoids content (2.03 mg g^{-1}) in the leaves of Kinnow trees were observed maximum in T_1 with minimum content in control (100 % RDF as soil application) whereas, internal CO_2 concentration (312.93 ppm) was found highest in T_1 but least in T_4 (60 % RDF as fertigation). Fruit physical parameter like fruit weight (164.82 g), Fruit diameter (6.94 cm), fruit length (6.90 cm), was found maximum in T_1 but highest juice per cent (44.76 %) in T_2 and it increases as fruit matures and reached to maximum value in the month of December (M_4). However, peel thickness (3.44 mm) was maximum in T_1 and decreases from the month of September to December as fruit matures and undergoes towards ripening.

No. of fruits at the time of harvest (59.25) and yield (12.64 kg /tree) was found maximum in T_1 and lowest in control. The maximum TSS (9.56 ^{0}Brix), TSS: acid ratio (12.13), ascorbic acid (32.35 mg/100 g) ,total sugars per cent (6.84 %), flavonoids content (0.37 mg/ml) in fruit juice and total carotenoids content (23.05 µg/g FW) in peel were found under fertigation with T_1 and it's value increases from the month of September to December as fruit matures and undergoes towards ripening while titrable acidity was found maximum (1.38 %) in control and with advancement in fruit maturation its value decreases.

Total chlorophyll content in peel was recorded maximum(23.57 µg/g FW) in T_1 minimum in control and it decreases as fruit matures. Total phenols content (0.75 mg/ml) and total antioxidant activity (8.32 µmol Trolox /g FW) were found maximum in T_1 and its value were more at the time of first sample investigation in the month of September (M_1) then, it decreases in October month and then, again start to rise and reached to peak value at last harvest i.e. in the month of December (M_4). Degree of granulation found maximum (1.75 %) in T_4 (60 % RDF as fertigation) which is at par with T_3 and minimum degree in T_1. Enzymatic activity linked to granulation as like diastase activity was recorded highest (24.80 mol/min.) in T_2 (100 % RDF as fertigation) and lowest (16.81 mol/min) in T_4 and with advancement in fruit ripening diastase activity decreases. However, for the pectin esterase activity, there was non significant effect of the different fertigation treatments but its value decreases as fruit undergoes maturation. Therefore, it can be concluded that economically, fertigation with 100 % RDF, NPK can be recommended for splits application for young Kinnow orchards and harvest the fruit in the month of December which having all optimum measure of biochemicals that pertains its excellent fruit quality.

ABSTRACT

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Minor subject	:	Plant Breeding and Genetics & Agronomy
Year	:	2019
Name of the University	:	Bihar Agricultural University, Sabour
Title of the thesis	:	**"Runner production of strawberry and its survivability in subtropical condition of Eastern India."**

The cultivated strawberry (*Fragaria x ananassa* Duch.) belongs to family Rosaceae is a natural hybrid, derived from two North American species, Scarlet (*Fragaria virginiana* Duch.) and Chilean (*Fragaria chiloensis* Duch.). This is an octaploid (2n=8x=56) developed in France during the 17th Century. Due to

popularity of strawberry, there is need of cultivation of strawberry but insufficient planting material is major limiting factor. As we know, commercially strawberry is propagated by runner therefore keeping the facts we need huge planting materials for the fulfilment of cultivation of strawberry. In view of potential commercial value of this crop, it is highly desirable to develop an efficient tissue culture protocol as well as runner production in field condition for rapid and large scale multiplication of strawberry under Bihar conditions.

In the experimental results, sterilizing agent $HgCl_2$ @ 0.1 % for 3 minutes was effective for 70 % establishment. The other parameters like the minimum number of days taken for shoot proliferation (21.67) and the maximum number of shoot generated per explant (5.40) were found in MS media supplemented with BAP @ 3.0 mg/l + NAA @ 0.5 mg/l respectively. The maximum shoot length (5.80 cm) was found in MS media consisting with BAP @ 3.0 mg/l and the maximum number of leaves per generated shoots (6.04) was found in MS media added with BAP @ 4.5 mg/l + NAA @ 0.5 mg/l. The maximum root formation (53.96 %), root length (4.80 cm), number of root generated per shoot (6.80) and the number of days taken for root initiation (18.40) were achieved in half MS media consisting with IAA @ 1.5 mg/l.

Strawberry plantlets obtained through micropropagation exhibited 20-60 per cent survival during acclimatization in different potting mixtures. In the field condition, the maximum plant height (28.54 cm), plant spread (39.00 cm), crown diameter (42.68 mm), petiole length (12.53 cm), number of leaves per plant (25.60), number of runner per plant (15.73), runner length (23.27 cm) and leaf area (36.52 cm^2) were found with application of GA_3 @ 250 ppm.

The results described various factors that influence the phenolic exudation, establishment, shoot proliferation, shoot multiplication, root induction and acclimatization of strawberry as well as runner production with application of GA_3 @ 250 ppm in order to make it commercial production of strawberry planting materials for future perspective.

ABSTRACT

Name of the Student	**:**	**Suparna Sinha**
Registration No.	**:**	**D/Hort./47/BAC/2015-16**
Chairman, Advisory Committee	**:**	**Dr. Rewati Raman Singh**
Major Subject	:	Pomology
Minor Subject	:	Postharvest Technology
Year	:	2019
Name of the University	:	Bihar Agricultural University, Sabour
Title of the Thesis	**:**	**Pre and postharvest approaches to**

improve quality of mango (*Mangifera indica* L.) cv. Zardalu

Zardalu mango is gaining immense popularity and area under its cultivation is increasing due to its desirable attributes like regularity, prolific bearing and good fruit quality. The excellent blend of sugar and acid in pulp with attractive peel and pulp colour makes the Zardalu fruit for fresh consumption as the demand of the fruit has increased in national and export market. The fruits of Zardalu mango are highly perishable and cannot be stored for long as it becomes over ripe and get spoiled within 6-7 days under ambient condition. The information on this aspect to prolong postharvest life is important in view of utilization of Zardalu mango fruits for distant marketing and export. Thus an experiment was postulated for a careful examination of the use of two pre and postharvest imposition of chemicals at two different concentration i.e SA (1.0 mM & 2.0 mM), GA (1.0 mM & 2.0 mM), SNP (1.0 mM & 2.0 mM) along with untreated control to increase the shelf life of mango cv. Zardalu. The treatments as pre and/or postharvest applications exhibited significant effect on extending shelf life and quality of fruits during storage. It was observed that postharvest dipping of fruits were noted better as compared to pre-harvest foliar feeding of the same chemicals under present experiment. Dipping of fruits immediately after harvest came up with about two fold decrease in weight loss when compared with pre-harvest spraying. However, among different postharvest treatments use of SA @ 2.0 millimolar retained the maximum value of peel thickness, AsA and total chlorophyll content throughout ambient storage. Among different pre-harvest treatments also use of SA @ 2.0 millimolar came up with least loss in weight, peel thickness with higher retention of ascorbic acid (AsA) content. Among different pre and postharvest treatments use of SA @ 2.0 millimolar concentration was found the best treatment with maximum retaintion of peel thickness, TA, AsA content and TPC throughout storage.

Thus we conclude that with the use of SA @ 2 millimolar as a preharvest and/or as a postharvest application came up with enhanced shelf-life of mango fruits for at least three days as compared to untreated control at ambient temperature.

ABSTRACT

Name of the Student	**:**	**Suparna Sinha**
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Chairman, Advisory Committee	**:**	**Dr. Rewati Raman Singh**
Major Subject	:	Pomology
Minor Subject	:	Postharvest Technology

Year	:	2019
Name of the University	:	Bihar Agricultural University, Sabour
Title of the Thesis	**:**	**Pre and postharvest approaches to improve quality of mango (*Mangifera indica* L.) cv. Zardalu**

Zardalu mango is gaining immense popularity and area under its cultivation is increasing due to its desirable attributes like regularity, prolific bearing and good fruit quality. The excellent blend of sugar and acid in pulp with attractive peel and pulp colour makes the Zardalu fruit for fresh consumption as the demand of the fruit has increased in national and export market. The fruits of Zardalu mango are highly perishable and cannot be stored for long as it becomes over ripe and get spoiled within 6-7 days under ambient condition. The information on this aspect to prolong postharvest life is important in view of utilization of Zardalu mango fruits for distant marketing and export. Thus an experiment was postulated for a careful examination of the use of two pre and postharvest imposition of chemicals at two different concentration i.e SA (1.0 mM & 2.0 mM), GA (1.0 mM & 2.0 mM), SNP (1.0 mM & 2.0 mM) along with untreated control to increase the shelf life of mango cv. Zardalu. The treatments as pre and/or postharvest applications exhibited significant effect on extending shelf life and quality of fruits during storage. It was observed that postharvest dipping of fruits were noted better as compared to pre-harvest foliar feeding of the same chemicals under present experiment. Dipping of fruits immediately after harvest came up with about two fold decrease in weight loss when compared with pre-harvest spraying. However, among different postharvest treatments use of SA @ 2.0 millimolar retained the maximum value of peel thickness, AsA and total chlorophyll content throughout ambient storage. Among different pre-harvest treatments also use of SA @ 2.0 millimolar came up with least loss in weight, peel thickness with higher retention of ascorbic acid (AsA) content. Among different pre and postharvest treatments use of SA @ 2.0 millimolar concentration was found the best treatment with maximum retaintion of peel thickness, TA, AsA content and TPC throughout storage.

Thus we conclude that with the use of SA @ 2 millimolar as a preharvest and/or as a postharvest application came up with enhanced shelf-life of mango fruits for at least three days as compared to untreated control at ambient temperature.

ABSTRACT

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Chairman, Advisory Committee	**:**	**Dr. M. Feza Ahmad**
Degree Programme	:	Ph. D
Major Subject	:	Horticulture (Pomology)
Minor subject	:	Postharvest Technology
Year	:	2019
Name of the University	:	Bihar Agricultural University, Sabour
Title of the Thesis	**:**	**Mineral nutrient studies in papaya *(Carica papaya* L.*)* cv. Red Lady under alluvial soil of Bihar**

An experiment entitled **"Mineral nutrient studies in papaya (*Carica papaya* L) cv. Red Lady under alluvial soil of Bihar"** was conducted during 2016-18 at the experimental site of Department of Horticulture (Fruit & Fruit Technology), BAC, Sabour to the main objective of the study was to verified effect of different source of fertilizers and its various doses on the quantitative and qualitative characteristics along with mineral nutrient uptake pattern during different growth stages of papaya. Treatments comprising three levels each of neem coated urea (0, 100 and 200 g/plant), calcium nitrate (0, 100 and 200 g/plant) and murate of potash (0, 200 and 400 g/plant) alone and its combination were taken under Randomised Block Design (factorial) with two replication. In each replication four plants has been considered as an experimental unit. In another experiment, three harvesting time (7 A.M, 12 P.M and 5 P.M) under RBD were also chosen to evaluate the effect of harvesting time on postharvest shelf life of papaya fruits. Significant variation among physical and quality parameters, nutrient content of leaf petiole and fruit at different developmental stages of papaya was observed. The vegetative parameters like plant height, stem thickness and no. of leaves/plant increased as the duration of planting increases, but the growth was faster at 3rd to 6th month of planting. After 7 month of planting, plant height, stem thickness and no. of leaves/plant varies from 99.34 to 103.05 cm; 67.91 to 76.90 mm & 18.55 to 20.89 for individual application and93.97 to 109.67 cm; 66.99 to 84.93 mm & 16.74 to 22.31 respectively due to interaction of these fertilizer sources. The total no. of flowers per plant increased significantly as the level of fertilizer increases alone (19.33-21.53) and its combination (18.00-22.29). From this study, we found that no. of fruits increased significantly with the increase of nitrogen and potash doses (14.97 to 18.14). Fruit weight increased up to 100 g dose of nitrogen then decreased at higher dose (200 g); however, it increased with the increase of potash level from 0 to 400g during both the year (0.896-0.928 kg and 0.890-0.956 kg respectively). Fruit yield varies from 13.79- 17.22 kg/plant and 16.10 - 19.41 kg/plant in 1st and 2nd year respectively. The quality parameters *viz.,* TSS and carotenoid content of fruits were found significant in alone (7.77-8.88 °B and 2.29 -

2.67 mg/100g, respectively) and combination of nitrogen and potash (7.28 - 9.00 °B and 1.75 - 2.94 mg/100g, respectively). Acidity content of fruit varies from 0.33-0.35 %. Firmness of fruit varies from 8.81- 9.57 kg/cm^{2}in alone application of all these fertilizers.

