



International Agriculture Conference: Haripur (08th-10th December 2016)  
FEEDING 9 BILLION THROUGH SUSTAINABLE AGRICULTURE

## CONFERENCE PROCEEDINGS

Conference

SUSTAINABLE CROP AND ANIMAL  
PRODUCTION SYSTEMS

December 08-10, 2016

ORGANIZED BY

PAKISTAN AGRICULTURAL SCIENTIST FORUM  
UNIVERSITY OF HARIPUR, HARIPUR

FEEDING **9** Billions  
through sustainable  
*Agriculture*

International Agriculture Conference: Haripur (8<sup>th</sup> – 10<sup>th</sup> December 2016)  
FEEDING 9 BILLION THROUGH SUSTAINABLE AGRICULTURE



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**International Agriculture Conference: Haripur (08th-10th December 2016)**  
**FEEDING 9 BILLION THROUGH SUSTAINABLE AGRICULTURE**

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**MESSAGES**

**President**

**Pakistan Agricultural Scientists Forum**

I am thankful to Almighty Allah that Pakistan Agriculture Scientists Forum is holding its annual conference at University of Haripur, Khyber Pakhtunkhwa. It is a matter of great satisfaction that members of this forum have contributed in high lighting the issues faced by agriculture sector and its related disciplines suggesting solutions with the help of eminent scientists from the country inciting them for such brain storming sessions. We were the first to highlight the issue and impact of climatic change back in 2008 at our annual conference held at Barra gali campus of Peshawar University and now again we have invited elite of scientists to suggest action plan to feed 9 billion populations in future. We are also concerned equally about animal food security as well. One of the achievements of PAS Forum is its official scientific journal which has recognition by shaving impact factor and we are thankful to Allah that this is being published successfully under the umbrella of PAS Forum regularly right from its inception. I pray that this year's conference will also serve as mile stone in highlighting the challenge of feeding 9 billion population.

**Hafiz Wasi Mohammed Khan**

**Vice Chancellor**

**University of Haripur**

Enhancing Sustainable Development through Agriculture addressing the common need for food, feed, fiber and fuel requires a global action plan to increase agricultural output in an environmentally-sustainable, economically-feasible, socially-responsible manner. A broad-based, knowledge-centered approach to agricultural development is needed. There is a need for a radical shift in thinking which places the farmer at the center of sound and sustainable agricultural practices. However, farming policies have neglected the critical role which farmers, especially smallholder farmers, must play in making sustainable development a reality. So, taking farmers on board to the center of policy decisions is fundamental to sustainable development.

**Prof. Dr. Nasser Ali Khan**

**Pro-Vice Chancellor**

**University of Haripur**

Modern intensive agriculture fueled by high inputs and supported by mechanization has caused dramatic increase in food and fiber production. But at the same time, the rise in production has been at the cost of depletion of soil fertility, groundwater contamination and environmental pollution jeopardizing the quality of life on earth and putting our future populations on risk. Sustainable agriculture is the answer to ensuring continued productivity and stability of the world's agriculture production in an environment friendly manner. Sustainable agriculture can sustain production indefinitely because it does not take more than it gives back to the land and protects the environment. Hopefully this conference will pave the way to moving toward the goal of sustainable agriculture.

**Prof. Dr. Abid Farid**





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**Conference Coordinator**

Ever increasing population has demanded increased food production, both from animal and crop sources. Since the green revolution, the increased food and fiber productivity has changed the agriculture a lot by introduction of new technologies and use of chemicals maximizes the food production. Manifold increased in crop yields and animal productivity is unable to eliminate the malnutrition on the earth. In Pakistan about 45% under 5 years children died due to under nutrition. The population is increasing at the rate of 2.07% in Pakistan as compared to world growth rate of 1.13%, which means we need more sustainable food production systems. Animal and crop production systems are very much interrelated; we need integration approaches for their sustainability. Sustainable agriculture is a wider term which requires considering environmental health, economic profitability, and social /economic equity while food production. Pakistan Agricultural Scientists Forum (PAS-Forum) is a great podium of agriculturists to develop a sustainable way out of national challenges, especially related food security and environmental stability. It is the only forum which brings the all the sectors of agriculture under one canopy, which is very necessary to face the future challenges of food security, especially the target population of 9 billion. It really requires the sustainability of present agricultural resources being degraded rapidly due to extensive use without replenishment. A great number of abstracts from diversified agricultural sectors including crop production, crop protection, soil management, animal nutrition, poultry/livestock health and agricultural economics indicate the thirst of agriculturists for such platform. I am very sure that this conference will provide a set of solid recommendations for policy makers after two days brain storming. I am also hopeful for the strengthening of PAS Forum after this very successful conference to provide suggestions to government keeping in view the current challenges.

**Dr. Abdul Wakeel**





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**Epidemiology of Theileriosis in Goats in Multan**

**Muhammad Ali<sup>1</sup>, Muhammad Rizwan<sup>1</sup>, Safdar Imran<sup>1</sup>, Muhammad  
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The present study was designed on various breeds of goats to investigate theileriosis in and around Lahore from November 2013 to December 2015. During this period of study, a total of 420 goats and sheep were examined for various species of *Theileria* microscopically. Blood smears were prepared from the blood of each goat and sheep for microscopic examination at Faculty of Veterinary Sciences, B.Z. University, Multan. Prepared blood smears were stained with 5% Giemsa's stain for microscopic study with oil immersion objective. The results of present designed study has shown that prevalence of *Theileria sp.* is 62 (14.76%) of 420 goats and sheep, while 35% blood samples were found positive for *Theileria* species by PCR, out of which 79% were positive for *theileria ovis* and 21% for *theileria lestoquardi*. The clinical signs were recorded in 30% goats and sheep out of the total samples the prevalence of *Hyalomma* was highest (45%) followed by the *Rhipicephalus* (41%) and *Boophilis* (14%). The presence of *theileria ovis* was (68%) as compared to (66%) for *T. lestoquardi* in *Rhipicephalus* and *Hyalomma* ticks respectively. From the present study, we can conclude that theileriosis is prevalent in both sheep and goats.

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**Nutrient Digestibility and IP6 Degradation of Different Sorghum Genotypes with Phytase  
Supplementation by Broilers 21-days Post Hatch**

**Rabia Ali, Asad Sultan, Sarzamin Khan, Naila Imtiaz and M.S. Qureshi\***

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Poultry industry is largely based on cereals for energy component in poultry ration. However certain anti nutritional factors hamper the bioavailability of nutrients and need to be addressed to avoid the compromised bird performance. Present study assessed the impact of a phytate degrading enzymes; phytase on enhancing the nutrient retention and phosphorus utilization in two different sorghum cultivars. In an open sided house 160, 14-day-old broilers were allotted to four dietary bioassay treatments and fed mash Red sorghum grain RS, red sorghum +phytase enzyme (500 FTU/kg) RSE, white sorghum WS and white sorghum + phytase enzyme (500 FTU/kg) WSE for 7 days (including 3 days adaptation period). Grain offered and fecal output was measured for last four days, stored in plastic bags, weighed and freeze dried. Standard lab protocols were adapted to measure proximate analysis, minerals and phytate content in grain and fecal samples. Sorghum cultivars were different in nutrient profile with red higher in protein content (11.41%) It was observed that phytase inclusion in grain increased the availability of all nutrients except crude lipids. Total tract nitrogen retention was increased by 3% in red sorghum compared to white (0.8). Minerals absorption was increased but differently in different cultivars with higher degradation of phytate in both red and white sorghum. Apparent metabolizable energy was significantly enhanced both in red and white sorghum by 5.9 and 4.5%, respectively. From these findings it can be deduced that phytase is effective in improving the utilization of nutrients of sorghum by broilers at day-21 and also reduces the losses of nutrients into the litter that could contribute in safeguarding environment as well. Further research work is however warranted to examine its efficacy in other cereals and complete poultry diets.

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**Meat Borne Pathogens: A Serious Concern for Reducing Quantity and Quality of Meat**

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Raw, washed and cooked meat samples (100) collected from different butcher shops as well household showed sever hygienic, sanitation, safety and quality issues. We did not find any effort for meat quality assurance at butcher shops, the process of slaughtering and dressing were no way near to any guidelines recommended by FAO or USDA. E coli, salmonella and pseudomonas were isolated and confirmed by employing conventional bacterial isolation techniques, biochemical tests and rapid amplifying methods (PCR). Hundred percent raw meat samples for positive for shiga toxins producing E Coli while 86% of these samples harbor salmonella. In contrast to common notion that washing eliminate the meat microbes load, E coli was isolated from 100 % washed sample although salmonella contamination was limited to only 20% samples. The sanitation standard is not only poor at butchers' place but at home as well. The cooked meat samples collected from home were also contaminated with E Coli (90%) and salmonella (20%). The poor meat hygiene and food sanitation at butcher's shop and homes were depicted by presence common environmental pathogen pseudomonas in 71% of meat samples. Two genes (algD1; 1310bp and PlcN;466bp) of the pseudomonas were amplified and sequenced. Meat is packed with high biological available protein, zinc, iron and loads of vitamin B12. These nutrients are very important for people living in developing countries to complement nutrition deficiency which they encounter due to use of diet from limited plant sources and provide them all nutrient necessary for development, growth and stay healthy. Heavy contamination of meat samples with microbes deteriorates quality and nutrition of meat and thereafter shelf life of the meat. Our findings suggest there is prompt need to improve meat hygiene in Pakistan to increase quality and shelf life of meat directly and quantity of meat and public health indirectly.

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**Sonographic Findings in Horses Affected with Tendinopathies and Associated Soft Tissue Injuries of Various Joints, from Lahore, Pakistan**

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The present study was conducted to precisely diagnose and evaluate the percentage occurrence and severity of injuries to the tendons and other soft tissue structures in horses, in and around Lahore city, Pakistan. The status of the joint, associated soft tissue structures, and seat of lameness, was confirmed through ultrasonography. Forty-eight horses were selected and divided into three equal groups (n=16) i.e. Group A (Race), Group B (Polo) and Group C (Draft-purpose) Horses, each group being further subdivided into two equal sub-groups i.e. sound and unsound, with eight horses in each sub-group. Using a high-frequency linear transducer (7.5-12 MHz), soundness was determined on the basis of various sonographic parameters, including echogenicity, fiber alignment severity of injury and degree of prognosis. Furthermore, unsoundness was also determined via ultrasound. The results showed that echogenicity was more significant in Race and Polo Horses ( $P \leq 0.014^{**}$ ) than in draft horses ( $P \leq 0.037^*$ ). Fiber alignment similarly, showed highly significant values for Race ( $P \leq 0.007^{**}$ ) and Polo ( $P \leq 0.002^{**}$ ) horse Groups A and B, than for Draft-purpose horse ( $P \leq 0.021^*$ ) group C. Severity of injury was more pronounced in Race ( $P \leq 0.003^{**}$ ) and Draft-purpose ( $P \leq 0.003^{**}$ ) horses. Group A (Race horses) showed the best prognosis ( $P \leq 0.001^{**}$ ), as compared to Polo and Draft purpose horse groups ( $P \leq 0.006^{**}$ ) while, statistical analysis to establish unsoundness via ultrasound depicted highly significant values for Race and Polo horses, with 80% unsound animals in each group, as compared to 77.8% unsound horses in the Draft purpose Group C, i.e. all unsound horses on clinical examination were confirmed unsound on the basis of ultrasound as well. On the basis of statistical analysis, it was concluded that injuries were generally more pronounced in race horses (Group A) as compared to the other two groups.

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**Role of Rural Women in Livestock Sector in Tehsil Depalpur**

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Pakistan is an agricultural country. Livestock is an essential part of agriculture. In the rural areas of Pakistan many farmers are attached with livestock management. Livestock is the source of livelihood for rural people. Therefore, livestock management is playing a major role for improving the economic and social life of rural people. Females play an important role in all agricultural activities especially livestock. Despite of performing daily house hold tasks (cooking, looking after children and house cleaning) etc. women helps in agricultural activities especially managing the livestock. They perform livestock activities such as cleaning of sheds, providing fodder to animals and treating sick animals. The present study was designed to determine the role of rural women regarding livestock management practices. The study was conducted in tehsil Depalpur. Keeping in view the time and resources available, four union councils were selected randomly. From each union council two villages were selected randomly. A sample size of 110 respondents was taken through snow ball technique. Only those women were selected who were engaged in livestock activities. Data were collected with the help of an interview schedule. The collected data were analyzed with the help of SPSS (Statistical Package for Social Sciences) for drawing conclusions and formulating the recommendations. The results of the study revealed that women were performing major livestock operations but despite of that major livestock decisions were taken by males. The study highlighted some serious problems that respondents were facing in livestock. Absence of agricultural female extension services were one of them. Proper training facilities should be provided to women linked to livestock.

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**Comparative Efficacy of Albendazole, PyrantelPamoate, Ajwain and Kamala against  
*Toxocara Vitulorum* parasitism in Bovine Calves**

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*Toxocara vitulorum* is a round of cattle and buffalo that is common in tropical and subtropical area. Resent study was designed to check the parasitism in calves with therapeutic trial against *Toxocaravitulorum*. Fecal samples from 300 bovine calves were examined for ova. Positive calves were divided in five groups and different treatments including herbal were given to each group and results recorded on day 7 and 14th post-treatment. Overall incidence of *Toxocaravitulorum* was 49% in cow calves and 59% in buffalo calves. Parasitism was higher in 1-3 month age group calves (78% in cow calves & 91% in buffalo calves) while sex wise parasitism was higher in female calves (52% in cow and 61% in buffalo calves) as compared to male calves (44% in cow and 55% in buffalo calves). Parasitism was seen in summer season. The efficacy of Albendazole (Zanil) in cow calves was 25% and 31% at day 7th and 14th, respectively while in buffalo calves the efficacy was 24% and 31% on these days respectively. The efficacy of Pyrantelpamoate was 98% and 100% in cow calves at day 7th and 14th, respectively while in buffalo calves the efficacy of Pyrantelpamoate was 81% and 100%. The efficacy of Ajwain in cow calves was 59% and 69% at day 7th and 14th, respectively while in buffalo calves it was 58% and 69% on these days. The efficacy of Kamala in cow calves was 33% and 39% at day 7th and 14th day of post-treatment, respectively while in buffalo calves the it was 34% and 42%. From this study, it was concluded that Pyrantelpamoate was the most effective drug against Toxocariasis followed by Ajwain, Kamala and Albendazole.