Nitrogen content of leaf petiole (1.48-1.87 %) increased with the increase of nitrogen and potash level; however, phosphorus (0.19 % - 0.23 %) and potash (2.01 % - 2.44 %) content of leaf petiole increased only up to 100 g concentration and then decreased in 200 g of applied nitrogen. Similarly, calcium and magnesium content of papaya petiole decreased as the levels of neem coated urea increased (1.31 % - 1.23 % and 0.63 % - 0.59 %) but their content increased with increasing levels of MOP (1.21 % - 1.31 % and 0.58 % - 0.63 %, respectively). The zinc and copper content of leaf petiole increased up to 100 g neem coated urea and then decreased at higher dose (200 g) whereas, Zn and Cu content increased with the increase of $CaNO_3$ and MOP level (19.19 - 20.75 ppm and 2.44 - 2.93 ppm, respectively). The iron and manganese content of petiole increased continuously with increasing levels of neem coated urea increases (30.76 - 43.01 ppm and 17.15 - 20.39 ppm); whereas, Fe and Mn content increased only up to 100 g of $CaNO_3$ and 200 g dose of MOP.

Similarly, the nutrient content of fruit at different growth stages from fruit set to ripening was recorded. Nitrogen and potash content decreased from fruit set (0.48 % and 2.02 %) to maturity stage (0.21 % and 1.81 %) and then again increased at ripening stage (1.33 % and 1.96 %) respectively. Similar pattern was observed for iron content in the fruit. However, the phosphorus content increased up to maturity (0.41 % to 0.58 %) and then decreased at ripening stage (0.29 %). The calcium content in the fruit fall drastically from fruit set to maturity (1.54 % - 0.16 %) and then increased at ripening stage (0.51 %). However, magnesium, zinc, manganese and copper content of fruit decreased continuously from fruit set to ripening.

Data related to quality parameters of harvested fruit at different time of the day and storage at ambient condition were varied significantly. The TSS content of fruit ranged from (8.48 to 9.95 °Brix), acidity (0.25 % to 0.29 %), TSS-Acidity ratio (30.27 to 38.25), PLW, (15.12 % to 19.81 %) and fruit volume (517 to 822 ml) at 9th day of storage. Whereas, ascorbic acid content varies between 26.62 - 54.47 mg/100 g, phenol, 143.63 - 178.05 mg GAE/100g FW and carotenoid, 3.13 - 4.46 mg/100 g at 9th days of storage. The highest fruit firmness (7.20 kg/cm^2) recordedat 5 PM and lowest (4.88 kg/cm^2) at 12 P.M.

Out of three levels of two nitrogenous fertilizers, calcium nitrate was found significantly superior over neem coated urea. Among different combinations, calcium nitrate @ 200g along with 100g neem coated urea showed best result. Interaction of neem coated urea @ 200 g, $CaNO_3$ @ 100 g and MOP @ 400g showed

best among different combination in governing the plant morphology. Among the different harvest time 5 PM harvested fruit show overall good in preserving antioxidant properties and quality of fruit for longer duration. After 6th days of storage fruit losses its market value due to loss of moisture firmness and appearance.The findings of these research might be beneficial for farmer to give optimum doses of nitrogen and potash at proper growth stage, and harvest the fruit at optimum time of the day, so that plant produce optimum yield and quality fruit with maximum storage life after harvesting.

ABSTRACT

Name of the student	**:**	**Miss. Abha Kumari**
Registration No.	**:**	**D/HORT-F/87/BAC/2016-17**
Chairman, Advisory Committee	:	Dr. Ruby Rani
Degree program	:	Ph.D.
Major Subject	:	Horticulture (Fruit Science)
Minor Subject	:	Molecular biology & Genetic Engineering
Year	:	2020
Name of University	:	Bihar Agricultural University, Sabour
Title of the Thesis	**:**	**Impact of bio-inoculants on growth and establishment of litchi [*Litchi chinensis* Sonn.] plants**

The present investigations entitled "Impact of bio-inoculants on growth and establishment of litchi [*Litchi chinensis* Sonn.] plants" were carried out during 2017-2019 in the Department of Horticulture (Fruit and Fruit Technology), BAU, Sabour. Three separate pot experiments was laid out in CRD with nine treatments consisting of different doses of three species of VAM i.e. *G mosseae*, *G coronatum* and *G decipiens*, *Azospirillum spp.* and *Trichoderma viride* alone or in combinations with the objective to increase the plant survival of litchi layers and seedlings with better plant growth. The plant morphological parameters, physiological parameters, growth parameters, soil biological parameters, soil and leaf nutrient status and survival of plants in nursery were taken at different time interval. It was found that treatment combination of *Azospirillum spp.* + *G. mosseae* followed by *Azospirillum spp.* + *G. coronatum* and *Azospirillum spp.* + *G decipiens* were the most effective treatments in improving growth parameters in term of plant height, number of leaf, leaf area, leaf area index, total biomass, fresh and dry wt. of shoot while better root development such as root size, root biomass and root development was found in single

inoculation of AM fungi and *G. mosseae* was the best among the species of AM fungi used in the experiment. Physiological parameters, relative water content and total chlorophyll content was found highest for co-inoculation of AM fungi and *Azospirillum spp*. Biological parameters included microbial population, colonization and dehydrogenase activity (DHA) significantly increased by the application bio-inoculants. Co-inoculation of *Azospirillum spp.* + *G. mosseae* performed better for microbial population and dehydrogenase activity, while root colonization was more pronounced in the growing media consisting AM fungi. Better leaf nutrient content in terms of nitrogen, phosphorus, potassium and micronutrients (Cu, Zn, Fe, Mn) was recorded with co-inoculation of three different species of mycorhhizae and *Azospirillum spp.* on all dates of observations. Application of *Azospirillum spp.* + *G mosseae* and *Azospirillum spp.* + *G. coronatum* was the most effective in this regard. Co-inoculation of AM fungi and *Azospirillum spp.* retained high soil nitrogen. However no significant effect of treatment was noted regarding phosphorus and potassium of soil. The highest plant survival and establishment of layered litchi plants and seedlings was noted for the treatment co-inoculation of *Azospirillum spp.* with AM fungi. Application of *Azospirillum spp.* + *G. mosseae* was the best treatment in minimizing plant mortality. It can be concluded that application of co-inoculation of bio-inoculants were the effective treatment to shorten the problem of higher mortality rate in nursery & field and slow rate of plant growth as compare to other treatments. However, application of *Azospirillum spp.* + *G mosseae* was found to be the best treatment.

List of Ph. D. passed out students from the Department of Horticulture (Vegetable & Floriculture),

Sl. No.	Name of student	Major Advisor	External Examiner	Publications from thesis
1.	Hemant Kumar Singh, D/Hort./11/BAC/2012-13	Dr. Randhir Kumar	Dr. Gita Prasad Sahni, Ex Assoc. Prof.—	Singh, H.K., Randhir Kumar, Akhtar, S. and Adarsh, A. (2017).Seasonal Variation and Genotypic Variability Studies on Bottle Gourd for Yield and it's Attributing Traits. International Journal of Agriculture, Environment and

			cum Sr. Scientist, BPAC, Purnea	Biotechnology. 10(3): 357-366.
2.	Pankaj Kumar Ray, D/Hort./10/BAC/2012-13	Dr. Randhir Kumar	Dr. D. N. Chaudhary, Ex Univ. Prof.—cum Chairman, BAC, Sabour	Under process
3.	Jagdeep Chaurasiya, D/Hort./15/BAC/2013-14	Dr. R. B. Verma	Dr. Sudhakar Pandey, Principal Scientist, ICAR – IIVR, Varanasi, U.P.	Jagdeep Chaurasiya, **R B Verma**, R K Verma,G S Panwar, V B Patel and B C Saha 2018. Effect of weed management practices on growth, yield and quality of onion. *Indian Journal of Horticulture,*75 (4): 717-722
4.	Md. Mukhtar Ahmad, D/Hort./13/BAC/2013-14	Dr. R. B. Verma	Dr. D. R. Bhardwaj, Principal Scientist, ICAR – IIVR, Varanasi, U.P.	Under process
5.	Rajesh Kumar, D/Hort./14/BAC/2013-14	Dr. Randhir Kumar	Dr. D. R. Bhardwaj, Principal	Kumar, R, Randhir Kumar,Prasad, B.D.,SolankeyS.S., Kumar, J. and Bamaniya,B.S. (2018).Genetic variation study usingmorphological and DNA marker- based genotyping in bottle

			Scientist, ICAR – IIVR, Varanasi, U.P.	gourd. Current J. of Applied Sci. Tech. 31(2): 1 – 10.
6.	Anupam Adarsh D/Hort./26/BAC/2014-15	Dr. Randhir Kumar	Dr. Sudhakar Pandey, Principal Scientist, ICAR – IIVR, Varanasi, U.P.	Adarsh, A., Randhir Kumar, Singh, H.K. and Bhardwaj, A.(2018). Heterosis Study in Bitter Gourd for Earliness and Qualitative Traits. *International Journal of Current Microbiology and Applied Sciences.* Special Issue-7 pp. 4239-4245.
7.	Neetu Nand D/Hort./25/BAC/2014-15	Dr. Randhir Kumar	Dr. Sudhakar Pandey, Principal Scientist, ICAR – IIVR, Varanasi, U.P.	Nand, N., Adarsh, A., Kumar, P., Prasad, B.D., Randhir Kumar, Verma, R.B., Kumar, R. (2019). Implementation of molecular markers for sex identification in pointed gourd (*Trichosanthes dioica* Roxb.*). J. Biot. and Crop Sci.* 8(12): 79-83.
8.	Amit Kumar D/Hort./24/BAC/2014-15	Dr. Randhir Kumar	Dr. Anil Kumar Singh, Asstt. Prof., DRCAU, Pusa, Bihar	Amit Kumar, Roy, C., Ravi Kumar, Randhir Kumar, Singh, V.K. and Verma, R.B. (2018) Study of genetic divergence for earliness and yield attributing traits in tropical cauliflower (*Brassica oleracea* var. *botrytis* L). *J. Pharmacognosy and Phytochem*. 7(2): 1761-1763.
9.	Rashmi Kumari D/Hort./50/BAC/2015-16	Dr. Randhir Kumar	Dr. S. K Singh, Professor, College	Kumari R., Kumar R., Akhtar **S**, Verma RB, Chand G, Kishore C (2019). Heterosis for Yield and Quality Traits in Eggplant Hybrids Grown in Rainy Season. *Environment and Ecology*. 37 (3B):

			of Agriculture, Indore, M. P.	971-978. Website: environmentandecology.com ISSN 0970-0420
10.	Amrita Kumari D/Hort./ 40/BAC/2015-16	Dr. Sangeeta Shree	Dr. G.C. Yadav, Assoc. Prof., NDUAT, Kumarganj, Ayodhya, U.P.	1. Kumari A, **Shree** S, Kumar R, Haque M, Kishor C, Singh, V.K. 2019. Study of *Per se* Performance of Parents and Hybrids for Yield and Quality of Bittergourd (*Momordicacharantia*L.). *Int.J.Curr.Microbiol.App.Sci.* 8(07): 1781-1789.doi: https://doi.org/10.20546/ijcmas.2019.807.212 2. Kumari A, **Shree S**, Kumar R, Kishore C, Singh, VK, Haque M. 2020. Estimation of Heterosis for Yield and Quality traits in Bitter Gourd (*Momordicacharantia L.). Int.J.Curr.Microbiol.App.Sci.* 9(02): 1614-1623.doi: https://doi.org/10.20546/ijcmas.2020.902.185

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Reg. No.: D/Hort./11/BAC/2012-13
Ph.D. (Ag.) Horticulture (Olericulture)

Topic 'Stability analysis in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]'

ABSTRACT

The experiment entitled "Stability analysis in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]" was undertaken with the objectives (i) to estimate genetic variability in parents (ii) to estimate heterosis all possible parental combination (iii) combining ability variances and their effects, and gene action for yield and yield attributes, and (iv) to estimate stable genotypes and hybrids for planning of an appropriate strategy for development of high yielding bottle gourd genotypes/ hybrid as with stable as well as breeding procedure. The materials of experiment consisted of nine diverse parents (Rajendra Chamatkar (P_1), Pusa Santushti (P_2), Pusa Naveen (P_3), Narendra Dharidar (P_4), SBBG-23 (P_5), SBBG-32 (P_6), SBBG-31-1 (P_7), SBBG-11 (P_8) and HZP-RC-1 (P_9) and their 36 F_1s obtained by crossing in diallel fashion were conducted in randomized complete block design in three replications and three seasons *viz.*, Early winter season (Eew, 3rd week of August-2013), Early summer season (Ees, 2nd week of November-2013) and Summer/ Main season (Es, 1st week of February-2014) having each experimental unit of single row with spacing of 4.0 m x 0.5 m at Vegetable Research Farm, Bihar Agricultural University, Sabour.

The presence of high heritability in broad sense (h^2_{bs}) along with high genetic advance in per cent of mean were observed for node number of pistillate flower in early winter season, average fruit weight, fruit length, and number of fruits per plant in over the environments and pooled showing additive gene effect.

High level of standard heterosis with respect to fruit yield in the top three ranking hybrid *viz*; $P_1 \times P_4$ (17.62 %), $P_1 \times P_2$ (17.21 %) and $P_3 \times P_4$ (16.96 %) in early summer crop and other three top crosses in off season early winter crop *viz*; $P_2 \times P_3$ (21.55 %), $P_3 \times P_4$ (20.12 %) and $P_3 \times P_6$ (18.75 %) asserted the hybrids in bottle gourd.

The three best cross combinations on the basis of *per se* performance for yield per plant during early winter season $P_2 \times P_3$ (6.79 kg) followed by $P_3 \times P_4$ (6.71 kg) and $P_3 \times P_6$ (6.63 kg); for early summer crops the three best hybrids were $P_1 \times P_4$ (6.65 kg) followed by $P_1 \times P_2$ (6.63 kg) and $P_3 \times P_4$ (6.61 kg); for summer season crop the three top ranking hybrids were $P_2 \times P_7$ (9.77 kg) followed by $P_3 \times P_6$ (9.67 kg) and $P_8 \times P_9$ (9.57 kg). The study further revealed that two parents either P_3 (Pusa Naveen) and P_9 (HZP-RC-) or both were invariably involved as parents (s) in the *per se* performance and g.c.a in the top three parents over the environments for almost traits. Magnitude of $\acute{\sigma}^2$g was higher than $\acute{\sigma}^2$s, and their ratios $\acute{\sigma}^2$g/$\acute{\sigma}^2$s were more than unity for calcium content in fruit, protein content in seed in Eew, Ees, Es and P; and ascorbic acid content in fruit in Eew, which indicate that these traits predominantly governed by additive gene action. While for the remaining characters indicate the ratios $\acute{\sigma}^2$g/$\acute{\sigma}^2$s was less than unity in all the environments as well as pooled analysis indicating therefore, preponderance of non-additive type of gene action. The found that high s.c.a. effects for the sixteen characters over the three environments and in pooled analysis in desirable direction, 88 crosses were the

produce of parents having high gca × low gca, 98 crosses were the produce of parents with low gca × high gca, whereas, only 3 crosses were produce of parents with low gca × low gca and high gca × high gca effects.

The result shown that inbreds and their hybrids had high ($\bar{X}_1$), bi = 1 and S^2di= 0 for average fruit weight in ten (01 parent and 09 hybrids) viz. HZP-RC-1, Pusa Santushti × Pusa Naveen, Pusa Santushti × SBBG-31-1, Pusa Naveen × Narendra Dharidar, Narendra Dharidar × SBBG-31-1, Narendra Dharidar × SBBG-11, Narendra Dharidar × HZP-RC-1, SBBG-32 × SBBG-31-1, SBBG-23 × HZP-RC-1 and SBBG-31-1 × HZP-RC-1. While, the only hybrid Pusa Naveen × HZP- RC-1 was found stable for fruit yield per plant, and Pusa Naveen × SBBG – 31-1 for ascorbic acid over the environments.

Bihar Agricultural University

Sabour, Bhagalpur, Bihar

Topic : **Introgression of gene for tomato leaf curl virus [ToLCV] resistance/ tolerance in tomato (*Solanum lycopersicum* L.)**

Speaker : Mr. Pankaj Kumar Ray

Registration No. : D/HORT/10/BAC/2012-13

Major Advisor : Dr. Randhir Kumar

ABSTRACT

Tomato (*Solanum lycopersicum* L.) belongs to the family Solanaceae and is the fourth most economically important crop in the world: after rice, wheat, and soybean (Nowicki *et al*., 2013). China is the world's leading tomato producing country with 30.7 per cent share followed by India with 11.5 per cent share (Anonymous, 2014). At present the hybrid cultivars were getting boon in tomato all over the world for higher yield, quality and disease resistance. Therefore, the present investigation were carried out with entitled "introgression of gene for tomato leaf curl virus [ToLCV] resistance/ tolerance in tomato (*Solanum lycopersicum* L.)." was carried out at the Vegetable Research Farm, Department of Horticulture (Vegetable & Floriculture), Bihar Agricultural University, Bhagalpur, Bihar to know the extent of heterosis, assessing combining ability and generating information on gene action for tomato leaf curl virus [ToLCV] resistance/ tolerance in tomato. In this respect sixteen diverse parents (12 lines and 4 testers) were selected and intermated in a line x tester fashion and in the next year forty eight crosses along with 16 parents were evaluated in RBD. Analysis of variance showed significant differences among all the genotypes for all the characters under study. The genotypes, IC-395457 and *Solanum peruvianum* among parents while H-86 × *Solanum peruvianum* and Arka Meghali × IC-395461 among cross combinations were found superior for earliness. Heterobeltiosis for fruit yield and quality traits was recorded significantly positive in LA-3948 × Pusa Rohini, H-86 × *Solanum peruvianum* and LA-3967 × IC-395461. Maximum negative heterosis for ToLCV incidence

was observed in LA-3948 × Pusa Rohini, H-86 × *Solanum peruvianum* and LA-3952 × *Solanum peruvianum*. For yield and quality traits LA-3930 and *Solanum peruvianum* was good general combiner. H-86 × *Solanum peruvianum*, LA-3948 × Pusa Rohini and LA-3952 × IC-395457 were good specific combiners for number of fruits per plant, harvest duration and fruit yield traits. Cross combinations *viz.* H-88-78-5 × IC-395457, Pant-T-5 × *Solanum peruvianum* and LA-3952 × IC-395461 were good specific combiners for all quality traits. LA-3976 was good general combiner for tomato leaf curl virus infestation. According to scaling test and generation mean analysis, epistasis (non-allelic interactions) and both additive and non-additive gene actions were found operating in the inheritance of almost all characters. Variance ratio was also found less than one for all the character except number of fruit per plants and phenol content, again it confirmed the predominant role of non-additive gene action for controlling almost all the characters. On the basis of investigation, H-86 × *Solanum peruvianum*, LA-3948 × Pusa Rohini and H-86 × Pusa Rohini were found most promising hybrids for yield and ToLCV tolerance in tomato and can be used in future breeding programme.

Department of Horticulture (Vegetable and Floriculture)
Bihar Agricultural University, Sabour 813 210, Bhagalpur, Bihar

Title of the Thesis	:	Effect of weed management practices on weed dynamics, growth, yield and quality of onion (*Allium cepa* L.)
Name of the Student	:	Mr. Jagdeep Chaurasiya
Registration No.	:	D/Hort./15/BAC/2013-14
Major Advisor	:	Dr. R. B. Verma

ABSTRACT

Onion (*Allium cepa* L.) is an important commercial crop of family Amaryllidaceae. The productivity of crop is affected due to several factors in which weed infestation is the global problem and reduces the bulb yield to a tune of 40-80 % depending on types of weed flora and their intensity. Besides having a shallow root system, onions are usually planted at very closer spacing which possess a problem in weeding and increase the cost of cultivation. Under such surroundings, herbicides are the best alternatives which are economically feasible. With this in view the present experiment was conducted at vegetable research farm Bihar Agricultural University, Sabour during 2014-15 and 2015-16 to appraise the efficacy weed management practices on weed dynamics, crop growth, yield and quality of onion. The 16 treatments were evaluated in randomized block design with three replications. The results revealed that, the predominated weed species were *Cynodon dactylon* L., *Cyperus rotundus* L., *Eleusine indica* (L.) Gaerth, *Polypogon monspeliensis* (L.) Desf., *Phalaris minor* L., *Chenopodium album* L., *Tridax procumbens*, *Rumex occidentalis* L., *Digera muricata*, *Phyllanthus niruri* L., *Anagallis arvensis* L., *Argemone mexicana* L., *Fumaria parviflora* Lam., *Coronopus didymus*, *Melilotus* spp., *Parthenium hysterophorus* L. The lowest weed population, their fresh and dry weight of weeds, weed index and N P K uptake by weeds and highest weed control efficiency and also all the growth and yield characters viz., plant height, No. of leaves per plant, fresh and dry weight of plant, average bulb weight, neck thickness, polar and equatorial diameter of bulb and bulb yield were observed higher and equally effective under treatments T_{15} (weed free check), T_{12} (PRE-Oxyfluorfen @ 250 g a.i. ha^{-1} + one hand weeding at 35 DAT) followed by treatment T_6 (PRE-Oxyfluorfen @ 250 g a.i. ha^{-1} + Oxyfluorfen @ 250 g a.i. ha^{-1} at 35 DAT) and T_{10} (PRE-Pendimethalin @1000 g a.i. ha^{-1} + Oxyfluorfen @ 250 g a.i. ha^{-1} at 35 DAT). The quality parameters *viz*; total soluble solids (TSS %) Total sugar (g 100 g^{-1}) and dry matter content of bulb (%) were not influenced by the different treatments of weed management. Highest benefit: cost ratio (2.20) was recorded under treatment T_6 (PRE-Oxyfluorfen @ 250g a.i. ha^{-1} + Oxyfluorfen @ 250 g a.i. ha^{-1} at 35 DAT) with net returns of Rs. 180793.00 ha^{-1} followed by 2.19 B: C ratio under treatment T_{12} (PRE-Oxyfluorfen @ 250 g a.i. ha^{-1} + one hand weeding at 35 DAT) with net return of Rs. 195075.00 ha^{-1}.

(R. B. Verma)	(Jagdeep Chaurasiya)
Chairman of Advisory committee	Student

ABSTRACT

Name of the student	**:**	Mukhtar Ahmad
Registration Number	**:**	D/Hort./13/BAC/2013-14
Degree Progamme	**:**	Ph.D (Ag.)
Major Subject	**:**	Olericulture
Minor Subject	**:**	Plant Breeding and Genetics
Year	**:**	2018
Chairman of Advisory Committee	**:**	Dr. R.B Verma
Department	**:**	Deptt. of Horticulture (Veg. & Flor.)
Thesis title	**:**	**"Genetic Divergence in Pointed Gourd for Antioxidant, Nutritional and Postharvest Quality."**

An experiment was conducted during 2014-15 and 2015-16 at Vegetable Research farm, Bihar Agricultural University, Sabour (Bhagalpur) to study the existing genetic variability and to assess the genetic diversity among twenty-five genotypes of pointed gourd. The analysis of variance revealed highly significant differences among the genotypes for all the twenty-two characters studied. High heritability accompanied with high genetic advance as per cent of mean were recorded for total flavonoids (77.38 %) chlorophyll 'b' (72.85 %), total phenols (71.14 %), titratable acidity (57.45 %), number of marketable fruits per plant (53.52 %), yield of marketable fruits per plant (47.26 %), CUPRAC (46.58 %), carotenoids (40.11 %), number of primary branches per plant (38.95 %), chlorophyll 'a' (38.68 %), node number at which first female flower appears (37.58 %), average fruit weight (28.00 %) and fruit length (22.31 %). Correlation analysis revealed that the yield of marketable fruits per plant was significantly and positively correlated with fruit length (0.23), number of marketable fruits per plant (0.82) and titratable acidity (0.23). Path analysis further revealed that the number of marketable fruits per plant (0.8569), average fruit weight (0.3261), total phenol (0.1978), days to last fruit harvest (0.1709) and chlorophyll 'b' (0.1145) had positive direct effect on yield of marketable fruits per plant. Genetic diversity study grouped all the genotypes into six clusters and revealed that there was presence of considerable amount of genetic diversity in the materials for different yield and yield attributing traits. The cluster I contained the maximum of 8 genotypes followed by 6 genotypes in cluster II and V, three genotypes in cluster IV, and only one (mono-genotypic) in cluster III and VI, respectively. The highest intra-cluster distance was exhibited by cluster V (289.96) followed by cluster IV (187.57), II (159.29) and I (105.68). The highest inter cluster distance was observed

ABSTRACT

Name of the student	:	**Rajesh Kumar**
Registration No.	:	**D/HORT/14/BAC/2013-14**
Chairman Advisor Committee	:	Randhir Kumar
Degree Programme	:	Ph.D (Ag.)
Major Subject	:	Olericulture
Minor Subject	:	Plant Breeding and Genetics
Year	:	2019
Name of the University	:	**Bihar Agricultural University, Sabour**
Title of the thesis	:	**Comparative analysis of genetic diversity in Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] using RAPD and ISSR markers for developing crop improvement strategies**