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**Evaluation of Antibody Response to Bivalent Peste des Petits Ruminants Virus and Goat Pox Virus Vaccine in Goats**

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Peste des Petits Ruminants (PPR) and Goat pox (GP) are the most acute viral disorders of sheep, goats, deer and other similar animals and are controlled through annual mass vaccination programs. The study was aimed to prepare freeze dried/adjutant based bivalent Peste des Petits Ruminants Virus (PPRV) and Goat Pox Virus (GPV) vaccine and to evaluate response in goats against both the immunogens. Seven types of vaccines such as 1. Freeze dried (FD) monovalent PPR virus vaccine (FD PPRV: 104.5 units TCID<sub>50</sub>), 2. FD GPV (104.5 units TCID<sub>50</sub>), 3. FD PPRV+GPV (104.5 units TCID<sub>50</sub>), 4. Oil (O) based PPRV+GPV (104.5 units TCID<sub>50</sub>), 5. Gel (G) based PPRV+GPV (103.5 units TCID<sub>50</sub>), 6. G-PPRV+GPV (104.5 units TCID<sub>50</sub>) and 7. G-PPRV+GPV (105.5 units TCID<sub>50</sub>) were prepared. Each vaccine was for 100 goats and was injected to each of the six goats of the respective groups. Serum antibody response of the goats was monitored on zero, 21, 42 and 63 days post vaccination through complement fixation test (CFT). There was non-significant difference between anti-PPR-CFT antibody / anti-GPV-CFT antibody response of goats to FD PPRV /FD GPV and FD PPRV+GPV vaccine (p>0.05). Antibody response of goats to either of the immunogen (PPRV or GPV) was directly proportional to amount of the immunogen in G-PPRV+GPV vaccine. There was non-significance difference in antibody response of goats to either of the immunogen in FD-PPRV+GPV-104.5 units TCID<sub>50</sub>, G-PPRV+GPV-104.5 units TCID<sub>50</sub> or O-PPRV+GPV- 104.5 units TCID<sub>50</sub> (p>0.05). It was concluded that the immunogens (PPRV and GPV) in bivalent vaccine did not interfere in antibody response of goats.

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**Evaluation of Probiotic Yeast on Blood Parameters in Dairy Cow**  
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Blood metabolite and minerals levels can be alter by nutritional changes which are directly or indirectly corrected to regulation of nutrients digestion and subsequently growth and production of the ruminants. Modulation of the ruminants GIT microflora can be done by the use of probiotics. The increased triacylglycerol and total cholesterol in cows fed metabolites of probiotic yeast may explain enhanced activity of lipolytic enzymes and improved utilization of dietary lipid and ultimately animals performance. The study is planned to compare indigenous versus commercial probiotic yeast to blood parameters of dairy cow. Nine dairy cow were divided into three groups and gives different treatments. Treatment I, cow eats control diet supplemented with no yeast. Treatment II, cow eat on control diet supplemented with commercial yeast (Yac-Sac1026; 10g/d/h) while in treatment III cow eat control diet supplemented with indigenous yeast (8g/d/h) for 60 days. Results showed that cholesterol concentration in serum and blood urea concentration of lactating dairy cattle was significantly ( $P<0.05$ ) decreased while serum glucose was significantly ( $P<0.05$ ) increased by probiotic yeast. Calcium and phorporous concentration in the blood serum of lactating cattle was not affected ( $P>0.05$ ) by probiotic yeast in our experiment. The outcomes of the blood parameters showed that the health increased in probiotic groups than non probiotic fed group. It is thus concluded that indigenously isolated yeast enhanced the health efficiency of dairy animals.

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**Assessment of Daily Intake of Aflatoxin M1 in Pakistani Population via Milk Consumption**

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Aflatoxin M1 (AFM1) is a monohydroxylated derivative of aflatoxin B1 (AFB1) formed in liver and excreted into milk. AFM<sub>1</sub> is an important biomarker used to evaluate aflatoxin exposure in both humans and animals. Study was planned to see trend of milk consumption in Pakistan, natural incidence of AFM1 in different types of milk; and assessment of daily intake of AFM1 in the population. A total of 1,414(775 females, 639 males) volunteers actively participated in the study. AFM1 was determined in 440 milk samples {open (n=265), UHT (n=85), pasteurized (n=70) and dried milk (n=20)} by AgraQuant ELISA kit (Romer Labs, Singapore). Study revealed that the highest trend of open milk, (72.5%) consumption is followed by UHT (14.38%); pasteurized (11.59%) and dried milk (1.53%) respectively. The concentration in all milk types (n=440) was ranging from 0.005 to 1.63 µg/L with an average of 0.026µg/L. The occurrence of AFM1 in open, UHT, pasteurized and dried milk was 81.13% (215), 58.82% (50), 84.6% (65) and 50% (10) respectively. The mean concentrations of AFM1 were 0.046 (0.01-1.63µg/L), 0.007 (0.01- 0.683µg/L), 0.032 (0.01-0.06µg/L) and 0.018 (0.005-0.18µg/L) in open, UHT, pasteurized, and dried milk samples respectively. The incidence trend of positive percentage of contamination was found as open > pasteurized >UHT >dried milk respectively. After considering the mean body weights the mean intakes of AFM1 calculated as children 0.73 & 2.31 ng/kg BW/day; teen-age boys 0.35 & 0.206ng/kg BW/day; teen-age girls 0.23 & 0.33 ng/kg BW/day; adult male 0.146 & 0.163 ng/kg BW/day; adult female 0.167 & 0.17 ng/kg BW/day; and for elderly male and female 0.164 & 0.17 ng/kg BW/day respectively. The estimated daily intake of AFM1 for children was found highest than other three groups teens, adults, elderly. Exposure of population to AFM<sub>1</sub> was low, but continuous monitoring of mycotoxin levels is essential to minimize population especially infant's health risk.

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**Role of Zinc in Immunity Development in Broilers**

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Animal's diets are supplemented with elements that have role in growth and immune system. Zinc is essential element for all kind of life. It was recognized as essential mineral for poultry in 1958 when leg abnormalities, poor growth, poor feathering were reported due to its deficiency. It is included in type-2 nutrients; required for general metabolism, fat, carbohydrate, protein, nucleic acid, membranes and vitamins metabolism. It is necessary for 300 metalloenzymes and more than 2000 transcriptional factors. At least one or more zinc depending proteins takes part in almost each signaling and metabolic pathway. It also improves the immunological functions, general health and disease resistance in broilers. The balance of nutrients in diet is directly involved in optimizing growth functions but mutual research across disciplines result in more approaching toward the hypothesis. It is clear that from genetic basis of immunity within lymphocytes to the skin barriers, zinc plays central role in multiple aspects of immunity development. Immunological aspects of zinc are due to its role in basic cellular functions such as r cell division, cell activation, RNA transcription and DNA replication. Zinc fingers help to read DNA sequences. Zinc supplementation enhances cellular components of immunity like phagocytosis by neutrophils and macrophages, NK cell activity, generation of oxidative burst, antibody responses, and the numbers of cytotoxic CD8+T cells. It sustains cellular membranes. Thymulin activity, in both humans and animals, is dependent on its plasma concentrations. It promotes T lymphocyte maturation, IL-2 production and cytotoxicity. It has antioxidant activity, protecting cells from the damaging effects of Reactive Oxygen Species generated during immune activation and heat stress. It is an integral part of superoxide dismutase and has synergistic effect with vitamin E. This is an attempt to provide role of zinc in biological basis of immunity and nutritional modification of immune functions.



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**Quail farming in Pakistan: Present Status and Future Perspectives**

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The Japanese quail (*Coturnix Coturnix Japonica*) is a type of popular commercial line commonly known as “betair” in Pakistan and has certain specific advantages including, it can be used for meat production at a short period of time (4 weeks) and matures at an early age (6 weeks) with comparatively shorter (17 days) incubation period. Quail farming is also attractive because the quails are robust, disease resistant, feed and space efficient, hence convenient to manage than other poultry species including chicken, turkey and duck etc. Although, quail farming possesses enormous potential, yet remained one of the neglected components of the poultry sector in Pakistan because of the less focus of research in the areas of quail breeding, incubation, housing, nutritional requirements, overall management and disease control under local environmental conditions. Some public and private organizations made efforts for the development of quail farming to produce quail meat at a reasonable price, the measures were not adequate to meet the challenges. Studies at Avian Research and Training (ART) Center have helped increasing the body weight of this bird and this improved bird is getting excellent market response from all over Pakistan.



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Semen Morphology and Effects of Artificial Insemination on Hatchability in Turkeys

(*Meleagris gallopavo*)

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Morphological characteristics of turkey *Meleagris gallopavo* semen were recorded and hatchability percentages of the artificially inseminated hens were assessed. To study the effect of natural mating on hatchability 15 (3♂, 12♀) *M. gallopavo* were randomly selected, were kept separately and were allowed to mate through stud mating. For artificial insemination, male (n = 3) and female (n = 12) birds were kept separately. Semen of the male birds was collected on weekly basis to record morphological characteristics and to inseminate the female birds. Mean abnormal spermatozoa rate was 14.61±1.61% with most common acrosome defects 39.67±3.80% followed by defects in mid-piece 29.61±0.24%, head defects 10.15±1.21% and tail defects 20.57±1.97%. Laid eggs were collected, stored and were incubated for hatching. Hatchability percentage in artificially inseminated hens was greater 88.30% than natural mating 80.51%.

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**Effect of Variable Dietary Energy Levels on Dry Matter Intake, Milk Production and Milk  
Composition of Early Lactating Friesian Cows**

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The aim of the study was to evaluate the effect of three different dietary energy levels on dry matter intake (DMI), milk production and composition of early lactating Friesian cows at Agriculture University dairy farm peshawar. Nine multiparous early lactating (10±5 days in milk) cows were selected on the basis of nearly the same body weight (410±10) and milk production (12±01) were divided into three groups with three animals in each group under a completely randomized design for a period of 75 days. Three types of diet were formulated being iso-nitrogenous (16%) but varying dietary energy levels, viz; Group A (E-100%), Group B (E-88%) and Group C (E-112%); Metabolizable energy levels for early lactating cows. High DMI (P<0.05) was recorded for diet E-112 (13.78±0.17 kg/day) followed by diet E-100 (13.14±0.12 kg/day). Significantly high milk yield (14.80±0.10 lit/day) was observed in diet E-112 and lower milk yield (13.01±0.10 kg/day) for diet (E-88). High milk fats (3.91±0.02) percentage was found at low energy diet E-88 followed by group A and C treatments, whereas no statistical difference found among the treatments for milk protein, lactose and solid not fat. It was concluded that diets containing high dietary energy (112 ) above than the NRC level of ME recommended for early lactating cows conferred in an increase in DMI and milk yield whilst feeding a diet containing less than the recommended level decreased DMI and milk production under local environmental conditions of Peshawar, Pakistan.

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**Growth Performance and Economic Efficiency of three Commercial Broiler Strains  
Reared at Different Bedding Materials**

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A study was conducted to evaluate the effect of four different bedding materials on the growth performance, carcass characteristics and economic efficiency of three commercial broiler strains (Ross 308, Cobb 500 and Arbor Acres). Three hundred and sixty day old broiler chicks, 120 from each strain having uniform body weight were procured and randomly distributed into 36 replicates under CRD with 10 birds in each. The experimental birds were reared on 4 bedding materials (wood shaving, wheat straw, corn cob pulp and rice husk) and fed same diet ad-libitum up to the age of 5 weeks under Completely Randomized Design with 4×3 factorial arrangement of treatments (brooding sources × strains). Weekly weight gain, FCR and mortality was recorded to evaluate the ultimate growth performance and economical appraisal in terms of running cost/Kg live weight. The results revealed that Cobb 500 reared on corn cob pulp (CP) exhibited significantly ( $P<0.05$ ) better body weight gain, FCR, Point spread (PS), European Production Efficiency Factor (EPEF), Growth performance index (GPI) and superior carcass characteristics leading to higher profit margin with better livability in comparison to other broiler strains reared on other bedding materials.

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**Effect of Season on Microbial Count and Chemical Properties of Dead Bird and Used  
Litter Compost**

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A study was conducted to investigate the physico-chemical, mineral and microbiological characteristics of dead poultry and litter compost during different stages of composting during winter. This investigatory research was performed in triplicates under completely randomized design (CRD). For this purpose, three composting bins were filled with organic waste comprising dead poultry and litter by following the internationally accepted standard method of bin filling. Sampling was done at the end of each phase to record the data for physico-chemical, mineral and microbiological parameters. The data were analyzed by using ANOVA technique under CRD. The data revealed higher maximum temperature, maximum moisture, and crude protein in primary phase, average temperature in secondary phase, dry matter, ash, calcium, phosphorus, and potassium content in curing phase of composting. However, nitrogen content, C: N ratio and bacterial count were significantly reduced during curing phase of composting. It can be concluded that composting technology is an environmentally safe method of dead birds' disposal that can be used to convert organic waste into useful organic fertilizer.