Among the all cultivated cucurbitaceous vegetables, bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) with chromosome no. 2n = 22, is an annual monoecious crop synonymously called as calabash gourd. For the above investigation twenty-four genotypes collected from various states adjoining Bihar including breeding lines developed, collected and maintained at department. The genotypes of bottle gourd laid out in statistical design named Randomized Block Design with 3 replications in spring summer season of 2014 and 2015, respectively to examine the magnitude of variability and genetic diversity for several traits horticultural importance. In morphological study genotypes performed significantly in all traits studied, however BRBG-65 (591.10 q/ha) was proved to be high yielder with supporting traits like yield of marketable fruits/plant (15.19 kg) and no. of fruits/vine (14.85) in pooled analysis of both season than compare to the all three check varieties used in past study. Traits like fruit length, fruit circumference, no. of fruits per vine, yield of marketable fruits/vine, no. of seeds/fruit and fruit yield/hectare exhibited high GCV and PCV. Almost all the traits under study shown high percentage of heritability with maximum genetic advancement percentage for the traits like fruit length, fruit circumference, average fruit weight, no. of fruits/vine, yield of marketable fruits/vine, no. of seeds/fruit and yield per hectare. Traits like average fruit weight, no. of fruits plant and yield of marketable fruits/vine shown strong character association with fruit yield/hectare. Based on D^2 values, twenty-four genotypes were classified amongst five clusters which indicated a large genetic diversity. Cluster II produced maximum no. (11) of genotypes followed closely by cluster I (8), whereas cluster V was proved to be mono-genotypic. Fruit length has given maximum contribution for total divergence. In the molecular study, average polymorphism percentage was obtained by RAPD pattern was studied by using 10 random primers. Total 58 reproducible amplicons were generated by 10 RAPD primers, of an average around 5.8 amplicon per primer. The value corresponding average polymorphic information content was 0.58 and ranged from 0.43 to 0.81. The major allele frequency was ranged from 0.33 to 0.73 with the average of 0.57. The major genetic diversity was ranged from 0.30 to 0.59 with the average of 0.41. ISSR pattern was studied by using 7 primers. Total 48 reproducible amplicons were generated by 7 ISSR primers of an average around 6.85

amplicon per primer. The value of average polymorphic information content was 0.56 and ranged from 0.29 to 0.76. The major allele frequency was ranged from 0.39 to 0.80 with the average of 0.59. The major gene diversity was ranged from 0.20 to 0.71 with the average of 0.44. Wide range of value regarding Jaccard's similarity coefficient in RAPD markers (0.46 to 0.86), ISSR markers (0.37 to 0.910) and in combination (0.50 to 0.80). The dendrogram concluded relative magnitude of resemblance also amongst different clusters formed. Dendrogram and similarity matrix produced from both the markers RAPD and ISSR data then compared and concluded similar but not genetically identical phylo-genetic relationships, when RAPD, ISSR, and RAPD combination with ISSR derived dendrograms were compared, the discrimination among genotypes within these clusters was more effective with the combined analysis. Most genotypes studied in the present experiment differed with their geographic origin. The promising lines collected from different source were classified amongst different clusters and sub clusters. The genotype BRBG 65 was extremely diverse from other genotypes and the genotype BRBG 11-1 was genetically similar to BRBG 52 and BRBG 12-3. The investigation highlights the potential utilization of these germplasm for future breeding programmes.The genotypes of more divergent cluster may be utilized in breeding programme for developing high yielding varieties and F_1 hybrids with desirable quantitative traits. The most promising genotype BRBG 65 may be recommended for commercial cultivation.

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Title: **Improvement in Bitter gourd (*Momordica charantia* L.) for yield and quality attributing traits**

(**ABSTRACT)**

Bitter gourd (*Momordica charantia* L.) is an important cucurbitaceous crop belonging to the family cucurbitaceae and is widely grown in Asia, Africa, and the Caribbean for its fruit. Bitter gourd being rich in all the essential vitamins and minerals, especially vitamin A, B_1, B_2, C and iron, its regular intake prevents many complications such as hypertension, eye complications, neuritis and defective metabolism of carbohydrates. It increases body's resistance against infection. The crop is highly cross pollinated due to its monoecious nature. The genetic variability, heritability, genetic advance, character association and path analysis for qualitative and quantitative characters were carried out in 21 accessions. The experiment was laid out in randomized complete block design with 3 replications in years, (Feb-June) 2015, (Feb-June) 2016 and (Feb-June) 2017.Significant variation was observed among most of the genotypes for all the traits under studied. High PCV along with high heritability, and genetic advance were observed for fruit weight, vitamin C, carotenoid and total phenol content whereas high PCV along with moderate value of genetic advance was observed for days to 1st fruit harvest, fruit length, fruit fly infestation, number of seeds/fruit, flavonoid, iron and fruit yield/plant. The correlation analysis for morphological traits revealed that all the traits were positively correlated with yield per plant at both genotypic and phenotypic level except node number to 1st staminate flower, node number to 1st pistillate flower, days to 1st staminate and pistillate flower anthesis, days to 50% flowering and days to 1st fruit harvest. The correlation analysis for biochemical traits revealed that all the traits were negatively correlated with yield per plant except Vitamin C, total chlorophyll, total phenol and iron both at genotypic and phenotypic level. Path analysis revealed that lowest positive direct on yield per plant was observed for fruit fly infestations. Negative direct effect on yield per plant were recorded on node number to 1st staminate flower, internodal length, no. of primary branches/vine, days to 1st fruit harvest, days to 1st pistillate flower anthesis, node no.to 1st pistillate flower, days to 1st staminate flower anthesis, vine length, number of seeds/fruits. The indirect path analysis for morphological traits revealed that characters fruit diameter had maximum positive indirect effect via fruit weight (1.128), fruit length (0.911), vine length (0.745), days to 50% flowering (0.223), number of fruits/vine (0.174) and fruit fly infestations (0.142). Days to 1st pistillate flower anthesis had maximum positive indirect effect via fruit weight (1.095), node number to 1st pistillate flower (0.582), node number to 1st staminate flower (0.640), days to 1st pistillate flower anthesis (0.381) and days to 1st fruit harvest (0.369). The indirect path analysis for biochemical traits revealed that characters total Phenols had maximum positive indirect effect via flavonoids and acidity. Chlorophyll a had

maximum positive indirect effect via Vitamin c, total sugar, flavonoids, chlorophyll b, acidity and total phenol. Residual effect of path analysis was very low (0.7339) suggesting inclusion of maximum yield influencing characters in analysis.

The multivariate analysis according to Tocher's method revealed that genotype was grouped into five clusters depending on their genetic divergence Cluster I had maximum number (11) of genotypes closely followed by cluster II (7). Cluster III, IV and V consists of only 1 genotypes. These accessions were further analyzed by multilocus RAPD and ISSR marker system. Combined data analysis of RAPD (17) and ISSR (11) markers provided 73.66 % polymorphism with 5.33 polymorphic amplicons per primer. The better discriminatory power of ISSR markers over RAPD markers may be due to comparatively higher values of average polymorphic information content (PIC;0.175), gene diversity (0.213) and allele frequency (0.814) as well as the diverse nature of the genotypes. The clustering of the both RAPD and ISSR marker divided the genotypes into five different sub-cluster.

Some genotypes *i.e.* BRBTL, BRBTW, Pusa Aushadhi, Karela Safed, Gangajalee small and Pusa Rasdar were selected based on molecular and morphological diversity of genotypes. Random crosses were made and their heterotic effects had estimated. BRBBTL x Pusa Aushadhi and BRBTL x Gangajalee small had shown significant heterotic effects for most of the traits in terms of better parent and standard parent.

Genetic effects of both qualitative and quantitative traits of both crosses of bitter gourd were studied using generation means analysis in six populations including P_1, P_2, F_1, F_2, B_1 and B_2 generations of cross BRBTL x Pusa Aushadhi and BRBTL x Gangajalee Small. Significant parental difference was observed for all the traits in both the crosses. Scaling test indicate significant additive, dominance and non-additive gene action were responsible for most of the traits. The cross BRBTL x Pusa Aushadhi exhibits additive × dominance (j) and dominance × dominance (l) were highly significant for most of the traits whereas the additive(d), dominance (h) and additive x dominance (j) had found significant in cross BRBTL x Gangajalee Small.

Thesis Abstract

Post-Graduate Degree Programme : Ph.D. (Ag.)

Department : Horticulture (Vegetable & Floriculture).

Name of the student : Neetu Nand

Major subject : Horticulture (Vegetable and Floriculture)

Minor subject : Plant Breeding & Genetics

Major Advisor : Dr. Randhir Kumar

Admission/Registration No. : D/Hort/25/BAC/2014-15

Field of Research Problem : **Morphological and SCAR marker development for early sex determination in Pointed gourd (*Trichosanthes dioica* Roxb.)**

Pointed gourd (*Trichosanthes dioica* Roxb., 2n=2x=22), a perennial vegetable crop and commonly known as parwal/patal, have Indo-Malayan origin. It is said to be native of South East Asia and probably the Northern and Eastern states of India especially of West Bengal, Assam and Bihar. It has high economic value with export potential. It is mainly cultivated along the riverine belts of Bihar. Pointed gourd (*Trichosanthes dioica* Roxb) is an economically important cucurbit and is extensively propagated through vegetative means, *viz;* vine and root cuttings. The plant's dioecious in nature and its vegetative mode of propagation makes its reproduction and multiplication labour intensive. Dioecy represents an inconvenience in pointed gourd breeding since at present there are only few reports distinguishing male and female plants prior to flowering. The use of molecular marker provides a quick and reliable identification of sex types in plants. RAPD (Random amplified polymorphic DNA) has been used previously for determining the gender of plants before flowering. The SCAR marker is one of the stable markers, generally derived from RAPD increase effectiveness of RAPD marker by selecting and redesigning primers whose priming sites occur in target sequence(s) of gene or organism at optimum distance. Therefore, the present study was undertaken to identify marker associated with male and female sex expression trait in *T. dioica* Roxb. followed by development of SCAR. The screening of genomic DNA samples representative of male and female plants of pointed gourd with RAPD was used to discover sex specific PCR amplification product. A total 40 RAPD primers were used for RAPD analysis, out of which 20 primers gave good results. Among these 20 primers, OPC-04 amplified a band of 400 bp specific to female lines. This RAPD marker was eluted, sequenced and the sequence was used to design primers for SCAR marker. From the sequence, a set of two SCAR primers (N6Fn and N7Fn) was designed to allow amplification of female specific region But, only single SCAR (N7Fn/r)amplify a product size of 400bp in female specific DNA.

Department of Horticulture (Vegetable and Floriculture)

Bihar Agricultural University, Sabour- 813210, Bhagalpur (Bihar)

Title of the Thesis : Early Generation Selection of Lines Suitable for Yield and Earliness in Cauliflower (*Brassica oleracea* var. *botrytis* L.)

Name of the Student : Mr. Amit Kumar

Registration No. : D/Hort./24/BAC/2014-15

Major Advisor : Dr. Randhir Kumar

Abstract

Cauliflower is a thermo-sensitive cool season vegetable crop. On the basis of temperature requirement to curd initiation the crop is grouped into early, mid and late cauliflower. The hybrid is most important as because of uniform maturity, compacted curd, and resistant to environmental stresses. Very few hybrids are available for cultivation in early group of cauliflower. Inbreeding programme in cauliflower is tedious, labour intensive and costly that slower down the effectiveness of hybrid breeding programme. To reduce these problems, Jenkin (1935) had been proposed a technique to early generation testing in genotypes during inbreeding based on GCA estimation. In the present experiment 19 S_2 generation lines were tested for combining ability analysis using line x tester mating design with two testers namely Sabour Agrim and Pusa Kartik Sankar. The experiment was laid out in Randomised Block Design with a spacing of 50x 50 cm in two replications with two dates of planting. The analysis of variance revealed the existence of significant genetic variability among the treatments. The MSS for parent vs. cross was also found significant which depicted that existence of heterosis among the cross for the traits under study. The characters net curd weight (NCW), harvest index (HI), marketable curd weight (MCW) and biological weight (BW) were found to be highly heritable and high expected genetic advance indicated that the selection of parental line for these traits could be effective. Pooled analysis of GCA recorded Hzp 108 (-7.22) and Sel 31-1 (-4.97) were significantly negative for D50 % CI; usefulness for the development of early maturity hybrid. However Hzp 106 (112.23), Hzp 101 (80.52) and Hzp 111 (44.70) were found to be good general combiner for NCW that means these genotypes will be useful for the development high yielding hybrids. Cross combination Hzp 106 x PKS (48.02 %), Sel 332 x PKS (33.68 %) and SA-1 x SA (37.05 %) were recorded positive significant relative heterosis and heterobeltiosis for NCW. In the present study, the high D^2 value indicated a high degree of genetic diversity among the genotypes. Pooled data analysis for morphological diversity revealed that all the 21 genotypes were grouped into four groups or clusters Cluster I includes 14 lines, cluster II includes 5 lines, cluster III and cluster IV include single genotype in each cluster. The highest inter cluster distance (580.42) was observed in between cluster I and cluster IV followed by cluster I and III (438.36), cluster I and II (180.79). On the basis of molecular diversity analysis, similarity values for all cauliflower genotypes were ranged from 0.50-0.90. The high ranges of similarity coefficient indicated the presence of narrow genetic variability. PIC value ranged from

0.121-0.290. All the SSR primers showed monomorphic band except SSR 73 and SSR 110.

From the above findings it can be concluded that among the 19 segregating lines Hzp 108 and Sel 31-1 would be desirable for breeding cauliflower hybrids for earliness and lines Hzp 106 and Hzp 101 would be effective to producing the heterotic hybrids for net curd weight.