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**Antibacterial Effect of Organic Acids in Broilers**

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Use of antibiotic in poultry are primarily disappear because of their residual effects which remains in meat and egg. As a replacement of antibiotic, organic acids are to be used as individual acid and blend of acids. Like antibiotic, organic acids are used for their antibacterial effect. Organic acids are considered to be any organic carboxylic acid, including fatty acids and amino acids of general structure R-COOH. Organic acid is more efficient than antibiotic growth promoter in improving broiler performance and decreasing intestinal *E. coli* and *Salmonella* and could be used as a replacement of antibiotic growth promoter in broiler diet. These acids have strong bacteriostatic effect. Dietary supplementation of organic acid results in reduction of pH which inhibits the growth of bacteria that are sensitive to acidic pH and improve protein digestion and energy digestibilities by reducing microbial competition with host for nutrients and stimulating pancreatic secretion. As it reduces intestinal colonization, it decreases inflammatory process at intestinal mucosa which improves villus height and function of secretion, digestion and absorption of nutrients. Reduction in harmful bacterial population could increase the surface area in intestine which increase the proliferation of *Lactobacillus* bacteria and nutrient absorption. So, on the basis of different studies it was concluded that organic acids supplementation reduces harmful bacterial and improve *lactobacillus* counts which increase nutrient absorption and ultimately growth of broilers.

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**Antioxidant and Antibacterial Activity of Turmeric in Poultry  
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Sub-therapeutic use of antibiotics as growth promoter has resulted in increased number of resistant bacterial strains. It generates a strong objection on the use of antibiotics. Thus, the use of antibiotics as growth promoter in poultry has been eliminated or rarely used. The European Union has banned the use of subtherapeutic level of antibiotics to prevent disease and to promote growth performance of birds. So, Alternate of antibiotics has been used in poultry industry which include prebiotics, probiotics, organic acids, enzymes and phytobiotics. Herbs and plant extracts in poultry feed also known as phytogenics or phytobiotics. They have similar effect on growth performance and gut microflora as antibiotics. Turmeric or *Curcuma longa* can be used as satisfactory alternative to antibiotics. Curcumin is the main active compound present in turmeric which is responsible for therapeutic effects, including antibacterial and antioxidant activity. The antioxidant activity of curcumin was reported as early as 1975. It acts as a scavenger of oxygen free radicals. Its derivatives, demethoxycurcumin and bis-demethoxycurcumin also have antioxidant effect. Curcumin exerts powerful inhibitory effect against H<sub>2</sub>O<sub>2</sub>-induced damage. Curcumin can significantly inhibit the generation of reactive oxygen species (ROS) like superoxide anions, H<sub>2</sub>O<sub>2</sub> and nitrite radical generation by activated macrophages, which play an important role in inflammation. Curcumin stimulates the secretion of bile acids and activities of lipase, amylase and proteases, which are responsible for important roles in metabolism and accelerated digestion which improves the *lactobacillus* population and decreased the *E. coli*. Turmeric and curcumin are well tolerated at a very high dose without any toxic effects. Thus, both turmeric and curcumin have the potential for the development of modern medicine for the treatment of various diseases.

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**Significance of Accelerated Ripening of Cheddar Cheese in Changing Perspectives of Dairy Sector of Pakistan**

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Cheddar is one of the most commonly consumed cheese in Pakistan. Cheese and fast food industry in not flourishing because of higher costs involved in cheese ripening and maintenance of cold chain for almost half a year. All over the world, people are trying to conserve the energy resources; unfortunately, our dairy industry is sticking to the outdated technology of cheese ripening. According to outdated technology, cheddar cheese is ripened for 6-months to develop desired flavor and textural perspectives. Prolonged ripening is a costly and patient able affair, it requires massive refrigeration and inventory cost. In our situation, the issue becomes more complicated, as the alternative sources of electricity are even more expensive. Ripening temperature had great effect on biochemical events which take place during the maturation of cheese, ripening of cheese at relatively higher temperatures can significantly accelerate the metabolic processes in cheese. Massive refrigeration and inventory cost has led the lower development of cheese industry in Pakistan, further; the price of cheese is quite high. For example, a cheese manufacturer is producing 100 kg cheese daily, cheese is ready for sale in 6-months, so he has to produce 180,000 kg cheese before the sale commences. Suppose the price of 1kg cheese is 700 rupees, the cost of inventory will be 126, 00,000 Rupees. If ripening time is reduced to 30 days the cost involved in the maintenance of inventory will be only 2100, 000 Rupees. Similarly, refrigerating cost will also be decreased by 5 times. Beneficiaries of this work will be cheese industry, fast food industry and ordinary consumer. Rapid ripening of cheddar cheese will attract large number of farms to convert their milk into cheddar cheese for better and quick and economic returns. Lower prices of cheddar cheese may also promote the fast food industry of Pakistan.

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**Sustainable Small Ruminant Production: A Case Study on Herbal Anthelmintics as  
Alternate Remedy against Small Ruminants Nematodes in Context of Drug Resistance in  
Pakistan**

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The gastrointestinal nematodes are common pathogens in grazing sheep/goats throughout the world which impairs productivity and leads to high economic losses. In most part of the world, drug resistance against anthelmintic is now very common. In this context, various alternative control programs including herbal use against these worms is also an important option. To explore the problem, three available synthetic anthelmintic (Oxfendazole alone, oxfendazole-Levamisole combination and Ivermectin) were administered to natural major nematodes (*Haemonchus*, *Trichuris*, *Strongyloides* and *Trichostrongylus*) infected sheep and goats. Overall results showed susceptibility of these anthelmintics (96% Faecal Egg Count Reduction-FECR) and no evidence of resistance recorded. However, three herbal anthelmintics (Atreefal Deedan, Deedani and Kirmar) available in Pakistan were tested against nematodes. Among these Atreefal Deedan showed highest (97%) FECR, followed by Deedani (85%) and Kirmar (70%). It is concluded that on small scale assessment no drug resistance observed against few worms in sheep and goats in Pakistan. A broader study is recommended for assessment of drug resistance and also evaluation of anthelmintic.

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**The effect of Administration of Variable Doses of Arginine and Lysine Combined with Zn  
in the Lactating Cows on the Zn Concentration in Milk**

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Zinc (Zn) plays a vital role in the form and structure of living body. Zinc deficiency causes serious disorders, so it is important to provide a sufficient amount of this micromineral in both animals and humans. Milk is the main source of Zinc. The present study was conducted to determine the transport of Zinc through the mammary epithelial cell into milk by a co-transport system with amino acids in the lactating cows. This experimental research included 100 lactating cows from the Experimental livestock farm at College of Veterinary sciences, BZU Bahadur campus, Layyah. All the cows were divided into 10 groups as follows: groups which received inorganic form as Zinc chloride (1, 2 and 4 mg/kg), and groups which received organic Zinc with variable doses of arginine either lysine (1, 2 and 4mg/kg) in the chelate form. Milk samples were collected 30 minutes before and 7 hours after intravenous injection of Zinc preparations. Concentration of Zinc in milk was measured through the flame atomic absorption spectrometric method. The results have shown that the concentration of Zinc in the milk of cows groups which received organic Zinc was 3.9mg/l which the concentration of Zinc in the milk of cows which received inorganic zinc was found 4.3mg/l. It shows that there were no significant differences ( $P>0.05$ ) between groups in Zinc concentration of the milk before administration of inorganic or organic Zinc. The present data analysis concluded that administration of inorganic Zinc caused a significant increase of Zinc concentration in the milk in a dose dependent manner. While administration of arginine or lysine with Zinc in chelate form caused a significant decrease in Zinc concentration of milk compared to inorganic Zinc in a dose dependent manner. From the results of present research we can say that the administration of different forms of Zinc influenced the Zinc concentration in milk.

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**Impact of Climate Change on Vector Borne-Diseases and Livestock Production**  
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Likewise other developing countries, Pakistan is also at risk of exposure to the devastating effects of Climate Change (CC). Agriculture and livestock sectors are greatly affected by CC round the globe generally and Pakistan specifically. The productivity of livestock is being affected due to increase in climatic temperatures followed by global CC impacts which include: loss in productivity i.e. meat and milk, physiological and chemical stress like: low conception rate and reproduction. Climate change may also affect the distribution of various vectors and an increment in the prevalence of these vectors will pose the livestock population at risk of various diseases which are transmitted by these vectors. With the increase in the ambient temperature there will be increase in the frequency of vector feeding on host and hence the chances for the transmission of vector borne diseases will also upsurge. In addition to the direct influence of temperature on the biology of vectors and parasites, changing precipitation patterns can also have short and long term effects on vector habitats. Increased precipitation has the potential to increase the number and quality of breeding sites for vectors such as mosquitoes, ticks, and the density of vegetation, affecting the availability of resting sites. Adaptation to climate change and variability will depend to a certain extent on the level of health infrastructure in the affected regions. Moreover, the cost and efficacy of prevention and cure will be critical to disease management. In areas, which have a great diversity of disease vectors that are sensitive to climate change and greater efforts and resources will be required to contain the expected change in disease epidemiology.

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**An Evidence of Myiasis in Lamb of District Poonch, Azad Kashmir: A Case Study**  
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Myiasis is the infestation of organ and tissues of human, wild, domestic and farm animals. Several flies larvae are able to produce myiasis like: *Oestrus ovis*, *Musca domestica*, *Hypoderma bovis* and *Hypoderma lineatum*. Myiasis can reduce animal production and cause significant economic losses to livestock industry. A lamb after sudden death was presented for post-mortem and expert opinion at livestock experimental station of Faculty of Veterinary and Animal Sciences, University of Poonch, Rawalakot, Azad Kashmir. Before performing post-mortem detail history of death was taken. Lamb was keenly observed for external and internal abnormalities. The finding of post-mortem includes: mild ascites, congested spleen, and petechial haemorrhages on lungs. All other organs were found normal. When skull was open for brain examination, four larvae/maggots were found from sinuous of brain. Larvae/maggots were identified macroscopically on the basis of their stigmal plates, which were identified as L4 stage of *oestrus ovis*. On the basis of this, it is concluded that myiasis causing flies might be responsible for animal death. This might be the first reported case of myiasis in the geographic setting of district Poonch, Azad Kashmir. Therefore, it is recommended to conduct a wide range surveillance throughout the Azad Kashmir to determine the true picture of myiasis.

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**PCR Based Diagnosis and Antigenic Affinity of Caecal Coccidiosis in Broiler Chicken by  
SDS-PAGE**

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The present investigation was undertaken with the objective of identification of caecal *Eimeria* using traditional, morphological and pathological as well as molecular diagnostic methodologies like DNA amplification and their antigenic affinity by SDS-PAGE. Polymerase chain reaction (PCR) was carried out using universal as well as species specific markers for identification and differentiation of species causing caecal coccidiosis in broiler birds. The SDS-PAGE was performed to determine the antigenic affinity of species causing caecal coccidiosis. In the present study, 800 caecal samples suspected for coccidiosis were collected from four districts (Lahore, Gujranwala, Sheikhupura and Kasur). Ten samples from twenty farms of each district were collected and examined for coccidiosis and species identification. Overall prevalence of caecal coccidiosis was found 66%. Prevalence was higher in district Gujranwala (71.5%) followed by Kasur (66.5%), Lahore (64.5%) and lowest in Sheikhupura (63%). *Eimeria* species were identified by conventional (Direct Microscopy, Sedimentation & Flootation Technique, Micrometry, predilection site) and molecular technique (PCR). Polymerase chain reaction was found to be the most sensitive and accurate technique for species identification as compared to all conventional techniques. The implementation of DNA amplification as a routine diagnostic technique can assist in monitoring as well as to limit the losses due to the disease, being a practical and precise method. Protein profiling was performed to check antigenic affinity between different isolates of *E. tenella* and *E. necatrix*. More than ninety percent isolates were antigenically identical which reflected that *E. tenella* isolates in all districts were antigenically related.

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Rising Level of Arsenic in Drinking Water and Fodder; Threat to Livestock and Human in  
Pakistan

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Arsenic is toxic metal and has potent carcinogenic effects on animals and humans. This metal is introduced in environment due to rise of anthropogenic activities as well as along the use of insecticides and pesticides. Now days it has been emerging as a new threat for livestock and human community at large because of recent report of arsenic mobilization in food chain. The presence of high arsenic concentration not only concern in drinking water but also in many food crops, meat and other consumables. Many parts of world are facing acute crisis such as Bangladesh, China, India, and in more than 70 countries, peoples are severely affected by groundwater arsenic contamination. Pakistan is facing the rising threats of arsenic in last ten years, where higher amount of arsenic is continuously increasing in water, fodder and animal tissues. The reported concentration of arsenic in drinking in certain parts of Pakistan is up to 290-906  $\mu\text{g/L}$  which is much higher than safe value of 10 and 50  $\mu\text{g/L}$  for human and animals respectively. The feeding of arsenic with 5 mg/kg body weights in goats resulted in the significant signs of toxicity. This treatment was continued for 12 weeks. The data was subjected to two factors CRD analysis of variance. The animals suffered from brown pellet faeces, anemic mucous membrane, rough body coat with erected hairs, and profound muscular weakness. There were polyuria, incoordination, inability to get up (knee-based posture) in treated animals. There was significant ( $p < 0.05$ ) increase in control vs treatment animal in respiratory rate ( $34.0 \pm 0.24$  and  $41.0 \pm 0.11/\text{min}$ ) and heart rate ( $97.0 \pm 1.23$  and  $123.0 \pm 0.33/\text{min}$ ). The concentration of this metal was increased significantly ( $p < 0.05$ ) in urine and faeces. The 90 % animals died with these signs and symptoms. It was concluded that the arsenic is the source of toxicity in animals and its accumulation in animal tissues is the threat to human health.



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**CROP IMPROVEMENT**



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**Exploration of Bread Wheat Germplasm for Drought Tolerance using Morphological and  
Molecular Markers**

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Wheat plant faces numerous biotic and abiotic stresses during its development. Among abiotic stresses, drought causes serious reduction in yield by affecting different yield contributing traits. The study investigated 40 bread wheat genotypes under normal and drought conditions. Analysis of variance showed significant differences among genotypes for the studied traits; plant height, Peduncle length, extrusion length, spike length, number of grains per spike and thousand grain weights. Genotypes varied significantly and showed a range of responses under different moisture conditions. Peduncle length showed significant association with extrusion length and spike length under both environmental conditions for both years. Principal component analysis revealed peduncle length as a most weighted character. More fluctuation in trait expression was observed under normal conditions as compared to drought. The Biplot analysis revealed close angle between peduncle length and thousand grain weight under drought condition. For molecular characterization, a total of 98 polymorphic bands were amplified by 20 ISSR markers. Primer UBC-846 depicted maximum PIC value (0.48), whereas minimum PIC value was depicted by UBC-810 (0.17). Genetic similarity matrix obtained by Jacard's coefficient method showed a range of genetic similarity from 0.26 to 0.78. Dendrogram generated on the basis of molecular characterization grouped genotypes into two major clusters (A and B) on the basis of similarity. Cluster A and B were further portioned into 3 more sub clusters. Genotypes located into same cluster were appeared to be more similar. Conclusively, high morphological and molecular diversity was observed among these genotypes. The genotypes identified as drought tolerant in current investigation would serve as parents to produce high yielding drought tolerant wheat cultivars.



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**Role of Chitosan and Salicylic acid in Alleviation of Salt stress in Leafy Vegetables**  
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Salinity is a severe problem of leafy vegetables throughout the world. A comprehensive study was conducted on leafy vegetables under different salinity levels in sand filled plastic pots. Four salinity levels 3.90, 2.90 and 1.45 dS m<sup>-1</sup> (as control) NaCl to four different leafy vegetables (lettuce, spinach, coriander and fenugreek) were applied with Hoagland's solution as nutrient medium. One month after germination of seedlings foliar applications of five concentrations of chitosan (0, 50, 75, 100, 125 ppm) and salicylic acid (0, 69.5, 347.5, 695 ppm) were applied. After two weeks of foliar application data were collected regarding morphological, physiological and ionic attributes. It was observed that dry weight decreased with the increase in salinity level. Chitosan and salicylic acid maintained the chlorophyll contents in all crops concluded and improve the turgor potential under saline condition. It was observed that with the increase in salinity level nitrogen contents were increased. 75 ppm of salicylic acid and 69.3 ppm of chitoan were found best under saline conditions. Chitosan improved the number of leaves. Overall these chemical were found to be effective in avoiding the ionic toxicity in leafy vegetables.



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***In vitro* Effects of Gibberellic Acid on Morphogenesis of CIP Potato Explants and Field  
Acclimatization of Plantlets**

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Potato microtubers and *in vitro* plantlets are valuable means for germplasm conservation and cross border exchange of disease free germplasm for quarantine regulators. Present study was aimed to investigate the effect of different concentrations of plant growth regulators (GA3 & kinetin) on micropropagation & microtuberization of 31 potato CIP genotypes acquired from International Potato Center, Lima, Peru. The nodal segments of selected CIP cultivars were excised under aseptic conditions and culture on MS medium with hormonal treatments. For shoot proliferation different concentrations of GA3 (1, 0.5, 0.1 mg/l) were used except control. Data were recorded for plant height, shoot & root length, number of shoots, roots, nodes & leaves after 4 to 5 weeks. Results showed that GA3 @ 1mg/l caused high elongation of sub-apical region in comparison to 0.5 and 0.1 mg/l for potato plants. In contrary treated plants showed reduced number of roots, nodes and leaves as compared to control. Moreover, tuberization study reflects the significant effect of sucrose on microtuber production. The results showed that the highest number of tubers was produced with double sucrose treatment. The effect of temperature (25, 16 and 10°C) on conservation studies was also investigated. The results revealed that the lower temperature (10°C) was found best for *in vitro* conservation. For acclimatization trail, micro plantlets were shifted to greenhouse, micro-plantlet was 100% survived and phenotypic diversity was recorded. The finding of this study have a potential utilization in virus free potato seed production, germplasm storage, maintenance of genetic purity of germplasm accessions and served as an experimental tool in basic research and *in vivo* selection of agronomically important characters in future. Moreover, Euclidian distances obtained from a dendrogram could help breeders to choose the diverse parents for a breeding program aimed at varietal improvement.

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**Genetic Transformation and Expression Analysis of Cold Tolerant Gene in Tomato**

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Chilling stress severely reduces the productivity of tomato as it is a cold sensitive plant. *CBF3/DREB1A* plays a key role in generating cold tolerance in tomato by regulating the response of multiple genes under chilling stress. In this study, cold tolerant gene (*DREB1A*) driven by Lip9 promoter, was transformed in three tomato genotypes (Rio Grande, Moneymaker and Roma) through *Agrobacterium tumefaciens*, employing tissue culture dependent and tissue culture independent transformation strategies. Subsequently, transformation experiments were conducted by optimizing various factors both for tissue culture based and *in planta* techniques. For tissue culture based method of transformation; fifteen days old *in vitro* seedlings, forty-eight hours pre-culture period, bacterial density (OD<sub>600 nm</sub> = 0.2), three minutes infection period, 60 µM acetosyringone, fortyeight hours co-cultivation period, pH 5.6 of co-cultivation media, six days preselection duration, cefotaxime (500 mg/l) and hygromycin (35 mg/l) as lethal dose were found optimum. For *in planta* technique of transformation, various factors such as growing medium; soil: vermiculite (1: 1), optical density (OD<sub>600 nm</sub> = 1.0) and incubation period (20 min) were found optimum for efficient transformation efficiency. Polymerase chain reaction, Multiplex polymerase chain reaction, Southern blotting and Reverse transcriptase PCR confirmed the presence, integration and expression of *DREB1A* in T0-T2 transgenic lines. Physiological and biochemical analyses of T2 transgenic plants depicted that after various chilling stresses; stomatal conductance, transpiration rate, CO<sub>2</sub> concentration rate, photosynthetic rate, relative water contents, proline contents, total soluble sugar contents, chlorophyll contents, carotenoid contents and ascorbic acid contents of transgenic lines were significantly higher than those of NT plants. These findings clearly indicate that transgenic tomato plants over-expressing *Arabidopsis CBF3* gene enhanced protection and provided cold tolerance under controlled conditions in transgenic containment.

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**Effect of Drought Stress on Plant Developmental Traits and their Association with Yield  
Related Traits in Wheat**

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Wheat is the leading cereal grain and most important crop of the world. Drought causes drastic yield losses in wheat which is ultimately threatening food security. The experiment was conducted to study the genetic diversity among 95 bread wheat genotypes. The experiment was raised using randomized complete block design and replicated twice. Drought stress was created by withholding irrigation after first irrigation. Analysis of variance depicted significant differences among genotypes for the studied traits; peduncle length, extrusion length, spike length, awn length, no. of spikelets per spike, thousand grain weights and No. of grains per spike. Two way interactions Year  $\times$  treatment, year  $\times$  genotypes and genotypes  $\times$  treatments were also observed significant. Mean performance of the genotypes depicted significant reduction in traits expression under drought conditions. Principal component analysis (PCA) was applied to determine the level of genetic variation among studied genotypes under drought stress. High genetic diversity was observed in the performance different traits under drought and normal irrigation conditions. Some genotypes were located very apart from each other depicted by PCA scatter plot. The biplot analysis was employed to determine association among various traits. Some developmental traits; plant height and peduncle length showed positive association with thousand grain weight under drought and normal irrigation during first year of the experiment. During second year thousand grain weight showed negative association with plant height. Conclusively, the study resulted that association among various traits is environment dependent therefore care should be taken during selection of the genotypes for breeding programs.

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**Use of RAPD Markers in Comparison with Agro-Morphological Traits for Estimation of  
Diversity among Chickpea Genotypes**

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Genetic diversity was assessed among 38 chickpea genotypes on the basis of random amplified polymorphic DNA (RAPD) in comparison with agromorphological traits. Evaluation of agromorphological traits revealed highly significant differences between genotypes. Days to 50% flowering ranged from 92 to 118, plant height (cm) ranged from  $54.16 \pm 2.11$  to  $87 \pm 2.65$ , Number of fruit bearing branches and pod per plant respectively varied from  $4 \pm 1.09$  –  $17.25 \pm 1.47$  and  $7.60 \pm 1.38$  –  $27.4 \pm 2.05$ , whereas grain yield per plant (gm) differed from  $3.50 \pm 0.6$  to  $9.8 \pm 0.64$ . The ascochyta blight score of these genotypes, recorded on 1-9 rating scale, varied from 3-9. The cluster analysis showing relationship based on morphological traits (scale: Euclidean distance) placed 35 genotypes into five distinct groups, and three genotypes, NOOR-91, Local Mankera and BR4 were not included in any cluster. The RAPD analysis showed that 35 RAPD primers amplified a total of 212 fragments out of which 45 were polymorphic. The polymorphic bands were generated by 21 primers whereas 14 primers were monomorphic. Genetic similarity matrix based on Nei & Li's index revealed similarity coefficients ranging from 92% to 97% indicating lower level of genetic polymorphism revealed by RAPD primers. The dendrogram constructed on the basis of these coefficients grouped all the genotypes in to 2 major and 3 small clusters at 92% similarity level. Two decamers, OPC5 and OPC14 distinguished between three Desi and two Kabuli genotypes. This study showed that the level of genetic variability observed in chickpea for agro-morphological traits was not reflected in DNA polymorphism obtained by RAPD analysis.

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**Rationalizing Water Pricing Based on Water Allocations in the Irrigated Indus Basin**  
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Water allocations for canal commands are not uniform throughout Pakistan. They vary from 2.5 to 15 cusec (ft<sup>3</sup>/sec) per 1,000 acres for different canal commands. This variability in water allowance (WA) has resulted in low water productivity (kg/m<sup>3</sup>). In this study, satellite imagery was used to estimate crop water use and corresponding water productivity for each canal command area of the Indus Basin Irrigation System. Three years were selected for the study and two representative canal commands (Lower Chenab and Muzaffargarh Canal) were selected for detailed analysis and ground truthing. Spatially distributed maps of land use, crop water use, groundwater use and quality, soil and water salinity, and crop yields at a pixel resolution of 250 m (6.25 ha) were prepared and then verified by field surveys. This spatial database was used to evaluate and create maps of water productivity in the different canal commands. The analysis shows that the area affected by soil salinity (strongly saline) in the basin has increased by 2.5% during the last five years. The average crop water use is 342 mm and 516 mm for *Rabi* and *Kharif* season, respectively. The variation in wheat yield ranged between 5,280 to 423 kg ha<sup>-1</sup>, while rice yield varied from 3,312 to 1,925 kg ha<sup>-1</sup>. Water productivity of wheat is also variable with a maximum of 1.34 kg m<sup>-3</sup> and minimum estimated at less than 0.2 kg m<sup>-3</sup>. The mean, median, and standard deviation are estimated at 0.66, 0.59, and 0.31 kg m<sup>-3</sup>, respectively. The water productivity of rice shows maximum of 1.12 kg m<sup>-3</sup> and minimum estimated at less than 0.4 kg m<sup>-3</sup>. The mean, median, and standard deviation are estimated at 0.59, 0.57, and 0.17 kg m<sup>-3</sup>, respectively. The cost incurred to irrigate one acre of land with groundwater is around Rs. 4,000 and Rs. 9,000 for wheat and rice, respectively, while canal water costs are only Rs. 50 and Rs. 85. Several rationalization policies based on cost and water productivity are suggested to reduce the cost gap between the two irrigation sources.

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Genetic Analysis of Oil and Yield Attributing Traits in *Brassica napus*  
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The present study was conducted to estimate genetic basis of variation, vigor manifestation and combining ability of various lines for yield attributes and quality traits in *Brassica napus*L. Six lines named DGL, ZLT-RBJ, B-56, ZMR-2, Long siliqua and ZM-RN were crossed in a 6×6 diallel scheme through controlled pollinations during 2013-14. Parental lines, F1 hybrids, reciprocal crosses and standard check variety Punjab Sarsoon were sown in field during 2014-15 in RCBD with three replications. Data were recorded on different growth and maturity traits including days taken to 50% flowering, days taken to flower completion, days taken to physiological maturity, primary branches/plant, number of siliquae/plant, seeds/siliqua, plant height, seed yield/plant, 1000-seed weight, oil contents and protein contents. Results indicated over-dominant action of genes for all the traits under study except for number of primary branches/plant which was found to be controlled by partial dominant action of genes. Among parents ZMR-2 and B-56 were found to be good general combiners for most of the traits. F1 hybrids ZLT-RBJ× ZM-RN, ZLT-RBJ × B-56 and Longsiliqua × ZM-RN exhibited their superiority for most of the traits studied and were noted as the best specific combiners. DGL carried highest number of dominant genes for days taken to 50% flowering, primary branches/plant, plant height, protein contents and 1000-seed weight. B-56 carried highest number of dominant genes for days taken to maturity, siliquae/plant and seed yield/plant. ZM-RN had highest number of dominant genes for days taken to flower completion. ZMR-2 had highest number of dominant genes for oil contents and seeds/siliqua respectively. Significant vigor was manifested for all the traits under study. So these better hybrids can be selected for further improvement on the basis of the results of the present investigations.