ABSTRACT

Name of the Student	**:**	**Rashmi Kumari**
Registration Number	**:**	**D/HORT/50/BAC/2015-16**
Chairman, Advisory Committee	**:**	**Dr. Randhir Kumar**
Degree Program	:	Ph.D (Ag.)
Major Subject	:	Horticulture (Olericulture)
Minor Subject	:	Plant Breeding and Genetics
Year	:	2019
Name of the University	:	Bihar Agricultural University, Sabour
Title of the Thesis	**:**	**Effect of seasonal variation on the performance of eggplant genotypes (*Solanum melongena* L.)**

Eggplant, brinjal or aubergine (*Solanum melongena* L.) is a commercially and nutritionally important solanaceous vegetable crop grown widely throughout the year in all parts of the world. With prime objective of developing season/region specific hybrid, the present investigation was undertaken to obtain the information on the *per se* performance, heterosis, combining ability, nature of gene action and stability parameters for fruit yield, its components and quality traits in brinjal (*Solanum melongena* L.) using 7 x 7 diallel (excluding reciprocal crosses) mating scheme. The findings revealed that sufficient genetic variability was present among the genotypes that provide ample scope for selection of promising genotypes under study. Rajendra Baigan-2 x BRBL-01 (1.70 kg/ plant) and BRBL-01 (1.48 kg/ plant) were high yielding hybrid and parent, respectively over the seasons on the basis of *per se* performance. While, Swarna Mani x BRBR-01 and Swarna Mani were superior hybrid and parent, respectively in quality traits. Swarna Mani x BRBL-01 (1.46 kg/ plant) was high yielding as well as rich in quality traits. Main season was congenial for yield but summer season was for quality traits.High standard heterosis for yield and quality was recorded in Rajendra Baigan-2 x BRBL-01 and Swarna Mani x BRBR-01, respectively. BRBL-01 and BRBL-04 were good general combiners in all seasons for yield traits and Swarna Mani for all biochemical traits. Rajendra Baigan-2 x

Muktakeshi, Rajendra Baigan-2 x BRBL-01 and Muktakeshi x BRBL-01 were the best

Name of the Student	**:**	**Amrita Kumari**
Registration Number	**:**	D/Hort./49/BAC/2015-16

three cross combinations over the seasons for yield trait and Swarna Mani x BRBR-01 for total phenolics and antioxidant capacity on the basis of *sca* effects. The additive component ($\widehat{D}$) was found to be significant for traits like plant height, plant spread, fruit length, fruit girth, average fruit weight, number of fruits per plant, yield per plant and total anthocyanin content in all the environments. Over dominance was observed for traits days to 50 % flowering, days to 1st harvest, number of primary branches, yield per plant, total ascorbic acid content, total sugar content, total phenolics content and total antioxidant content in all seasons. In present investigation predominance of dominant allele in parents for the traits days to 1st harvest, plant height, fruit length, number of fruits per plant, total ascorbic acid content, total sugar content, and total phenolics content in all environments. Result described that narrow sense high heritability was observed for traits and fruit length, fruit girth, average fruit weight, number of fruits per plant and total anthocyanin content in all seasons. Stability analysis revealed that Rajendra Baigan-2 x BRBL-02, Rajendra Baigan-2 x BRBL-01, Rajendra Baigan-2 x BRBL-04, Muktakeshi x BRBL-01, Muktakeshi x BRBL-04, BRBL-02 x BRBL-04, Swarna Mani x BRBL-01 and BRBR-01 x BRBL-04 were stable hybrids and BRBL-01 and BRBL-04 were stable parents in terms of yield/ plant. BRBL-02 x BRBL-04 was stable in terms of total sugar content, total anthocyanin content and total phenolics content.

ABSTRACT

Degree Programme	**:**	Ph.D. (Ag.)
Major Subject	**:**	Olericulture
Minor Subject	**:**	Plant Breeding and Genetics
Year	**:**	2019
Chairman of Advisory Committee	**:**	**Dr. Sangeeta Shree**
Department	**:**	Deptt. Of Horticulture (Vegetable & Flori.)
Thesis title	**:**	**"Heterosis and combining ability in bitter gourd (*Momordica charantia* L.) for yield and postharvest quality."**

An experiment was conducted in Vegetable Research farm, Bihar Agricultural College, Sabour (Bhagalpur) during 2016 and 2017 to study the *per se* performance of parents and hybrids, degree and direction of heterosis and combining ability with gene action for growth, yield and quality and also to study the postharvest quality of promising parents and their hybrids of bitter gourd.The experimental material for this experiment comprised of seven promising and diverse genotypes *i.e.,* Pusa Ausadhi, Jhalri, Kathi No.1, Pusa Rasdar, BRBT Local, Konkan Tara, Solan Hara and NBGH 167 (Standard check). They were crossed in all possible combination in diallel fashion excluding reciprocals to get 21 hybrids. All the 29 treatments (7 parents, 21 F_1 hybrids with one check) were grown in randomized block design with three replications with spacing of 2.0 m × 0.5min plot size of 4.0 m × 3 m.

The pooled analysis of variance for design of experiment also showed that the mean squares due to environments and genotypes were found to be highly significant for all the characters under studied. The *Per se* performance of the parental lines and F_1 hybrids for all the characters revealed that a wide range of mean values which indicated that the parental lines involved in this study were genetically diverse and had good breeding value, which confirmed the predictions of analysis of variance.

Among the parental lines, Pusa Ausadhi was the earliest with respect to node number of 1st male flower and node number of 1st female flower, days taken to 1st male flowers appears, days taken to 1st female flowers appears and days to 50 % flowering. While, the minimum internodal length was found in Konkan Tara. The BRBT Local considered as best promising parent for other parameters like vine length, number of primary branches, fruit weight and fruit length

Fruit yield is the ultimate character which shows the utility of a genotype in farmer's field. As per the present findings, the parents Pusa Ausadhi (151.80 q/ha)

followed by BRBT Local (151.04 q/ha) and Kathi No.1 (145.85 q/ha) were the most promising. Among hybrids, Pusa Ausadhi × BRBT Local (190.33q/ha) followed by Kathi No.1 × BRBT Local (187.26 q/ha) and BRBT Local × Konkan Tara (184.72 q/ ha).

For quality point of view, the best promising parent were found in BRBT Local for total soluble solid (TSS) and chlorophyll content, Kathi No. 1 (137.49mg/100g) for total phenol content, Konkan Tara for ascorbic acid (93.29 mg/100 mg) and carotenoid content (1.72 mg/100g). Out of 21 hybrids, BRBT Local × Konkan Tara (107.37) had highest ascorbic acid content followed by Kathi No.1 × Konkan Tara (97.44mg /100g).

The parent BRBT Local was generally best combiner in terms of fruit length, fruit weight, fruit diameter, number of seed per fruit, vine length, yield per plant and total yield (q/ ha). While the parents such as, Konkan Tara, BRBT Local and Pusa Rasdar were noted good combiner for fruit fly infestation.

For qualitative traits, the parent BRBT Local proved best general combiner for both total soluble solid as well as total chlorophyll content. Whereas, Konkan Tara for ascorbic acid, carotenoids and total phenol content. The three outstanding F1 hybrids showing the highest and significant SCA effect in desirable direction for total yield *i.e.,* Pusa Ausadhi × BRBT Local, Kathi No.1 × BRBT Local and BRBT Local × Konkan Tara.

For another trait yield per vine, the extent of mid parent heterosis varied from 5.18 % (Pusa Rasdar × Konkan Tara) to 26.15 % (Kathi No. 1 × BRBT Local). The heterosis over better parent ranged from -6.77 % (Pusa Ausadhi × Solan Hara) to 25.38 % (Pusa Ausadhi × BRBT Local), while the range of standard heterosis for this trait was varied from -16.86 % (Jhalri × Solan Hara) to 26.88 % (Pusa Ausadhi × BRBT Local). The results exhibited that the hybrid Pusa Ausadhi× BRBT Local showed maximum heterosis over better parent (25.38 %) and (26.88%) over standard check.

Ihe economic heterosis of bitter gourd, the range varied from -1.93 % (Pusa Rasdar × Solan Hara) to 52.76 % (Jhalri × BRBT Local) for TSS traits, Ascorbic acid varied from -20.47 % (Pusa Ausadhi × Jhalri) to 58.68 % (BRBT Local × Konkan Tara), chlorophyll content varied from -32.33 % (Pusa Ausadhi × Solan Hara) to 70.91 % (BRBT Local × Konkan Tara), carotenoid content varied from -6.42 % (Jhalri × BRBT Local) to 158.95 % (Kathi No.1 × Solan Hara) and the total phenolic contents varied from -28.05 % (Jhalri × Solan Hara) to 15.87 % (Kathi No.1 × Konkan Tara).

The estimates of D, H_1, H_2, F and E parameters along with its components of bitter gourd obtained from diallel analysis then significant value of additive (D) and non additive component (H_1 and H_2) were observed for all traits which indicates the involvement of both additive and non additive gene action for the expression of these characters. However, magnitude of dominance component (H_1, and H_2) were

higher than additive component (D) for days to 1st male flower, internodal length, number of primary branch , number of fruits per plant, fruit length, fruit weight, number of seed per fruit, vine length, yield per vine. This suggests the preponderance of non additive genetic variation in the expression of these characters.

Correlation study revealed that fruit yield per vine was found highly significant and positively correlated with number of primary branches per plant, fruit length, fruit diameter fruit weight, vine length, total chlorophyll, carotenoids and total phenol. Path analysis indicated that the highest direct positive effect was exhibited by fruit weight followed by number of fruits per plant vine length, number of primary branch per plant and fruit length on total fruit yield.

The present experiment showed that the physiological loss in weight, TSS, Ascorbic acid and rotting percentage in fruits increased markedly with the advancement of storage period, however, the chlorophyll content decreased with advancement of storage periods. The lowest average physiological loss of weight and rotting percentage were found at both 2 and 4 days of storage in Konkan Tara. Maximum average TSS was recorded in BRBTL Local, highest average chlorophyll content and ascorbic acid in BRBTL Local and Konkan Tara both at 2 and 4 days of storage.

From the two years of experimentation, it can be concluded that the parents identified superior were BRBT Local, Pusa Ausadhi and Konkan Tara can be used in breeding programme for the improvement of specific traits which targeting the yield and quality parameters which will be very beneficial for grower of bitter gourd crops.

List of Ph. D. passed out students from the Department of PBG

SI. No.	**Name of Student & Roll. No.**	**Name of Advisor**	**Name of External Examiner**	**Title of Thes**
01.	Neha Rani D/PBG/20/BAC/2013-14	Dr. R.B. P. Nirala	Dr. Sohan Ram BAU, Kanke , Ranchi	Combining a maize (*Zea m* normal and h
02.	Mr. Amit Kumar Mishra D/PBG/19/BAC/2013-14	Dr. P.K. Singh	Dr. D.N. Singh, BAU, Kanke Ranchi	"Stability an and quality (*Oryza sativa*
03.	Mr. Rishav Kumar D/PBG/54/BAC/2015-16	Dr. P.K. Singh	Dr. D. N. Singh BAU, Kanke Ranchi	"Marker assi major QTL

				yield unc reproductive L.cv. Sita"
04.	Mr. Sudhir Kumar D/PBG/30/BAC/2014-15	Dr. Nitish De	Dr. N. K. Singh Dr. RPCAU, Pusa , Samastipur	"Study of G Stability in G *hypogaea* L.) C
05.	Ms. Smriti D/PBG/55/BAC/2015-16	Dr. S. P. Singh	Dr. Arup Sarkar Uttar Banaga Krishi Viswavidalay, Cooch Bihar	"Marker Breeding Tolerance in Sweta"
06.	Ms. Hemlata Kumari D/PBG/53/BAC/2015-16	Dr. P.K. Singh	Dr. S.B. Singh, Regional Maize Research and Seed Production Centre Kushmahbout Farm, Begusarai	"Study of Co Yield Stabilit Protein Maize
07.	Prity Sundaram D/PBG/31/BAC/2014-15	Dr. S. P. Singh	Prof. B.C. Saha Ram Krishna Mission, Vivakanand University, Morabadi, Ranchi	"Identificatio mapping of tolerance i *arietinum* L.)"

Bihar Agricultural University, Sabour

Department of Plant Breeding & Genetics

Title of the Thesis	:	Combining ability and heterosisin maize (*Zea mays* L.) crosses under normal and heat stress conditions.
Name of the student:		Neha Rani
Registration no.	:	D/PBG/20/BAC/2013-2014
Chairman Advisory Committee	:	Dr. Ram Balak Prasad Nirala Junior Scientist-cum-Assistant Professor Ph.D.
Degree Programme	:	Plant Breeding & Genetics
Major Subject	:	Plant Pathology
Minor Subject	:	2017
Year	:	

ABSTRACT

The present investigation entitled "Combining ability and heterosis in maize

(*Zea mays* L.) crosses under normal and heat stress conditions"was conducted at Maize Section of Bihar Agricultural University Sabour, Bhagalpur, Bihar (India). Twenty nine maize inbred lines were evaluated in normal (30th January, 2015) and heat stress (3rd March, 2015) conditions in Randomized Complete Block Design with objective to screen the maize inbred lines for heat tolerance on the basis of morphophysiological traits. The 13 SSR markers were used among 29 inbred lines with objective to study of molecular diversity among the inbred lines. During *kharif,* 2015 seven identified inbred lines i.e. five (CML 307,CML 306, CML 305, CML 411, CML 304) heat stress tolerant and two (CML 164, CML 25) heat stress susceptible were crossed in full diallel for making all possible 42 crosses. These forty two crosses, seven parents and two checks (DHM-117, SHM-2) were evaluated in a Randomized Block Design in normal (2nd January, 2016) and heat stress (15th March, 2016) conditions with objectives to determine general and specific combining ability of inbred lines and crosses, respectively and to estimate heterosis of crosses of inbred lines. Data were recorded on thirteen quantitative characters viz; days to 50 % anthesis, days to 50% silk, pollen viability, anthesis-silkingineterval, cell membrane thermo stability, plant height, ear height, days to 50 % physiological maturity, grain filling period, number of grains per plant, 500-grain weight, shelling per cent, grain yield per plant. The analysis of variance of maize inbred lines for the design of experiment in both the conditions and pooled analysis indicated highly significant mean squares due to genotypes for all the characters except pollen viability per cent in normal condition. In normal condition, the mean performance of inbred lines, namely, CML 308, CML 451, CML306, CML18 and CML 474; in heat stress condition, inbred lines, namely, CML 307, CML306, CML305, CML 411 and CML 304; and in pooled analysis inbred lines, namely, CML 307, CML306, CML 411, CML 304 and CML 305 were found to be top five rankers of grain yield per plant. The five inbred lines, namely, CML 307, CML 305, CML 306, CML 411 and CML 304 were categorized top five heat tolerant inbred lines due to their higher YSI and lower ASI values. Similarly, two inbred lines, namely, CML 164 and CML 25 were categorized highly heat susceptible inbred lines due to their lower YSI and higher ASI values. Level of polymorphism was found to be 100 per cent among the inbred lines for almost all the primers pairs except for phi062. The polymorphic information content value for the primer pairs ranged from 0.067 to 0.499. The inbred lines were characterized into two cluster ie I and II. The further cluster I was divided into two sub cluster i.e. cluster Ia and cluster Ib. Cluster Ia had five inbred lines whereas, cluster Ib had three lines. Cluster II had the highest number of twenty parents. The minimum Jaccard's similarity co-efficient value was found between G9 and G23, whereas, on the other hand, the maximum Jaccard's similarity co-efficient value was found between G2 and G3.The seven selected inbred lines [CML 164 (P_1), CML 411 (P_2), CML 305 (P_3), CML 304 (P_4), CML 25 (P_5), CML 306 (P_6) & CML 307 (P_7)] on the basis YSI, were found to be genetically distinct among them. Analysis of variance revealed that the mean squares due to genotypes (seven parents and their 42 cross combinations and two checks) were found to be highly significant in both the conditions and pooled analysis for all the characters studied. In normal condition, the mean performance, crosses, namely, P_4 x P_1, P_2 x P_3, P_1 x P_2 and P_2 x P_1 ;in heat stress condition, crosses, namely, P_4 x P_1 and P_2 x P_7 ; and in pooled analysis, crosses P_4 x P_1 and P_2

x P_7 were found to be top rankers for grain yield per plant in comparison to the better check, SHM-2. The analysis of variance for combining ability, in both the normal and heat stress conditions, revealed highly significant mean squares due to general combining ability(GCA), specific combining ability (SCA) and reciprocal combining ability (RSCA) for all the characters studied except due to reciprocal combining ability for anthesis-silking interval in normal condition. The pooled analysis of variance revealed significant mean squares due to general combining ability, specific combining ability, reciprocal combining ability, environments, GCA x environments, SCA x environments, reciprocal x environment for all the characters studied, except due to GCA x environments for anthesis-silking interval and due to reciprocal x environment for 500-seed weight. Estimates of components of variance for thirteen characters revealed that variance due to SCA was more than variance due to GCA and reciprocal for all the characters studied in both the conditions. The pooled analysis revealed that variance due to GCA was more than variance due to SCA and reciprocal for the characters viz., days to 50% silk, pollen viability, anthesis-silking interval, cell membrane thermo stability, days to 50 per cent physiological maturity, grain filling period, grains per plant, 500-seed weight and shelling percentage. Variance due to SCA was more than variance due to GCA and reciprocal for the characters, namely, days to 50 % anthesis, plant height, ear height, grain yield per plant. Parents CML 411 was found to be good general combiner for grain yield per plant in both the normal and heat stress conditions and in pooled analysis, whereas, CML 306, CML 164, CML 307 were considered as good general combiners in heat stress condition, while CML 164 and CML 304 were found to be average general combiners in normal condition and pooled analysis. Similarly, CML 306 and CML 307 were found to be average general combiners in pooled analysis for grain yield. In normal condition, crosses, namely, P_1 x P_4, P_2 x P_3, P_1 x P_2, P_6 x P_7 and P_5 x P_7; in heat stress, crosses, namely, P_2 x P_7, P_1 x P_7, P_4 x P_6, P_3 x P_6 and P_1 x P_4 ;and In pooled analysis crosses, namely, P_1 x P_4, P_2 x P_7, P_2 x P_3, P_5 x P_7 and P_1 x P_7 were found to be top five good specific combinations for grain yield per plant. Reciprocal specific combinations, in normal condition, crosses, namely, P_4 x P_1, P_3 x

P_2 and P_6 x P_2; in heat stress condition, crosses, namely, P_4 x P_1, P_4 x P_2, P_6 x P_2, and P_5 x P_4 ; and in pooled analysis, crosses, namely, P_4 x P_1 and P_3 x P_2 were found to be top combinations good for grain yield per plant. Standard heterotic combinations, in normal condition, crosses namely, P_2 x P_3 and P_1 x P_2; andin heat stress condition and in pooled analysis, cross P_2 x P_7 were found to be significantly top two for grain yield per plant. The best experimental hybrid was identified on the basis of SCA/RSCA, GCA, mean performance and standard heterosis for grain yield in different situations. The experimental hybrid, CML 411 x CML 305 was identified as the promising hybrids for normal condition, whereas, the experimental hybrid, CML 411 x CML 307 was identified for heat stress condition and the experimental hybrid CML 411 x CML 307 was identified as the promising hybrids over the environment.

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BIHAR AGRICULTURAL UNIVERSITY, SABOUR
Department of Plant Breeding and Genetics
(Bihar Agricultural College, Sabour)
Bhagalpur (Bihar) 813210

Problem of Research	:	Stability analysis for grain yield and quality traits in indica rice (*Oryzasativa* L.) lines
Research Scholar	:	Amit Kumar Mishra
Registration Number	:	D/PBG/19/BAC/2013-14
Major Advisor	:	Dr. P. K. Singh
Degree Programme	:	Ph.D (Ag.)
Major Subject	:	Plant Breeding and Genetics
Minor Subject	:	Plant Pathology
Year	:	2018

Abstract

The present study was undertaken with the objective to determine the nature and magnitude of genetic variability, heritability and genetic advance, degree of association among yield and quality traits, direct and indirect effects, genetic diversity on the basis of morphological and molecular level, phenotypic stability among 36 advance indica rice lines including 3 checks for 21 yield and quality attributes. The trials were conducted in randomized complete block design (RCBD) with 3 replications and 4 environments (including control and reproductive stage drought stress conditions) during kharif 2014 and kharif 2015. The analysis of variance indicated highly significant differences for the majority of traits studied except few quality traits which indicated the significant differences among these rice lines. In congruence with the previous reports, phenotypic variance (VP) and phenotypic coefficient of variance (PCV) were higher than the genotypic variance (VG) and genotypic coefficient of variance (GCV) subsequently which indicated the influence of environment on the development of the characters. Moderate values (10-20) of GCV and PCV was observed for some traits hence; selection for these traits may be ambiguous if we adopted for its improvement. The higher magnitude of GCV was observed for number of spikelets per panicle, kernel elongation ratio and head rice recovery while maximum PCV was observed for number of spikelets

per panicle, harvest index and number of tillers per plant. High heritability along with higher magnitude of genetic advance as percent of mean was observed for the traits namely; number of spikelets per panicle, head rice recovery and kernel elongation ratio which revealed the preponderance of additive gene action in the inheritance and these traits could be improved through direct selection as GCV is also comparatively high for such traits. Positive or negative significant association with higher positive or negative direct effect were observed for the traits *viz;* plant height, biological yield per plant and harvest index which indicated the effectiveness of these traits for utilization in future rice breeding programmes. Genetic divergence among rice lines showed sufficient amount of genetic diversity hence, crossing among the divergent lines grouped in different clusters would produce superior hybrids and valuable transgressive segregants with higher genetic advance. The molecular diversity also validated the morphological differences among these rice lines and higher PIC values of the markers indicated their utility in explaining the genetic diversity. In case of phenotypic stability on the basis of stability parameters for grain yield per plant, IR 92521-24-5-1-3 was found stable line across all the environments and had maximum grain yield per plant, earliest in days to 50% flowering, better maturity duration, maximum number of spikelets per panicle, good head rice recovery, moderate L/B ratio and it also performed better than all three checks therefore, such line can be recommend to farmers or variety release proposal. Rice line IR 92545-53-4-1-3 was identified for unfavourable or poor environment while IR 92546-17-6-4-3 and IR 92546-17-6-4-4 lines was identified for rich or favourable environment.

Keywords: **Rice, Genetic variability and Diversity, Heritability and Genetic advance, Interrelationship, Phenotypic stability, Grain yield and quality.**

ABSTRACT

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Major Subject	:	Plant Breeding & Genetics
Minor Subject	:	Molecular Biology & Genetic Engineering
Year	:	2019
Name of the University	:	Bihar Agricultural University, Sabour

Title of the Thesis	:	Marker assisted introgression of a major QTL (*qDTY*$_{1.1}$) for grain yield under drought at reproductive stage in *Oryza sativa* L. *cv.* Sita

Rice is the second largest crop in the world in terms of area and production which is grown in all the continents except Antartica. It is the primary source of food, nutrients, energy and provides employment to more than 3.5 billion people. But being one of the staple food crops, it is also affected by biotic and abiotic stress. With the change in environmental condition, drought is emerging as one of the major threats to rice. As per India Meteorological Department, there was an early departure of monsoon in 2018 which resulted in failure of Hathiya Nakshtra, causing drought coincide with the reproductive stage. Last but not the least is the susceptibility of most of the mega varieties of rice like Sita during reproductive stage. Hence, there is need to improve such varieties which can cope up such harsh period. Previously, conventional methods were used for improvement of crop variety but it takes a lot of time. With the advancement in the field of molecular biology, MAS acts as a milestone in this field. Now with the discovery of QTLs efficiency of MABB has surpassed the conventional breeding. With this view, marker assisted introgression of a major QTL (*qDTY*$_{1.1}$) for grain yield under drought at reproductive stage in *Oryza sativa* L. *cv.* Sita has been taken under consideration. To incorporate drought tolerance, the variety 'Sita' was introgressed with QTL *qDTY*$_{1.1}$ from Nagina-22. The present research work started from *Kharif* 2015 and Sita and Nagina-22 were sown for availability of pollens. Twenty five F_1 plants obtained were sown in *Kharif* 2016 and validated with RM431 which identified ten heterozygous plants were identified on which further backcrossing was done with Sita to obtain sixty seven BC_2F_1 plants that were sown in *Kharif* 2017 and validated with RM431. A total of sixty seven heterozygous plants were obtained which were again backcrossed with Sita to produce 179 BC_2F_1 plants. Through foreground selected marker RM431 identified 98 plants which were found heterozygous. The selected plants were subjected to recombinant selection with RM3825 and RM12091. RM3825 identified three plants (plant number 23, 65, 94) sowing band size similar to Sita (130 bp), while through RM12091 a total of six recombinant plants were identified (plant number 23, 63, 65, 94, 97 and 119). Three plants were common when checked with both the recombinant markers. So, six recombinant plants (plant number 23, 63, 65, 94, 97, 119) were selected for carrying out background selection with 49 polymorphic markers. Recipient allele percentage ranged from 69.38 to 79.59%. Plant number 119 showed maximum background recovery (79.59%) followed by plant number 94, 97, 65 and 23 with 77.55%, 75.51%, 74.48%, 73.46% recovery respectively. Plant number 63 exhibited minimum recovery (69.38%). Morphological observations (days to

anthesis, plant height, panicle length, number of panicles, grains per panicle and grain yield per plant) were taken during drought and it was found that recombinants obtained were superior with respect to recurrent parent Sita for all the characters. Biochemical observations (proline content, relative water content and total chlorophyll content) also revealed that recombinants were superior with respect to recurrent parent. On the basis of molecular, morphological and biochemical observations the plant number 119 should be carried forward for further backcrossing to improve its recipient allele percentage.