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***In Vitro* Tubertization in Selected Potato Germplasm  
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Potato industry in Pakistan is under constant threat due to it being a vegetatively propagated crop and more prone to diseases and only less than 3% of the total seed requirement complies with standards of certified seed. Availability of diverse germplasm and its maintenance in disease-free state are the most crucial factors in seed potato production cycle. Production of *In Vitro* micro-tubers is a very effective technology for disease free seed production and propagation. Due to their small size and weight they have huge advantage in terms of storage, disease free transportation and mechanization. Consequently, to overcome the problems, present study was designed to produce disease free micro-tubers. For this purpose, 6 exotic potato genotypes namely 304405.42, 304405.47, 392781.1, 395436.8 and 397006.18 were acquired from CIP, Peru. *In Vitro* grown potato plantlets were multiplied on plane MS media and then transferred to MS media supplemented with different treatments of BAP (1, 2, 3, 4 and 5mg/L) and Kinetin (1, 2, 3, 4 and 5mg/L) for micro-tuber induction. The experimental design was completely randomized design (CRD). After 4 weeks, data for No. of tubers/Plant and Tuber size (cm) was recorded and subjected to statistical analysis (2 factor CRD). Results showed that highest No. of micro-tubers/plant (0.8 tubers) along with greatest tuber size (0.42 cm) were produced in MS media supplemented with 5mg/L Kinetin. Among the genotypes under study, 304405.42 and 304405.47 were more promising for micro-tuber production. Hence these genotypes can be used for disease free micro-tuber production in potato if grown on MS Media supplemented with 5mg/L Kinetin.

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**Effect of Heat Stress on Morphological, Physiological and Quality Traits of Wheat**  
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Crops experience different environmental conditions which affect their growth. Wheat is sensitive to heat stress which affects its production. To meet the demand of food requirements of ever increasing population there is a need to develop varieties which can tolerate heat stress for which screening of germplasm is pre requisite. In the present study, thirty genotypes were used to check their response to heat stress using randomized complete block design following two different sowing dates. Analysis of variance and multivariate analysis were used for finding important traits and best genotypes in relation to heat stress. High broad sense heritability coupled with high genetic advance was measured for gluten and zeleny indicating the presence of additive gene effect for these traits. Principal component analysis showed that under heat stress conditions genotype 11, 14, 15, 20 and 30 performed good and can be used in further breeding programs for development of heat tolerant genotypes.

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Comparative Computational Analysis of WRKY Transcription Factor Gene Family in  
*Arachis hypogaea* and *Vigna unguiculata*

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The transcription factors are the main modulators of gene expression in plants. WRKY transcription factors belong to one of the magnanimous families of expression regulators. These factors solely belong to plant species, responsible for many vital plant process including biotic and abiotic stresses, embryogenesis and many hormone modulated processes. These contain specific DNA binding region comprising zinc finger domain adjacent to conserved sequence of approximately 60 amino acid WRKY domain. The WRKY factors have ability to activate or repress the expression of genes having *cis* regulatory element called W-box in their promoters. In this study, we performed a comparative genomewide analysis of members of WRKY family from groundnut (*Arachis hypogaea*) and cowpea (*Vigna unguiculata*) using different techniques like multiple sequence alignment, phylogenetic analysis, gene structure analysis, chromosomal mapping, motif analysis and synteny analysis. Different analysis performed in this study revealed high conservation of WRKY signature domains in the WRKYs from both species. Synteny analysis showed that several genes are orthologues of each other in both species. It concludes that this study provides obligatory genomic and protein information about the WRKY transcription factors in *Arachis hypogaea* and *Vigna unguiculata* and the extent of functional homology present b/w them to elucidate the WRKY function in various plant mechanisms under stress conditions.

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Assessment of Genetic Variability in Potato (*Solanum tuberosum*) Varieties using  
Multivariate Analysis

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Genetic diversity is an important aspect of exploring inherent resources for desirable characteristics including both quantitative and qualitative traits. A field experiment was conducted to examine genetic variability among 27 potato varieties using Randomized Complete Block Design (RCBD) with four replications in the Directorate of Potato, Department of Horticulture Research and Development, NARC, Islamabad. Correlation coefficient and linear regression was computed to determine the yield contributing traits and single linkage clustering method was employed with Euclidean test to construct a dendrogram on the basis of their qualitative characters. Four main clusters were produced namely Group I, Group II, Group III and Group IV. Group I comprised of one variety, Group II contained twenty three, Group III included one and two varieties were covered by Group IV. Data showed that the varieties are diverse for qualitative parameters under studied. Violet queen (Group I) and Arizona (Group III) are unique for all traits observed. Florice and KO-03-2017 (Group IV) are closely related with each other but diverse from others. Correlation studies showed that number of tubers/plot (0.74), number of tubers/m<sup>2</sup> (0.711), number of stems/plot (0.53) and tuber weight (0.983) had highest significant positive correlation with yield. The linear regression (R<sup>2</sup> value: 0.998) showed significant results among all the characters studied, which suggested that all characters affected yield components.

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Seed Priming with Paclobutrazol Improves Waterlogging Tolerance of Oilseed Rape  
Seedlings

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Waterlogging induces significant threat to yield losses of various crops. A pot experiment was conducted to investigate the effects of seed priming with paclobutrazol (PBZ) on the waterlogging tolerance of oilseed rape (*Brassica napus* L. cv. Zhongshuang No. 11) seedlings. Experiment was designed with four priming treatments: seed priming with 0, 100, 300 and 500 mg PBZ L<sup>-1</sup> solution. Primed seeds were sown in pots filled with soil and at seven true-leafstage water logging stress was induced. Results have shown that waterlogging significantly decreased the growth of oilseed rape seedlings. However, seed priming with lower dose of PBZ (100 and 300 mg L<sup>-1</sup>) has significantly ameliorated the dry weights reduction caused by waterlogging, which might be due to the increase in root development, photosynthetic pigment concentrations and anti-oxidative enzymes activities. In the present study, seed priming with 300 mg L<sup>-1</sup> PBZ is the best dose to improve waterlogging tolerance of oilseed rape.

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**Efficacy of Different Methods of Endophytic Bacterial Application for Improving Growth and Yield of Black Cumin (*Nigella sativa* L.)**

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Black cumin (*Nigella sativa* L.) is an annual medicinal herb and has many compounds such as thymoquinone which is used medicinally as an anti-cancer agent, anti-diabetic agent, anti-inflammatory agent and anti-oxidant agent. A pot experiment was conducted to investigate the effect of endophytic bacteria for improving growth and yield of *Nigella sativa* L. Pre-isolated endophytic bacterial strains i.e. AS-3, MN6, MW4C, and their consortium were used to evaluate their potential besides untreated (control). The bacterial inocula applied as soil and foliar application methods. Recommended doses of N, P, K fertilizers at the rate of 90, 60 and 30 kg ha<sup>-1</sup> was applied respectively. Each treatment was replicated three times and different growth and morphological parameters were measured. Results indicated that all treatments showed significant results with respect to control. Among treatments, T2 (strain AS-3) and T5 showed more significant effect with respect to control and other two treatments. Consortium increased root and shoot length 50% and 41% in foliar application method of bacterial strains inoculation and 58% and 53% in soil application method of bacterial strain inoculation. Whereas T2, T3 and T4 increased root and shoot length 32%, 20% and 13% in foliar application method and 38%, 25% and 17% in soil application method. Similarly, consortium increased highest yield in both foliar and soil application methods which is 39% and 50% with respect to control. Whereas T2, T3 and T4 increased yield 33%, 17% and 7.9% in foliar application method of bacterial strains and 43%, 22% and 11% in soil application method. Endophytic consortium also showed good antioxidant properties with having total flavonoid (TF) 58% and 48% in foliar and soil inoculation method and total phenolic (TP) content 37% and 41% in foliar and soil application method with respect to control. Between these two inoculation methods soil application performed better.

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**Effect of IBA Concentrations and Cutting Taking Height of Plant on the Rooting of Guava  
(*Psidium guajava* L.)**

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Vegetative propagation of horticultural crops with cuttings is more preferable techniques than using seeds. The present study was carried out over a period of three months from mid-September to mid-December 2014-15 for two consecutive years at Nursery Sanitation Project, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Influence of different IBA concentrations (0 mg kg<sup>-1</sup>, 250 mg kg<sup>-1</sup> and 500 mg kg<sup>-1</sup>) and cutting taking height of plant (Bottom, Middle and Top) was evaluated by using single rooting media (sand) which was previously optimized. Significantly higher number of roots (28.78), root length (24.95 cm), number of leaves (4.88), number of sprouts (3.79), shoot length (26.86 cm), sprouts length (19.09 cm), stem diameter (5.30 mm), dry weight of guava cuttings (139.25 mg), fresh weight of guava cutting (877.57 mg) and survival percentage (83.33) was recorded in cutting planted after treating with 500 mg kg<sup>-1</sup> IBA. No significant difference was observed among various cutting taking height in terms of all parameters studied except dry weight of guava cutting, number of leaves and survival percentage where cutting taking from the bottom of plant were highly significant, 138.32, 4.41 and 78.89, respectively. Our data indicates that guava cuttings sown after treating with 500mg<sup>-1</sup> IBA along with cuttings taken from middle of the plat can increase root initiation and survival percentage of guava cuttings.



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**Multivariate Analysis of Genetic Divergence in Peas using Yield Traits**  
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Eleven genotypes (Lina Pak, Peas-2009, 9800-10, Leader, Asian Chief, Champion, Safeer, Meteor, P1-5001, FS-2187 & IT-96) of peas were studied at Department of Horticultural Research and Development, National Agriculture Research Centre, Islamabad during year 2015-2016 for genetic variability, heritability, genetic advance and character association for seed yield/plant and related attributes. The maximum variability was observed for seed yield/plant (315.76) followed by 1000-seed weight (154.02) and number of pods (82.311). Heritability estimates were higher for pod weight (1.002), number of seeds per pod (0.223) and number of pods (0.0026), respectively. Genetic advance was maximum in case of yield that was 24.85% followed by 1000-seed weight 17.28% and number of pods 12.67%. Results indicated that Meteor, Lina Pak, Champion and Safeer were showing maximum diversity in term of traits studied.



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Genetic Association and Path Coefficient Analysis among Yield and Yield Related Traits in  
Tomato (*Solanum Lycopersicon* MILL.)

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The proposed research study was conducted at the experimental field of Department of Horticultural Research and Development, National Agricultural Research Centre, Islamabad. The aim of this study was 'Genetic association and path coefficients analysis among yield and yield related traits in tomato (*Solanum lycopersicon* MILL)'. Total nine parents and 15 F<sub>1</sub>s crosses developed through line x tester model were evaluated in proposed experiment. Results of correlation analysis showed that plant height, number of branches plant<sup>-1</sup>, number of clusters plant<sup>-1</sup>, number of flowers cluster<sup>-1</sup>, number of fruits cluster<sup>-1</sup>, single fruit weight and fruits setting percentage cluster<sup>-1</sup> exhibited significant correlation with yield plant<sup>-1</sup> at genotypic level and highly significant at phenotypic level and these traits could be used as selection criteria for improvement of yield plant<sup>-1</sup>. Days to flowering, days to 50% fruits maturity showed negative correlation which indicated earliness in genotypes and number of locules fruit<sup>-1</sup> exhibited non-significant negative correlation with yield plant<sup>-1</sup> which indicated that yield could not be improved significantly by increasing this character. Path analysis revealed that plant height, number of branches plant<sup>-1</sup>, number of clusters plant<sup>-1</sup>, number of flowers cluster<sup>-1</sup>, single fruit weight and fruits setting percentage cluster<sup>-1</sup> were directly contributing to yield improvement. It was concluded that there were more chances of selection on these traits for yield improvement.

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**Salt Stress Alleviation in Watermelon through the Use of Salicylic Acid**

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Salicylic acid (SA) is a vital plant growth regulator providing promising role in plant development and adopts defense mechanism to abiotic stresses. A pot experiment comprised of two phases under CRD was conducted. In first phase of research screening procedure for selection of bellpepper cultivars six cultivars (Crimson, Charleston Gray, Black stone F1, Black king F1, Sugar Baby and Aisha Hybrid F1) for salt tolerance was observed under four salinity levels (3, 4.5, and 6 dS m<sup>-1</sup>NaCl) and tested for screening and results compared with control (1.5 dS m<sup>-1</sup>). On the basis of morphological parameters (shoot length, root length, total length, total fresh weight, total dry weight), Na<sup>+</sup> and chlorophyll contents Charleston Gray was found to be more tolerant as compared to others under all salinity levels. In induction phase Charleston Gray was grown in next year in same season under 3 dS m<sup>-1</sup> NaCl salinity levels and after 45 day of germination foliar application of salicylic acid with four doses (0.5, 1.0, 2.5 and 5.0 mmol/L) was done and compared with control. It was observed on the attributes mention in first phase that 2.5 mmol/L of SA was much effective. Overall of salicylic acid alleviate the drastic effect of salinity at each level as compared to control under saline condition.

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**Effect of Plant-derived Smoke Solution on Seedling Growth and Nodulation of Mungbean**  
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**Rehman<sup>1</sup>**

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Plant-derived smoke solution shows positive effects on seed germination and biomass in different plant species. Therefore, the goal of this study was to investigate the influence of plant-derived smoke solution on plant biomass, nodulation, total soluble sugars, flavonoids and total nitrogen and nitrate in mung bean. The seeds were sown in pots having sterilized sand inoculated with compatible rhizobium with a 14-h photoperiod at 24/20° C (day/night), 60% relative humidity, and 200 mol m<sup>-2</sup> s<sup>-1</sup> photon flux density in growth chamber. In the present study it was observed that plant-derived smoke solution (500X) increase the root and shoot length as well as fresh weight and lateral roots in mung bean as compared to control (distilled water). Plant-derived smoke solution also showed promising results in terms of root hairs number. The numbers of nodules were increased two to three fold in mung bean treated with plant-derived smoke solution. The total soluble sugar and flavonoids were significantly higher in seedlings treated with plant-derived smoke solution. Similarly, the total nitrogen and nitrate content was also higher in mung bean treated with plant-derived smoke solution. This study indicates that the application of plant-derived smoke solution may be a useful and inexpensive technique for enhancing seedling growth, number of nodules, nutritional values of crops and can be commercialized as biofertilizer in future.