ABSTRACT

Title of the Thesis	:	"Study of Genetic Diversity and Stability in Groundnut (*Arachishypogaea* L.) Genotypes"
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Minor subject	:	Deptt. of Molecular Biology and Genetic Engineering
Year	:	2019

Groundnut (*Arachishypogaea* L.) is an important oilseed crop globally. The present study was aimed at the phenotypic assessment of 51 groundnut genotypes and five control varieties for yield, oil and related traits under irrigated and post flowering drought stress conditions. These genotypes were evaluated under ten environments for seventeen traits. Experimental material was evaluated at two distinct locations, one at ICRISAT Patancheru, Hyderabad and at Bihar Agricultural University (BAU) Sabour. At ICRISAT the experiment were

conducted during *Kharif*, 2015, *Rabi* 2015-16, *Kharif* 2016, *Rabi* 2016-17. At BAU Sabour the experiment was conducted during summer 2016. ICGV 13097, ICGV 13098 and ICGV 13100 showed higher pod yield per plot (kg/ha) with higher oil content and good buffering capacity. These genotypes for their specific performance can be utilized as cultivar for reference environments to harvest maximum pod yield with higher oil content. For nutritional quality traits like oleic acid content and O/L ratio, ICGV 13099, ICGV 13103, 13115, ICGV 13117, ICGV 15321, ICGV 15323, ICGV 15325, ICGV 15333 and ICGV 15339 had good buffering capacity with higher mean than population mean. These genotypes will be used for the quality oil production with international acceptance. In present investigation, there were heavy losses of pod yield in post flowering moisture stress conditions. Pooled mean yield (kg/ha) was higher in irrigated condition than rainfed condition and a loss of more than 29 per cent in stress conditions than in rainfed conditions for yield. ICGV 15314 had highest drought tolerance efficiency (DTE) with pod yield 2725 kg/ha in irrigated and 2242 kg/ha in rainfed conditions. Five best drought tolerant genotypes were ICGV 15314, ICGV 15321, ICGV 15325, ICGV 15331 and ICGV 15315. The higher yield level was due to higher number of branches/plant, higher number of pods per plant, pod yield per plant, 100 seed weight and shelling percentage and which are most important and key traits for stability of pod yield and these traits could be successfully employed for realization of higher productivity and ensures the possibility of predicting the performance of genotypes for higher productivity in groundnut.

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		Engineering	***AB***
Year	:	2018	***ST***
Name of the University	:	Bihar Agricultural University, Sabour	***RA***
Title of the Thesis	**:**	**Marker assisted backcross breeding for submergence tolerance in rice variety RajendraSweta.**	***CT***

Submergence stress regularly affects rice crop in major parts of eastern India comprising Odisha, West Bengal, Bihar, Assam, Chhattisgarh and eastern Uttar Pradesh. Out of 42 biotic and abiotic stresses that prevail in rainfed lowland rice areas of eastern India, submergence stress is the third most important limitation to rice production. A major QTL mapped on chromosome 9, designated as *sub1*, has provided the scope to apply marker assisted backcrossing (MABC) to develop submergence tolerant varieties suitable to be grown in these regions. Developing rice cultivars with tolerance of submergence and with agronomic and quality traits acceptable to farmers is a feasible approach to address this problem. In the present study, BC_2F_1 generation was developed between a submergence tolerant donor, Swarna-Sub1and the widely grown recurrent parent, RajendraSweta. A parental polymorphism survey between these two parents revealed 46 polymorphic SSR loci covering all the chromosomes of rice genome. Foreground selection was done in each generation for the confirmation of *Sub1* QTL. Molecular markers that were tightly linked to *Sub1*, flanking *Sub1* and unlinked to *Sub1* were used to apply foreground, recombinant and background selection, respectively, in BC_2F_1 generation. Out of 91 plants, 50 plants were found positive in foreground selection using Indel primer Sub1bc2. Recombinant selection was done on these 50 heterozygous plants with RM219. Out of these 50 individuals, five recombinants were selected namely, BC_2F_1-4,BC_2F_1-28,BC_2F_1-37,BC_2F_1-43 andBC_2F_1-79. Background selection was carried out on these five recombinants with 46 SSR markers. Recipient allele frequency was calculated for these five recombinants which ranged from 51.1% to 78.2%. In BC_2F_1 generation, maximum recipient parent recovery obtained was 78.2% for individual BC_2F_1-79. Screening for submergence tolerance revealed that the recombinants were able to survive complete submergence for 14 days and were also able to recover faster upon de-submergence. Higher ADH enzyme activity was observed in donor as well as recombinants during submergence. Similarly, higher concentration of carbohydrate before submergence and its slower depletion during submergence was observed in all the recombinants. Chlorophyll content was found greater in the recombinants than the recipient parent RajendraSweta.Morphological observations (days to flowering, plant height, tiller number, flag leaf length, panicle length, number of grains per panicle and grain yield per plant) under stress condition revealed that for all the traits Sub1's were similar to or better than

RajendraSweta. The newly improved rice line, BC_2F_1-79 containing *Sub1*and showing highest recovery may further be utilized in backcross breeding program to improve its recovery percentage and the similar strategy can be followed to introgress other QTLs for biotic and abiotic resistance into the high yielding varieties.

ABSTRACT

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Minor Subject	:	Plant Pathology
Name of University	:	Bihar Agriultural University
Year	:	2018
Title of the Thesis	:	**Study of Combining Ability and Yield Stability Analysis in Quality Protein Maize (*Zea mays* L.)**

The present investigation entitled "Study of Combining Ability and Yield Stability Analysis in Quality Protein Maize (*Zea mays* L.)"was conducted during rabi 2016-17,kharif 2017 and rabi 2017-18. Six parents were crossed indiallel fashion including reciprocal during rabi, 2016-17 at farm of Bihar Agricultural University Sabour, Bhagalpur, Bihar (India). The 38 genotypes (06 parents, 30 F_1's and 2 checks) were evaluatedin six environments during kharif 2017 and rabi 2017-18, at three different farm of Bihar Agricultural University, Sabour (Bhagalpur),namely ,Bihar Agricultural College, Sabour; BholaPaswanShashtriCollege of Agriculture College, Purnea and Pulse Research Centre, Mokama with objectives to study inter-relationship of component character with grain yield and among themselves, to estimate the general and specific combining ability of inbred lines and crosses, respectively and to study the G x E interaction and stability parameter of crosses. Data were recorded for twelve quantitative characters such as days to 50 per cent anthesis, days to 50 per centsilk ,anthesis-silking interval, plant height, ear height, days to 75 per cent maturity, number of grain per plant, 1000-grain weight, protein per cent in kernel, lysine per cent in kernel protein, tryptophan per cent in kernel

protein and grain yield per plant. The pooled analysis of variances for the design of experiment revealed that, the mean squares due to genotype and environment were highly significant for all the characters.Similarly, mean squares due to genotype x environment was alsofound to be highly significant for all the characters except, protein, lysine and tryptophan. The mean performance, crosses, namely, CML 167 x CML 161, CML 161x CML167, CML 167 x VL1037, VL1056 x CML 167 and CML 167 x VL1056 were found to be top rankers for grain yield per plant in comparison to the better check, Shaktiman-4. Pooled analysis of variance revealed highly significant mean squares due to general combining ability (GCA) for the characters viz., days to 50 per cent anthesis, days to 50 per cent silk, plant height, ear height, number of grain per plant, 1000-grain weight, protein per cent in kernel, lysine per cent in kernel protein, tryptophan per cent in protein and grain yield per plant were highly significant except anthesis-silking interval and days to75per cent maturity was found to be non-significant. The mean squares due to specific combining ability were highly significant for the characters, namely, days to 50per centanthesis, days to 50 per centsilk, plant height,ear height, days to75 per cent maturity , number of grainsper plant, 1000- grain weight, protein per cent in kernel, lysine per cent in kernel protein, tryptophan per cent in kernel protein and grain yield per plant except anthesis-silking intervalwas found to be non-significant. mean squares due to reciprocal specific combining ability (RSCA) for the characters viz., days to 50 per centanthesis, days to 50 per centsilk, plant height, ear height,number of grain per plant, 1000-grain weight, protein per cent in kernel protein, lysine per cent in kernel protein, tryptophan per cent in kernelprotein and grain yield per plant were highly significant except anthesis-silking intervaland days to75 per cent maturity was found to be non-significant.

Estimates of components of variance for twelve characters revealed that variance due to SCA was more than variance due to GCA for the characters viz., days to 50 per centanthesis, days to 50 per cent silk, anthesis-silking interval, plant height, ear height, days to 75 per cent maturity, number of grain per plant, 1000-grain weight, protein per cent in kernel, lysine per cent in kernel protein, tryptophan per cent in kernel protein and grain yield per plant. Parent CML 167 was found to be good general combiner for grain yield per plant. Crosses, namely, CML 161 x CML 167, CML 167 x VL 1056, CML 171 x VL 1037, CML 161 x CML 193 and CML 193 x VL 1037 were found to be top five good specific combinations for grain yield per plant. Reciprocal specific combinations, VL 1037 x CML 167, VL 1056 x CML 171, VL 1056 x CML 161, VL 1037 x CML 161 and CML 171 x CML 161 were found to be top combinations good for grain yield per plant. The best hybrid CML 161 x CML 171 and CML 161 x VL 1037 was identified on the basis of SCA/RSCA, GCA, mean performance and stability for grain yield across the environment. So, the experimental hybrid, CML 161 x CML 171 was identified as the promising hybrids

for grain yield per plant and VL 1037 x VL 1056 for quality parameter across the environment.

ABSTRACT

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Degree programme : Ph.D.

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Minor subject : Molecular Biology and Genetic Engineering

Year : 2019

Name of the University : Bihar Agricultural University, Sabour, Bhagalpur

Title of the thesis : **"Identification and molecular mapping of QTLs for herbicide tolerance in chickpea (*Cicer arietinum* L.)"**

Competition with weeds is a major constraint to chickpea production, exacerbated by limited herbicide control options. Because of the sensitivity of chickpea to herbicides choices for post-emergence herbicides are limited. Imazethapyr, an imidazolinone compound, is used as selective herbicide to control most annual grasses and certain broad leaf weeds. Identifying quantitative trait loci (QTLs) for herbicide tolerance may facilitate breeding for improved herbicide tolerance in chickpea. An essential pre-requisite for such understanding is the development of standardised method for phenotypic classification of data and for this, preliminary experiments were conducted, which revealed that 3.5 mL/L dose level of imazethapyr was the optimised dose for screening of the ICC 14077 (susceptible parent) × ICCV 10 (tolerant parent) derived mapping population. A set of 188 F_8 recombinant inbred lines (RILs) was evaluated under field conditions to assess the genetic variability, to study the relationships of herbicide tolerance with grain yield and associated traits and identification of QTLs associated with herbicide tolerance in chickpea. Apart from field experiment, four times screenings of RILs and parent for herbicide tolerance were done in glasshouse. The population means for all the studied traits in herbicide sprayed condition were found to be lower than that of respective trait in unsprayed conditions except days to 50% flowering and days to maturity. 100-seed weight was the least affected and grain yield

was the most affected trait by herbicide treatment. The genotypic coefficient of variation and phenotypic coefficient of variation estimates were recorded high for grain yield and visual score in herbicide sprayed condition. Negative correlation of visual score with grain yield, plant height, biomass, 100-seed weight and harvest index were observed indicating, lines lower in visual score, with taller plant height, larger seed size, more biomass accumulation and higher harvest index will be more tolerant to herbicide and will yield more grain in herbicide sprayed conditions. The cost-effective Affymetrix® Axiom® genotyping array was used for genotyping of the population. A high-density linkage map of eight linkage groups was constructed covering 704.67 cM of the chickpea genome with an average interval of 0.07 cM between markers using 9410 single nucleotide polymorphisms (SNPs). The highest number of markers was observed on CaLG03 (4227) while, the lowest number of markers was observed on CaLG05 (294). A total of four QTLs were identified for herbicide tolerance. QTL analysis detected a single genomic interval containing a major QTL- *qIMIT6* (on position 20cM, phenotypic variance explained ranging from 15.24% to 27.83% and logarithm of odds score value ranging from 8.46 to 13.47) for visual scores in all four screenings in glasshouse and all four scorings at different days after herbicide spray in field condition, which was responsible for herbicide tolerance in chickpea. Apart from this, three other minor QTLs were identified (*qIMIT-2* on CaLG02, *qIMIT-3* onCaLG03 and *qIMIT-4* onCaLG04) explaining phenotypic variation for visual score ranging from 5.71% to 7.30% in field scoring. The tolerant parent ICCV 10 was contributing the desirable alleles for all the QTLs found for herbicide tolerance in the four genomics regions on CaLG06, CaLG02, CaLG03 and CaLG04. The traits that were found to be associated with grain yield under herbicide spray can be used as the indirect selection criteria for herbicide tolerant lines in chickpea. Further, the lines with higher grain yield, lower visual score, more biomass and taller plant height in the present RIL population can be used directly in the breeding programme for developing herbicide tolerant chickpea cultivars. And finally, the markers linked to the major QTLs can facilitate marker-assisted breeding for herbicide tolerance in chickpea.

List of Ph. D. passed out students from the Department of Soil Science and Agricultural Chemistry

S.No	Name	Title of Thesis	Year of Admission	Year of completion	Remarks
1.	Shalini Kumari	Characterization, classification and land suitability evaluation of Banana growing areas under Bhagalpur district	2015	2020	ICAR-NET, Asstt. Director (Chem), Bihar Govt.
2.	Santosh Kumar	Characterization, classification and management of hydromorphic soils under Khagaria district of Bihar	2015	Continuing	
3.	Hena Praveen	Impact of Integrated Nutrient Management on Chemistry of Native Zinc in Alluvial soil under rice-wheat system	2016	2020	

Title of thesis	:	**Characterization, classification and Land suitability evaluation of banana growing areas under Bhagalpur district in Bihar**
Name of student	:	Shalini Kumari
Registration no.	:	D/SSAC/568/BAC/2015-16
Degree of programme	:	Ph.D.
Major Subject	:	Soil Science and Agricultural Chemistry
Minor Subject	:	Agronomy
Major Advisor	:	Dr. Y.K. Singh
Co-advisors	:	Dr. Rajkishore Kumar, Dr. Mainak Ghosh, Dr. Fozia Homa and Dr. Shirin Akhtar
External Examiner		Dr. V.K. Mishra

Year of passing	:	2020
Name of University	:	Bihar Agricultural University, Sabour, Bhagalpur, Bihar

Abstract

Banana (*Musa paradisiaca* L.) a tropical fruit crop and it is originated from South East Asia. It is one of the most leading fruit crops grown in India and contributes approximately 31.74 per cent in fruit pool and Bihar stands 7th rank towards banana production. Soil and water resources were varied because of Kosi and Ganga river, act as sandwiched in banana growing areas of Bhagalpur during flood known as New Alluvium.

The experimental results has been laid out by collecting soil and water samples from six blocks and total 960 soil samples from surfaces and sub surface layer were collected from 240 locations at various effective depth layer viz., 0-15, 15-30, 30-45 and 45-60 cm, respectively. Apart from these, 144 water samples were collected from pre and post monsoon from various sources as well, tube-well, river and ponds, respectively after two consecutive years of 2016 and 2017. As per water quality concern, pH, EC, RSC and SAR were varied from 7.01-8.08, 0.41-1.24(dSm^{-1}), -7.2 to +8.0, 1.22 to 8.03 and 7.01-8.21 and 0.22-0.94 ($dS\ m^{-1}$), -6.8 to +6.6 and 1.30 to 10.17 in 2016 and 2017, respectively. Overall, we can conclude that 19 percent more samples falls under C_3S_3 class in 2017 compared to 2016 over the year.

For characterization of soils, six pedon has been excavated *viz*., Rangra (P_1), Gopalpur (P_2), Bihpur (P_3), Naugachiya (P_4), Narayanpur (P_5) and Sabour (P_6) and results revealed that Rangra (P_1) and Gopalpur (P_2) were classified as *Aquic Ustifluents* falls under *Entisols*. The pedon selected from Bihpur (P_3), Naugahchia (P_4), Narayanpur (P_5) and Sabour (P_6) classified as *Flueventic Haplustepts, Typic Endoaquepts, Aeric Endoaquepts and Typic Haplustepts,* respectively were falls under *Inceptisols.* The bulk density was varied from 1.27-1.43 (g/cc), porosity (47.13 to 51.55 %) and MWHC (20.82 to 57.75 %), respectively. The FC, PWP and AWC were varied from 20.18 to 33.80, 7.41 to 16.04 and 10.24 to 26.25 (%), respectively. MWHC (v/v), PAWC, and moisture retention was varied from 29.35-74.90 percent, 1.157-6.875 and 4.93-19.93 ($cm\ ha^{-1}$) respectively. Total PAWC, total WSC and fraction of PAWC/WSC were varied from 0.134-0.238, 0.518-0.668 and 0.200- 0.388 ($m\ ha^{-1}$), respectively. However, pH and EC (dSm^{-1}) was varied from 7.01- 8.61 and 0.28-0.58, respectively. The organic carbon and $CaCO_3$content was varied from 0.24-0.91 and 4.50-21.00 percent, respectively. The CEC, ESP and base saturation were varied from 10-21meq/100, 0.60-1.97 and 60-94 percent, respectively. The CEC/clay ratio of selected pedon was varied from 0.33 to 0.99 indicates recently and more weather of new alluvial deposited plain of soils. From the fertility point of selected pedon, N, P_2O_5 and K_2O content were varied from 156-290, 14.67-64.60 and 188-664 (Kg/ha), respectively. DTPA-Fe, Mn, Zn and Cu were varied from 5.56-14.08, 2.14-13.48, 0.62-4.44and 0.28- 2.46 (mg/kg), respectively. The microbial count *viz*., bacteria, actinomycetes and fungi was varied from (8-45 ($cfu\ g^{-1}\ *10^6$), (5-25 $cfu\ g^{-1}\ *10^5$) and (2-15$cfu\ g^{-1}\ *10^4$) respectively. The alkaline phosphates and

dehydrogenase activity was varied from (0.036-0.202 mg PNP gm^{-1} hr^{-1}) and (9-61µg TPF g^{-1} $24hr^{-1}$), respectively. The $CaCO_3$ content was varied from low to medium and organic carbon content was varied from low to high status at various layer due to raw organic matter prevails in rhizopshere layer beneath the roots of banana crops. From the fertility point of view, most of the samples belongs to nitrogen status was varied from deficient in nature at various layer. The phosphorous content was varied from low to high status because of indiscriminate use phosphate fertilizer and potassium content was varied from medium to high due to micaceous parent material. The abundance of cationic micronutrients was sufficient in nature due to alluvial deposit of parent material at various layers of banana growing soils in Bhagalpur district.

Thus, it is concluded that, soil suitability model of banana growing areas of all selected pedon (P_1 to P_6) by Storie (1974) and FAO (1983) falls under S_3 (marginally suitable) and S_2 (moderately suitable), respectively. As per Naidu et al (2006), though, integration of climate, soil and water quality pedon (P_2) and (P_3) indicates S_1 (highly suitable) and rest of the selected pedon falls under S_2 (moderately suitable). Whereas, apart from biological properties, incorporation of local situation, Riquier's *et al*. (1970) model was best suited and fit for banana growing soils and found S_3(Marginal suitable) towards actual productivity and place S_2(moderate suitable) in potential productivity. Moreover, validation of suitability model approach, slight intervention of the target yield is being achieved by P_3 (Bihpur) and P_4 (Naugachiya block).

Title of thesis	:	**Characterization, classification and Management of Hydromorphic Soils under Khagaria District in Bihar.**
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Minor Subject	:	Agronomy
Major Advisor	:	Dr. Y.K. Singh
Co-advisors	:	Dr. Rajkishore Kumar, Mr. B. K. Vimal, Dr Mizanul Haque, and Dr. S. N. Singh
External Examiner		Dr. Sonal Tripathi
Year of passing	:	2020
Name of University	:	Bihar Agricultural University, Sabour, Bhagalpur, Bihar

Abstract

The present study was planned entitled on "**Characterisation, classification and management of Hydromorphic soils under Khagaria district in Bihar**". Total six pedons was investigated for intensive study of morphological, physical, physio-chemical, fertility status, and their genesis through mineralogical analysis in hydromorphic areas.Total two hundred and twenty soils samples and forty two water samples were collected from occupying areas for proper interpretation and maintain its accuracy and precision level in this study area. Results revealed that P_1, P_3, P_4 and P_6 were fall under *hyperthermic temperature regime* as well as *aquic moisture regime,* and further taxonomically placed in *Entisols*, and P_2in *Inceptisols*.The mineralogical data (XRD analysis) revealed that land unit *viz*., P_1, P_3, P_4, P_5 and P_6 have been observed three consecutive peak at 1.00 nm (001), 0.49 nm (002) and 0.33 nm (003) after advocated with various K-treatments like K25^{0}C, K110°C, K 300 °C and K 550 °C, respectively, and its further indicative of predominance of mica, and rest of the mineral present in sub amount followed by smectite, kaolinite, chlorite and quartz, respectively. Whereas, land unit (P_2) have been sharply observed sharp peak at 0.71 nm after advocated with Ca-Eg solvation which pose to significant amount of smectite content was prevailed. Whereas, other mineral was evident in sub amount followed by mica, kaolinite, chlorite and quartz, respectively.

The intensive study of physical properties of pedons like sand, silt and clay content were observed, and it varied from1.8 to 72.0, 9.2 to 73.20 and 11.10 to 54.40 per cent, respectively. The uneven distribution of clay fraction was justifying the fluvial action of river.The bulk density and water holding capacity were varied from 1.31 to 1.63 $Mgm^{-3}$and 30.77 to 45.03 percent respectively. While, physio-chemical properties of pedons (P_1 to P_6), soil reaction was varied from 7.00 to 8.00,and ΔpH (pH 1N KCl - pH H_2O) was varied with-0.3 to -0.40 unit difference which was referred to negatively charged was predominate on soil colloids. The EC value ranged from 0.81 to 1.09 (dSm^{-1}), and none of samples faced to salinity problem in this areas. The ESP, and CEC Cmol (P^+) $kg^{-1}$and BS value range from 1.54 to 9.07, 10.10 to 41.00, 81.49 to 99.66, respectively. From fertility point of view, the value of organic carbon content varied from 0.16 to 0.74 per cent. The available nitrogen, available phosphorus and available potassium content were varied from 104 to 341, 4.65 to 17.9, 249 to 392 kg ha^{-1}, respectively. In general, major nutrient content was observed higher at surface layer, and further decreasing at sub-surface layer. While, as per concerns of DTPA-micronutrients, the DTPA-Fe, Mn, Zn and Cu content of surface and sub-surface layers were placed under above the critical limit.

The physico-chemical properties of surface samples in hydromorphic areas, the value of soil pH $_{(1:2.5)}$ and $EC_{1:2.5}$ (dSm^{-1}) and OC (%) was varied from 5.76 to 8.61, 0.28 to 0.58 and 2.50 to 5.70(%), respectively.From fertility point of view, the content of available nitrogen, available phosphorus and available potassium of surface soils were varied from low, low to medium and high in nature. In respect of micronutrient content, the DTPA-Fe, Mn, Zn and Cu content ranged from 2.83-8.53 and 2.41-19.90, 0.37-4.44, 0.28-2.46$mgkg^{-1}$, respectively at surface layers (0-15 cm) in studied areas.

In characterisation of water quality resources, pH value was ranged from 6.83 to7.89 *i.e.,* neutral to alkaline in reaction. As per concern of EC, all water samples were placed

under non-saline in nature. The irrigation water quality classification (USSL, 1954), 5.56, 52.77 and 41.67 per cent water samples were placed under C_1S_1, C_3S_1 and C_2S_1 class and none of the samples were placed under C_4S_1 class. The SAR and RSC value of water samples ranged from 2.59 to 4.47 and -6.20 to 2.20meqL^{-1}, respectively. As per soil site suitability class proposed by Sys et al. (1991), P_1, P_3 and P_5 were placed under moderately suitable (S2) for paddy, wheat, soybean, maize and sunflower crop, whereas, P_2 and P_4 were placed under marginal suitable (S3) for paddy, wheat, soybean, maize and sunflower, respectively. However, based on the integration of various parameters like soil limitation (Soil texture, structure and soil fertility constraints), and ground water potential (pH, EC, RSC, SAR) enable to improved the productivity potential in Hydromorphic areas.

Title of thesis	:	**Impact of Integrated Nutrient Management on Chemistry of Native Zinc in Alluvial soil under Rice-Wheat system**
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Abstract

Integrated nutrient management aims for proficient and careful use of all

the major sources of plant and soil nutrients in an integrated manner. The present study was carried out at Bihar Agricultural College farm Sabour entitled **"Impact of Integrated Nutrient Management on Chemistry of Native Zinc in Alluvial soil under Rice-Wheat system"** under IFS scheme started from 1984 comprising four replication and twelve treatment permutations. The treatment included three organic sources *viz.*, FYM, wheat straw (WS) and green manuring (GM) with *Sesbania aculeate* replacing 25 % and 50 % of the optimum N during *kharif* season, treatment replacing 50 % N through organic manure were given 100 % RDF in wheat while those receiving 25 % N replacement in rice got only 75 % RDF in wheat. Thus it was making six INM treatment permutations, which were assessed against 100 % RDF along with unfertilized absolute control. The results indicated that the replacement of 50 % and 25 % N of RDF to rice through organics either FYM/ GM/WS, significantly augment the organic carbon, CEC, available N, P, K, S, DTPA-Zn, Cu, Fe & Mn and boron (B) content of post-harvest soil after 34 years of the experiment and also increased the crops yield, nutrient concentration and uptake of rice and wheat. It has been found that the application of FYM, WS and GM increased the soil organic carbon (22-32%), available N (23-46 %), P_2O_5 (03-29 %), K_2O (07-14 %) and DTPA-Zn (38-73%) than 100 % RDF over a period of 34 years continuous cultivation. The adsorption data were fitted into Langmuir and Freundlich equations to test its fitness and gave a linear relationship between amount of Zn adsorbed per unit mass and equilibrium concentration with high R^2 values might be due to the prominent contribution of INM leads to maintain the soil health and it improved significantly Zn- adsorption and desorption capacity of soil as compare to sole mineral fertilization.