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**Isolation and Characterization of Cypermethrin Resistant Bacteria and their Role in Plant Growth Enhancement**

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Pesticides have been applied in agriculture and household to protect plants, animals and humans from insects and vector diseases. The negligent and random uses of pesticides can cause environmental damage, food and water contamination. Cypermethrin a class II parathyroid pesticide are widely used to control many pest species in agriculture. Due to their high toxicity there is an increasing interest and need to develop safe and economically feasible methods for pesticides remediation. Currently bioremediation is one of the most environmentally safe and cost effective method of decontamination and detoxification of a pesticide contaminated environment. So in the current study we have isolated cypermethrin resistant bacteria from cypermethrin contaminated soil. We identified the bacterial strains with different biochemical tests and also characterized cypermethrin resistant bacteria. The results showed that they have phosphate solubilizing activity and produce ammonia and indole acetic acid which enhance the plant growth and then we analyzed their potential in plant growth enhancement. For this purpose we use maize plant to check the effect of cypermethrin and also with different bacterial strains. Our results showed that the strains which showed high resistance against cypermethrin can also alleviate the toxic effect of cypermethrin at higher level. In this study it was observed that pesticides stress causes significant deformities in physiological parameters of plants as reduction in germination rate, root shoot length and root shoot biomass production. Also pesticidal stress causes production of ROS and for ROS in plants antioxidant enzymes are formed. By pretreatment of bacterial strains a significant result was seen in all pesticidal stress parameters as significant increase in germination rate, root shoot length and biomass and decrease in ROS was observed. So it can be said that cypermethrin resistance bacteria can alleviate pesticidal stress in maize and enhance their growth.

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**Basmati Rice Improvement for Drought Tolerance through Marker Assisted Breeding  
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Molecular markers endow access to agronomically wanted alleles present at quantitative trait loci (QTLs) that impinge tolerance responses. Harnessing the full potential of backcross breeding with marker assisted selection enables to develop the drought tolerant varieties with superior traits of recipient more effectively. For introgression of drought QTLs, IR55419-04 was used as a donor parent on the basis of phenotypic performance. Super Basmati, a popular basmati rice variety possessing unique grain quality traits and typical aroma, was used as the recipient parent because this variety has shown sensitivity to water stress. In the BC1F1 generation, a total of 151 individual plants were grown and preliminary selection was performed for the plants showing close phenotypic resemblance with recurrent parent. These selected plants were genotyped to identify the plants that were heterozygous at *QTL1*, *QTL4* and *QTL9* using respective linked SSR markers to reduce the population size for further screening. Individuals possessing the target *QTLs1*, *QTL4* and *QTL9* were then surveyed using 2-4 flanking markers for recombinant selection. Background selection was exercised by using markers specific for the recurrent parent genome to identify individuals containing the largest number of marker alleles of the recipient parent i.e., Super Basmati. The desired best plants were backcrossed with recurrent parent to obtain BC2F1 seeds. Nineteen BC2F2 introgression lines were used to evaluate for drought tolerance to estimate the tolerance level of the newly developed introgression lines having Super Basmati background as compared with their parents. Six superior introgression lines were marked that can potentially be used for breeding new drought tolerant rice varieties with basmati background for water stress conditions.

Computational Analysis of NIMIN Proteins Interaction Network during SA Induced  
Response in *Arabidopsis thaliana*

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Micro-organism exploits on plants biosynthetic and energy-producing capabilities. Plants have developed effective defense mechanism to cope with pathogen attack. The *Arabidopsis thaliana* NPR1/NIM1 is regarded as the central regulator of systemic acquired resistance (SAR) induced by elevated level of salicylic acid (SA), governing the expression of Pathogenesis-related (PR) genes. Here we studied the *in silico* protparam analysis, 3D structure prediction and protein-protein interaction of novel NIMIN1, NIMIN2, NIMIN3 proteins from *Arabidopsis* that are found to interact with NPR1 by applying different bioinformatics tools. Protparam analysis showed that the molecular weight of NIMIN1 is 16817.6, NIMIN2 13508.1 and NIMIN3 13293.7. Protein-protein interactions of NIMINs with NPR1 provided us interactive residues involved in bindings, from obtained 100 models of GRAMM-X, 10 models were selected on the bases of highest numbers of hydrogen bonds, interactive residues of selected 10 models were analyzed, 3 models extracted from selected 10 models based on common interactive residues of NIMINs and NPR1. NIMIN1 residues Glu43, Ile46, Phe50, and Gln57 interact with NPR1 residues Lys495, Thr500, Lys505, Arg510, Cys511, and Ser512. NIMIN2 residues Arg31, Thr32, Thr34, Glu35, Glu37, His49, Val50, Arg53 binding with NPR1 was similar to NIMIN1, and NIMIN3 residues Arg31, Glu32, Arg34, Val37, Ser40, Met41, Arg45, Glu48 as actively participating in interactions with NPR1 residues Ile211, Pro242, Ser276, Tyr305, Lys495, Thr500, Lys505, Pro509, Cys511, Ser512 NIMIN3. It is concluded that NIMIN1 and NIMIN2 both bind with NPR1 at the C-terminus while NIMIN3 interact with NPR1 at the N-terminal and also revealed the binding regions at the C-terminal of NPR1. Moreover, the exact interacting residues of NIMINs with NPR1 helped in understanding the SAR proteins interaction network in *Arabidopsis thaliana* and this study could benefit in improving crop disease resistance against broad-spectrum of pathogens.

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**Genetic variability in Proline and its Relationship with Yield and Yield Parameters of Cotton Cultivars under Drought**

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Water scarcity is an important factor limiting cotton production worldwide particularly in Pakistan. To identify drought tolerant genotypes, it is vital to understand their genetic variation for different biochemical traits under water limited conditions. In the present study, cotton (*Gossypium hirsutum* L.) accessions were evaluated under two irrigation regimes viz. well watered (W1) and limited water (W2) conditions. Before physiological maturity, cotton leaves were collected and analyzed for proline accumulation. At maturity, data regarding yield and yield parameters were recorded. Significant reduction in case of proline, and yield parameters was observed under W2 condition in all the genotypes; however, Correlation between the yield parameters of cotton and proline was determined. This study shows that proline was regulated genetically and environmentally in the tested cotton genotypes. It was concluded that proline can be used as biochemical marker for screening cotton germplasm for drought tolerance as well as for evolving high yielding drought tolerant varieties of this crop. The findings are useful in bridging plant biochemistry and molecular biology for identifying and selecting genes involved in conferring drought tolerance in cotton.

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Genetic Comparison of *Moringa oleifera* Germplasm Through Molecular Markers and Sequencing

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Of the 13 species of Moringaceae, *Moringa oleifera* is the most widely cultivated species throughout the world. This species is popularly called as a “Miracle tree” to nourish the under developed countries. *Moringa oleifera* Lam is often regarded as indigenous to Himalayan belt of Pakistan and India. The analysis of genetic diversity in accessions of the Punjab Province of Pakistan through molecular markers and their comparison with *Moringa* germplasm of India, Senegal, Tanzanai, Mozambique, Zimbabwe, USA, Belize, Mexico and Haiti was made. The molecular markers, Random Polymorphic DNA (RAPD) generated the polymorphic information content (PIC) with an average of 0.44 while principle component analysis (PCA) divided the population into four groups. The analysis of molecular variance (AMOVA) revealed 10% similarity between and 90% in population. Nineteen microsatellite markers/ Simple Sequence Repeats (SSRs) and partial sequencing of chloroplast *atpB* gene of 161 accessions from ten different countries proved that the average heterozygosity was 0.58. The average polymorphic information content (PIC) and number of allele were 0.59 and 8.3/SSR, respectively. The STRUCTURE analysis based on delta K value divided this population into three groups, indicating unique genetic makeup of Pakistan’s germplasm than the other nine countries germplasm. The phylogenetic tree (made in MEGA5) through the partial sequencing of the chloroplast *atpB* gene demonstrated that the wild germplasm of Pakistan made a different and unique group with different genetic makeup. This also proved a wide range of genetic diversity present in Pakistan as compared to the other countries, which can be utilized in varietal development programs to introduce new varieties for the nutritional consumption of human as well as animals of the world.

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**Potential of Endophytic Bacteria to Improve the Growth and Yield of Flax Seed under  
Different Application Methods**

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Flaxseed (*Linum usitatissimum* L.) belongs to family Linaceae and is being used significantly as human diet for improving their nutritional and health status from last few decades. Flaxseed is an oilseed crop which contains important chemicals constituent omega-3 fatty acids, lignin and mucilage that are used to control high cholesterol, high blood pressure, heart disease, and asthma. A pot culture study was conducted to investigate the effect of endophytic bacteria for improving growth and yield of flaxseed (*Linum usitatissimum* L.). Pre-isolated endophytic bacterial strains i.e. PsJN, FD-17, MW4C and their consortium were used to evaluate their potential compared to control. The bacterial inoculum applied as soil and foliar while control was treated with broth only. Each treatment was replicated three times and different growth and morphological parameters were measured. It is concluded from the results that all treatments performed better as compared to uninoculated control. Among treatments T2 (PsJN) and T5 (consortium) showed more significant effect with respect to control in both soil and foliar application. Between these two inoculation methods soil application performed better. T5 (consortium) increased root length upto 38 and 57% while shoot length enhanced upto 37 and 42% in foliar and soil application method. Yield was recorded highest in T5 in both foliar and in soil application method which was 64% and 70% with respect to their controls. Other treatments T3 (FD- 17) and T4 (MW4C) increased root length upto 13% and 7% in foliar where as 29%, 18% and 13% in soil application compared to their respective uninoculated controls. Similarly yield was increased about 51%, 44% and 23% with the application of T2, T3 and T4. Maximum chlorophyll contents were observed with the application of consortium and PsJN. These bacteria and their consortium have no adverse effects on plants but increased yield and growth parameters.

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**Cluster Analysis, Association and Path Coefficient Analysis for Seed Yield Improvement in Rapeseed**

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The present investigations were designed to find out the best selection criteria for yield enhancement in rapeseed (*Brassica napus*). For these purpose thirty six rapeseed hybrids were sown in a RCBD with four repeats at NARC, Islamabad during the cropping season 2014 and 2015. Cluster analysis indicates the degree of genetic diversity. In the first year, thirty- six Brassica accessions were grouped into thirteen clusters on the basis of WARD's method. Cluster-IV comprises of maximum number of accessions (six). The clusters mean and standard deviation marked that accession in Cluster XI (CRH-80) was short durational and high yielding mainly due to more branches and pods per plant. CRH-35 in cluster-VI was high yielding and has more seeds per pod. Similarly in second year, these thirty-six brassica accessions were grouped into ten clusters. Cluster-I consist of seven accessions. Analysis for mean and standard deviation showed that accession in Cluster-VII (Hyola-401) was short durational and produced more number of seed per pod. Genotypes CRH-84 and CRH-235 grouped in cluster IV which produced maximum number of branches and pods per plant. It has been observed that accessions in Cluster-X (CHR-286 and CHR-102) having more pod length and were high yielding. Genotypic and phenotypic correlations studies revealed that number of pods per plant had highly significant correlation with seed yield. The results of path coefficient analysis indicated that in both years the direct effects of pod length and number of pods per plant on grain yield were positive and of high magnitude. Finally it was concluded that the trait pods per plant can be exploited for the improvement of seed yield in rapeseed.

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**Effect of Seed Priming and Foliar Application of Plant Growth Regulators on the  
Performance of Late Sown Wheat**

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Despite the application of inputs like chemical fertilizers, pesticides and irrigation, wheat cropping areas of Punjab are usually less productive due to late sowing of wheat. Current field study was conducted to investigate the effect of exogenous application of plant growth regulators on the performance of late sown wheat at Agronomic Research Area, University of Agriculture, Faisalabad in Rabi season 2012-2013. Four plant growth regulators viz. moringa leaf extract (MLE); indole acetic acid (IAA); indole butyric acid (IBA); and gibberillic acid (GA3) were applied with different methods viz. seed priming; seed priming and foliar application; and foliar application. The experiment was laid out in randomized complete block design (RCBD) with factorial arrangement using three replications. The net plot size was kept 2.4 m × 4.5 m. Results of study showed that seed priming of gibberillic acid (GA3) significantly reduced time to start emergence, mean emergence time and time to start 50% emergence as compared to indole acetic acid and moringa leaf extract. Similarly seed priming and foliar application of MLE significantly improved yield contributing traits like number of productive tillers, number of grains per spike, 1000-grain weight and grain yield by 28%, 16%, 18% and 29%, respectively as compared to GA3 application. The results of this study revealed that exogenous applications of MLE, IAA and IBA significantly increased the yield of late sown wheat. This benefit was attributed to vigorous growth and development, high accumulation of metabolites, relative water contents and lower oxidative damage. Economic analysis revealed that MLE was the most economical in improving the productivity and net profit of late sown wheat. In this regards, exogenous application of plant growth regulators significantly improved the productivity of wheat cropping areas of Pakistan.

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**Association Among Wheat Kernel Morphology and Agronomic Traits in Bread Wheat**  
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Wheat is the most important cereal crop which provides food more than half of the world's population. It is the third largest crop in terms of produced grains. Traits related to kernel morphology have significant effect on wheat yield. The current research was conducted on 70 bread wheat genotypes for two years, consecutively. The trials were conducted under field conditions using Randomized Complete Block Design with two replications. Row to row distance was maintained 9 inches. Wheat kernel related traits were analyzed by digital image analysis. Analysis of variance depicted high significant difference among genotypes for all the agronomic traits; days to heading, days to physical maturity and yield per spike and wheat kernel traits; horizontal area, vertical area, horizontal perimeter, vertical perimeter, factor from density, horizontal deviation from ellipse and vertical deviation from ellipse. Interaction effect between year  $\times$  genotypes was also observed significant. The biplot analysis was conducted to investigate genetic diversity among the studied genotypes and the association among various morphological traits and seed attributes. The biplot analysis revealed negative association of vertical area, vertical perimeter and factor from density with days to heading and days to physical maturity whereas, horizontal perimeter showed positive association with days to heading and days to physical maturity. Days to heading showed positive association with days to physical maturity. Kernel morphology related parameters studied in this research have not been extensively utilized in breeding programs in early studies. Therefore, important associations observed in this study are very important and should be considered for yield enhancement programs of plant breeding.

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**Carbon Fractions, Aggregate Size Distribution and Associated Polysaccharides in Biochar  
Amended Soil**

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Soil aggregation influences many soil physical, chemical, and biological processes, such as soil aeration, soil water infiltration, and soil microbial activities. The research work involves estimation of dry soil aggregate size distribution and associated polysaccharides influenced by the application of biochar and its combination with other organic amendments. The treatments were i) Control, ii) Biochar, iii) Poultry litter, iv) Sugarcane bagasse v) Crop residue vi) Biochar + Poultry litter vii) Biochar + Sugarcane bagasse and viii) Biochar + Crop residue. All amendments were applied on 1% total organic carbon based on soil weight. Mungbean crop was sown as a test crop. At maturity crop data was collected and soil samples were analyzed for different parameters. Dry soil aggregate size distribution determined through sieves of >8, 4-8, 2.5-4, 1.25-2.5, 0.63-1.25, 0.25-0.63, 0.05-0.25 and <0.05 mm using rotary sieve machine. Among the tested organic amendments, poultry litter produced relatively higher macro aggregation than other treatments. Among the treatments, polysaccharides contents had the following incremental trend sugarcane bagasse > biochar + sugarcane bagasse > poultry litter > biochar + crop residue > crop residue alone > Biochar + poultry residue > biochar > control. Highest plant available water contents were recorded in the treatments where biochar applied with the combination of sugarcane bagasse. The highest total organic carbon and particulate organic carbon were observed in the soils treated with biochar.

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**Role of Fertilizers in Sustainable Agriculture**

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Pakistan being 6th largest population of world with annual growth rate of 2.0% needs to fulfill agricultural productivity gaps through easily adaptable and environment friendly technologies. Agriculture is the mainstay of Pakistan's economy that contributed 19.8 percent in national GDP and remained largest employer absorbing 42.3 percent of the Country's total labour force during 2015-16. However, average annual growth dropped from 5.4 per cent during 1980-90 to 2.2 per cent during 2011-16. Past fiscal year (2015-16) plummeted to -0.2 per cent mainly contributed by -6.3 per cent decline in the crop sector. Agricultural productivity could not be increased without expansion in mineral fertilizer use. Contribution of fertilizers towards increase in food grain production is estimated to be 50%. Analysis of soil samples collected across the Country revealed that 96% soils were deficient in Organic Matter, 92% in Phosphorous and 51% in Potash. The deficiency of Zinc was found in 84% soils and Boron in 65% soils. Fertilizer programme for any crop should take into account the availability of nutrients already present in the soil, crop removal, crop requirement and other factors. The demonstration plots of different crops in farmers' field proved that balanced fertilization is the major contributing factor in enhancing average yield. Value cost ratio of 2.5-3.0 recorded in these demonstrations established that balance use fertilizers not only increased average yield but also improved farmer economics. It is therefore, necessary to promote balance use of mineral fertilizers for increasing crop productivity on sustainable basis.

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**Integrated Effect of Organic and Inorganic Soil Amendments on Growth and Yield of  
Wheat**

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A pot study was conducted at the research area of University College of Agriculture, University of Sargodha to check the soil health, growth and yield of wheat crop as influenced by combining organic and inorganic nutrient sources. For this was filled in the pots @ 10kg per pot. Different organic fertilizers like OFS (Organic Fertilizer from Sugar Industry), OFP (Organic Fertilizer from Poultry Industry) and FYM (Farm Yard Manure) were applied along chemical fertilizer sources. Seven treatments were applied T1= Recommended NPK, T2=T1+ OFS 1 % of Soil Weight, T3= T1+ OFP 1 % of Soil Weight, T4= T1+FYM 1% of Soil Weight, T5= Recommended NPK + OFS 1 % of Soil Weight, T6= Recommended NPK + OFP 1 % of Soil Weight, T7= Recommended NPK + FYM 1 % of soil weight. Each treatment was replicated thrice. Proper irrigation was applied on day to day basis. All the pots were arranged according to completely randomized design (CRD). The maximum number of spikelet per spike, number of grains per spike and grain weight were observed with the application of OFP 1% of Soil Weight with half recommended NPK fertilizer (75-50-30). However, the soil health, growth and yield of wheat crop were higher with half recommended NPK fertilizer (75-50-30) + 1 % of Soil Weight of OFS and FYM as compared to the full dose of Recommended NPK + OFS, OFP and FYM 1% of Soil Weight and alone Recommended NPK. It is concluded that integrated nutrient management recorded 50% saving of inorganic fertilizer with the application of FYM, OFS and/or OFP but among them OFP showed excellent results regarding yield contributing factors and soil health.

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Response of Wheat to Various Levels of Nitrogen and Phosphorus in Agro-Climatic  
conditions of Peshawar

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To investigate response of wheat to various levels of nitrogen (N) and phosphorus (P) a field trial was conducted at Cereal Crop Research Institute, Pirsabak, Nowshera. Four levels of N and P in 2:1 were used. Various levels of NP (kg ha) used were 190:45, 120:60, 150:75 and 180:90. Experiment was laid down in randomized complete block design with three replications having a plot area of 9 m (5x1.8 m), having 6 rows 30 cm apart was used. All other agronomic practices were kept uniform for all plots. Different NP levels significantly affected all the noted parameters, except emergence. Days to anthesis, days to physiological maturity and plant height at maturity, significantly increased with increasing NP application. Highest NP level of 180:90 (kg ha) took more days to heading (125 days) as compared to lowest NP level (90:45) which took 118 days. More days to physiological maturity (157) were observed for highest NP level (180:90), while least days to physiological maturity (148) were noted for lowest NP level (90:45). Highest level of NP application (180:90) produced taller plants (97 cm) as compared to lowest NP level (90:45) which produced dwarf plants (93 cm). Biological yield, grains spike, thousand grain weight and grain yield were increased with increasing NP level up to 150:75 (kg ha) and then decreased at highest level (180:90) of NP. Application of 150:75 (NP, kg ha) produced 14.2% and 9.1% more biological and grain yields (14907 and 5533 kg ha, respectively) as compared to lowest NP levels of 90:45 (1356 and 5070kg ha, respectively). Grains spike and thousand grain weight were highest (48 and 47.7g, respectively) for NP application of 150:75 (kg ha) while lowest (42 and 43.3g, respectively) for lowest NP application of 90:45 (kg ha). Based on the above results, it was concluded that 150:75 (kg ha) is the optimum level of nitrogen and phosphorus for optimum wheat productivity in Peshawar valley.

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Effect of Potassium Application on Phosphorus use Efficiency in Maize Crop  
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Phosphorus (P) is an essential nutrient required by plants in large amounts, and play a major role in plant metabolism. P is taken up by the plants as  $\text{HPO}_4^{2-}$  and  $\text{H}_2\text{PO}_4^-$  and very immobile in soil because of precipitation with calcium, aluminum and/or iron decreasing its availability to plants. P solubility may be improved by applying potassium (K) fertilizer because K improves  $\text{H}^+$  release from plant roots via plasma membrane  $\text{H}^+$ -ATPase. A pot experiment was conducted to investigate the effect of K on phosphorus use efficiency in maize crop. Earthen pots with 20 kg soil per pot were used for nine treatments with different combinations of K and phosphorus. K1 (No K fertilizer), K2 (125 kg  $\text{K}_2\text{O ha}^{-1}$ ) and K3 (250 kg  $\text{K}_2\text{O ha}^{-1}$ ) with recommended dose of P through different sources i.e. rock phosphate, single super phosphate and di-ammonium phosphate. Crop was harvested after seven weeks, fresh and dry weight of root and shoot were measured. K was determined by flame photometer and P was determined by spectrophotometer in shoot and root. The data recorded was analyzed using two-way ANOVA and differences among the treatment means were compared using LSD test at 5% significance level. When K was applied at the rate of 250 kg  $\text{K}_2\text{O ha}^{-1}$  with recommended rate of nitrogen and phosphorus using DAP source increased shoot length, shoot fresh weight, shoot dry weight, root fresh weight and dry root weight. Furthermore, 20% shoot length, 30% shoot fresh weight, 35% shoot dry weight, and ~34% P uptake was also increased by application of elevated K fertilization as compared to its control. It is concluded that application of elevated level of potassium may increase P uptake and plants growth due to increased  $\text{H}^+$  release by roots increase P fertilizer use efficiency. However further research is still required for recommendations.

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**Solubilization of Phosphorous From Rock Phosphate using Farmyard Manure**  
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It is critical to improve solubility of rock phosphate for phosphorus management. In the presence of farmyard manure, the solubilization of P from rock phosphate increases significantly. This experiment was conducted in the research area of University College of Agriculture, University of Sargodha to determine the P solubilized from rock phosphate through farmyard manure application. A pot experiment was designed according to completely randomized design (CRD). For this purpose normal soil was collected and brought to the experimental area after chemical analysis. Pots were filled @ 10 Kg soil per pot. Rock Phosphate and FYM were applied as organic amendments. The experiment was comprised of nine treatments with five replications; T1: control, T2: rock phosphate @ 5g/kg, T3: rock phosphate @ 10g/kg, T4: rock phosphate@5g/kg+5% farmyard manure, T5: rock phosphate@5g/kg+10% farmyard manure, T6: rock phosphate@5g/kg+20% farmyardmanure, T7: rockphosphate @ 10g/kg + 5% farmyard manure, T8: rock phosphate @10g/kg+10% farmyardmanure, T9: rock phosphate@10g/kg+20% farmyard manure. Sufficient water was applied according to need on day to day basis. Soil samples were collected after every 15 days. Soil EC, pH, organic matter contents and available Phosphorous were the chemical parameters studied during this experiment. Different agronomic practices were applied whenever required. The experiment showed that there was gradual increase in the values of organic matter contents and available phosphorus as proceeded from T1 to T9, at each time of sampling (8 Samplings). In contrast, soil pH and EC decreased as proceeded from T1 to T9. Results showed that there was the maximum solubilization of phosphorus with T9: rock phosphate@10g/kg+20% farmyard manure.

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**Response of Wheat to Different Levels of Potassium and Planting Geometry**  
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Wheat (*Triticumaestivum*L.) is regarded as staple food in most of Asian countries regardless of their economic or social status including Pakistan. Being its utmost importance, wheat crop is grown in varied geographic zones of the world with different factors effecting yield of the crop comprising nutritional and planting geometry aspects. For this regard, a field experiment was conducted to investigate the effect of different nutritive element levels such as potassium with ranges of (0, 50, 100, 150 and 200 kg ha<sup>-1</sup>) and planting geometry (broadcast and line sowings with 22.50 cm and 11.25 cm) with growth and yield associations of wheat. Different yield components like No. of fertile tillers (m<sup>-2</sup>), Spike length (cm), Number of grains/spike and 1000-grain weight (g) were significantly increased by increasing potassium levels. Planting geometry did not influence on yield components. The crop fertilized with 100 kg Potassium ha<sup>-1</sup> gave higher grain yield (5.48 t ha<sup>-1</sup>) with reference to grain yield parameter of planting geometry. It concludes that 100 kg K ha<sup>-1</sup> fertilization gives optimum yield of wheat under Faisalabad condition. Increasing of potash fertilizer dose will not increase yield significantly and lower dose will reduce the produce. Regarding output maximum net income of Rs. 111379 ha<sup>-1</sup> was obtained when crop was fertilized with 100 kg K ha<sup>-1</sup>, while minimum net income of Rs. 81649 ha<sup>-1</sup> was obtained when crop was fertilized 50 kg K ha<sup>-1</sup>. The maximum benefit-cost ratio of 2.07 was observed in case of 100 kg K ha<sup>-1</sup>, while the minimum benefit-cost ratio of 1.82 was obtained when crop was fertilized with 50 kg K ha<sup>-1</sup>. It concludes that 100 kg K ha<sup>-1</sup> fertilization gives optimum yield of wheat under Faisalabad condition. Increasing of potash fertilizer beyond 100 kg K ha<sup>-1</sup> did not increase yield of wheat significantly moreover, input cost also increased while lower dose reduced the produce dramatically.

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**Effect of Phosphorus and Zinc on Wheat Yield in Alkaline Calcareous Soil**

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Phosphorus is a key nutrient which controls the plant growth by stimulating major metabolic processes. Zinc though a micronutrient but is of great importance in crop growth and is of high regard in controlling enzymes activity. The availability of both P and Zn and their interactive relationship is vital for good crop growth. An appropriate dose of these two nutrients needed to be quantified to minimize their antagonist effects. To quantify the appropriate levels of P and Zn, a field experiment was conducted to study the integrated effect of P and Zn on growth and yield of wheat crop at The University of Agriculture Peshawar, Pakistan during winter 2013-14. Experimental plots were arranged in a split plot design having five P (0, 60, 90, 120 & 150 Kg ha<sup>-1</sup>) and four Zn (0, 2.5, 5 & 10 Kg ha<sup>-1</sup>) levels. Phosphorus applied @ 90 kg ha<sup>-1</sup> proved to be most appropriate level for plant growth and increased plant height, biological and grain yield significantly. Zinc applied @ 5 kg ha<sup>-1</sup> improved biological and grain yield significantly. Moreover higher zinc application levels antagonized P availability. Most appropriate level for P and Zn showing least antagonistic effects was 90 and 5 Kg ha<sup>-1</sup> respectively. The good performance of 90 kg P along 5 kg Zn ha<sup>-1</sup> demonstrated that this could be used as a combination to obtain better wheat yield in prevailing soil and climatic conditions because higher doses of these antagonize one another.

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**Micronutrients, Biofertilizer and Humic acid Increase Yield of Potato**

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Potato is a member of the family solanaceae and ranks fourth largest crop of the earth following wheat rice and maize. Yield/ha of potato in Pakistan is less i.e. 19.5t compared to other countries. The objective of the study was to evaluate the effects of different nutrient sources on growth, yield parameters of two locally grown varieties of Potato in Mansehra. For this purpose Biofertilizers (PGPR) and Humic acid were used with the combination of 75% recommended dose of fertilizer (RDF). Effects of Micronutrients (Zn, B) were also observed with 100% recommended dose of fertilizer (RDF). The results of the experiment showed that Biofertilizers (PGPR) and Humic acid with the combination of 75% recommended dose of fertilizer (RDF) positively influenced the growth and all yield parameters among the treatments while there was non-significant interaction between the treatment and varieties. Micronutrients (Zn, B) in combination with 100% recommended dose of fertilizer (RDF) also positively influenced the growth and all yield parameters of Potato. Potato seed treated with the Biofertilizers (PGPR) had showed best result and can reduce the recommended fertilizers up to 15% for the maximum yield with low cost. The Humic acid added in the soil 7-10 days before the cultivation also increased the yield of potato. Micronutrients (Zn and B) foliar spray in combination with recommended chemical fertilizers had also positive effect on the yield of potato.

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**Influence of Elemental Sulfur on Maize Production and Soil pH**

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Sulfur is one of the major nutrients for crop productivity which is an essential component of leaf chlorophyll. The pH of Pakistani soils is increasing day by day, which is a limiting factor for agricultural productivity. A field experiment was conducted to ascertain the effect of varying soil applied elemental sulfur levels viz; 0, 10, 20, 30, 40 and 50 kg ha<sup>-1</sup>, on maize production and soil pH. Experiment was conducted in randomized complete block design (RCBD) with three replicates. Yield attributes and grain quality parameters were computed and experimental results revealed that increasing sulfur levels were pragmatic in improving maize yield. However, soil applied elemental sulfur @ 30 kg ha<sup>-1</sup> improved growth and yield attributes. Maximum protein (8.78%) and oil contents (4.5%) were recorded @ 40 kg ha<sup>-1</sup> and 30 kg ha<sup>-1</sup> respectively. Soil pH decreased by -0.0256%, -0.0256% and -0.0296% with application of sulfur @ 30, 40 and 50 kg ha<sup>-1</sup> respectively. Therefore, elemental sulfur @ 30 kg ha<sup>-1</sup> was recorded most suitable for sustainable maize production and declining soil pH.

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Growth and Yield Response of Late Sown Wheat Cultivars to Exogenously Applied  
Thiourea

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The late sowing of wheat is the major problem of low wheat yield in Pakistan due to delayed harvesting of rice and cotton in rice-wheat and cotton wheat cropping system. Priming and foliar application of different agents may be used to increase the yield of late sown wheat. A field experiment was conducted to evaluate the growth and yield response of late sown wheat to exogenously applied Thiourea. The net plot size was kept 1.8 m × 5 m. Two cultivars of wheat, (Millat-2011 and Punjab-2011) were subjected to different priming level (200, 400, 600 and 800 ppm) and foliar levels (100, 200, 300 and 400 ppm) of thiourea solutions respectively. Non primed and hydro-primed seeds were used as control in this experiment. All other agronomic practices were kept uniform for all treatments. The results of study showed that seed priming of thiourea significantly reduced time to start 50% emergence. Similarly seed priming and foliar application of thiourea significantly improved yield contributing traits like number of productive tiller, number of grain per spike, 1000-grain weight and grain yield by 10.32%, 13.1%, 23% and 17%, respectively as compared to control. Economic analysis revealed that thiourea was the most economical in improving the productivity and net profit of late sown wheat. In this regards, exogenous applications of thiourea significantly improved the productivity of late sown wheat.

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**Effect of Micro Nutrients on Growth and Yield of Indeterminate Tomato Hybrid under  
Plastic Tunnel**

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Hybrid seeds for vegetables including tomato for open field and off-season cultivation are being imported from different countries. Therefore, aim of this study was to compare the performance of tomato hybrid under tunnel conditions and evaluate the yield and fruit quality for both fresh consumption and processing. The experiment was laid out in randomized complete block design, at NARC, Islamabad. Indeterminate tomato hybrids (NTT-04-08) were evaluated along with 'Different micro nutrients' as check under plastic tunnel for yield and yield components at National Agricultural Research Centre, Islamabad. Maximum yield of 58.63 t/ha was recorded in T5 which was treated with .03% zinc, 0.04% Mn, and 0.07% Fe also 0.01% boron was applied as wetting agent. While minimum yield (55.11 t/ha) was observed in T2 (check) which was treated with 0.03% zinc. T5 have maximum number of fruits per plant (27.00) and followed by T1 and T3 bearing (23) and (22) fruits per plant, respectively. Highest mean fruit weight of 70.3 g was recorded in T4 (check) while minimum fruit weight (45.4 g) was observed in T2 (check). Maximum fruit length of 6.1 cm was recorded in T5 which is oblong in shape while minimum (4.4 cm) in T1. Similarly a significant difference was observed among hybrid for fruit diameter. Fruits having more diameters are round to roundish in shape. Fruit diameter ranged from 5.13 to 4.5 cm. Maximum pericarp thickness (0.70 cm) was recorded in T5 while minimum pericarp thickness 0.57 cm was observed in T1 (control). T5 exhibits the highest number of locules (4.0). While minimum (2.8) locules were observed in T1 (control). It is concluded that indeterminate tomatoes was successfully grown in this production system, yielding a potentially profitable “out of season” crop and resulted in higher yields, improved fruit quality, fewer culls, and a reduction in pesticide applications.

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Comparative Performance of Organic Sources for Sustainable Food-Feed Production  
System in Northwest Pakistan

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A food-feed system is an integrated livestock-crop production system where crops grown on farms are harvested for human consumption and the crop residues or by-products are used as feed for livestock. Livestock farming is very important in Pakistan and especially in Khyber Pakhtunkhwa as a source of livelihood for resource poor farmers' — provision of food and food products and as a source of income. However, livestock productivity throughout Khyber-Pakhtunkhwa is below their genetic potential because of inadequate and imbalanced feeds and feeding available to the livestock. The objective our research was to investigate the food (grain yield) and feed (biological yield) response of cereal crops to different sources of organic sources. Therefore a series of field experiments were conducted to investigate the impact of different organic sources (animal manures, plant residues, composts, biofertilizers etc.) in combination with nitrogen or phosphorus on the grain and fodder yield of rice and maize and their residual effect on wheat under rice-wheat and maize-wheat cropping systems. Significant differences in the performance of different organic sources was observed. The results revealed that the use of organic manures not only increase the grain and fodder yields of the current maize and rice crops but their residual effect had positive impact on the grain and fodder yields of the succeeding wheat crop under rice-wheat and maize-wheat cropping systems in Khyber Pakhtunkhwa. Moreover, the organic sources not only improved grower's income but also had positive effect on soil health and sustainability.

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**Role of Organic Amendments and Micronutrients in Maize Sown on Calcareous Soils**  
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Micronutrient status and organic matter are two main contributing factors in soil productivity. Unfortunately, our soils are deficient in both of them. Addition of poultry manure and humic acid along with application of micronutrients can recover their deficiency efficiently. So, keeping in view this fact, a field experiment was conducted to check the role of organic amendments and micronutrients in spring planted maize (*Zea mays* L.). Experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad during the spring season 2014. Randomized complete block design with three replications was used to conduct the experiment. Plot size was 6 m × 3 m with row to row distance of 75 cm having plant to plant distance 25 cm. The treatments were, control, poultry Manure (PM) @ 8 ton ha<sup>-1</sup>, Humic Acid (HA) @ 15 kg ha<sup>-1</sup>, Micronutrients (MN including Zn, Fe, Cu and Mn) @ 6.25 kg ha<sup>-1</sup> each, PM + HA, PM + MN, HA + MN, PM + HA + MN. Standard procedures for recording parameters related to yield and quality of maize were followed. Maximum plant height at maturity (218.67 cm), cob length (20.47 cm), number of grains per cob (372 g), 1000-grain weight (260.33 g), biological yield (18.58 t ha<sup>-1</sup>), grain yield (7.35 t ha<sup>-1</sup>), harvest index (39.56) and grain protein contents (9.64%) were recorded where 8 t ha<sup>-1</sup> Poultry Manure + 15 kg ha<sup>-1</sup> Humic Acid + 6.25 kg ha<sup>-1</sup> Micronutrient (Zn, Fe, Cu, Mn) were applied. So, it is concluded that 8 t ha<sup>-1</sup> Poultry Manure + 15 kg ha<sup>-1</sup> Humic Acid + 6.25 kg ha<sup>-1</sup> Micronutrient (Zn, Fe, Cu, Mn) would be an efficient nutrient management strategy for farming community in order to enhance maize production on sustainable basis.

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**Influence of Nitrogen on Dual Purpose Use of Wheat, Oat, Barley and Triticale**

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Growing winter cereals like wheat, oat, barley and triticale as dual-purpose (DP) crops is an important tool for increasing farm income without disturbing the existing cropping system. An experiment on the influence of nitrogen on dual purpose use of wheat, oat, barley and triticale was conducted in RCB design with split plot arrangement in three replications at the Agronomy Research Farm of the University of Agriculture, Peshawar during winter 2013-14. Crops (wheat, oat, barley and triticale) and dual purpose practices (cut and no-cut) were assigned to the main plots while the nitrogen rates i.e. 100, 125 and 150 kg ha<sup>-1</sup> were kept in the sub plots. The results of the experiment indicated that maximum fresh fodder yield, dry fodder yield, grains spike<sup>-1</sup>/panicle<sup>-1</sup>, plant height and biological yield were produced by oat as compared to wheat, barley and triticale. Higher number of tiller m<sup>-2</sup>, spikes/panicles m<sup>-2</sup> and harvest index were produced by wheat followed by triticale. Higher thousand grains weight and grain yield was produced by triticale followed by wheat. No-cut plots produced maximum number of tiller m<sup>-2</sup>, spikes/panicles m<sup>-2</sup>, grains spike<sup>-1</sup>/panicles<sup>-1</sup>, taller plants, thousand grains weight, biological yield, and grain yield. Dual purpose oat fetched more net income as compared to wheat, barley and triticale. Maximum fresh fodder yield, dry fodder yield, number of tiller m<sup>-2</sup>, and plant height were produced by nitrogen applied at the rate of 150 kg ha<sup>-1</sup>, whereas maximum spikes/panicles m<sup>-2</sup>, grains spike<sup>-1</sup>/panicles<sup>-1</sup>, thousand grains weight, biological yield and grain yield were produced by nitrogen applied at the rate of 125 kg ha<sup>-1</sup>. It is concluded that dual purpose wheat, oat, barley and triticale crops with cutting and 125 kg N ha<sup>-1</sup> performed better as compared to sole grain wheat, oat, barley and triticale due to higher net income.

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**The role of Root Phenols in Acquiring Aged Phosphorus**  
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Phosphorus (P) fertilization results in P adsorption to the crystalline oxides, and then, P becomes occluded by amorphous oxides, termed P-ageing. The aged P is not available to plants. The crop-plant species do show variations in their root architectures in acquiring soil P. Maize (*Zea mays* L. cv. Amadeo) and white lupin (*Lupinus albus* L. cv. Amiga) were cultivated to investigate the bioavailability of aged-P in a Luvisol subsoil in pots. The root system of both plants differs from each other. Maize has fibrous root system, while, white lupin has cluster root system. Each pot had 1 kg of soil with one plant. Ten mg P kg<sup>-1</sup> soil were applied as Al oxide-occluded P, Fe oxide-occluded P and Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub>. Occluded P was prepared by mixing phosphate solution to freshly prepared Fe and Al oxides. These oxides were prepared according to a method a prescribed method. Plants were harvested 35 d after sowing. Data showed that plants (both maize and white lupin) grown with Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub> had significantly higher P contents than those grown with occluded P. Further, white lupin grown with Fe oxide-occluded P had significantly higher P content than when grown with Al oxide-occluded P and control condition i.e. without P application. The difference between control and Al oxide-occluded P were non-significant. In maize, differences in P content among control, Al oxide-occluded P and Fe oxideoccluded P were non-significant. Data regarding soil-occluded P showed that a significant decrease in occluded P occurred only when white lupin was grown with Fe oxide-occluded P. From the results it is concluded that Fe oxideoccluded P is plant-available for white lupin due to the presence of cluster roots but not for maize.

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**Combined Effect of Polymer Coated Urea, Phosphorus and Potash Fertilizers on Growth and Yield and Nutrients Use Efficiency of Wheat**

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Food production requires application of fertilizers containing nitrogen (N), phosphorous (P) and potassium (K) on agricultural fields in order to sustain crop yield. Use of synthetic fertilizers is increasing to fulfill need of food for everyday increasing population. But loss of fertilizer in the field is a big issue in arid and semi-arid regions about 40-70% nitrogen, 80-90% phosphorus, and 50-70% of the total applied conventional fertilizers are lost to the environment due to different soil reactions. Moreover, saving the fertilizers granules from these soil reactions in fact enhance nutrients use efficiency along with crop growth and yield. Various approaches are engaged to increase the P use efficiency including agronomic approaches, genetics, seed coating, microbial coating but results are inconsistent. So to enhance the fertilizers use efficiency, the fertilizers coated with polymer can be considered effective in improving the growth, yield of wheat. To test this hypothesis, a field trial was conducted at wire house Institute of Soil and Environmental Sciences (ISES), University of Agriculture Faisalabad (UAF). The study was planned according to randomized complete block design (RCBD) with three replications. Different rates of coated fertilizers i.e. 100, 75 and 50% in various combinations along with control and uncoated DAP was applied. Standard procedures were followed to record the different parameters. Results showed that application of 100% of recommended NPK from polymer coated fertilizers increased plant height (20%), biological yield (27%), grain yield (40%), agronomic efficiency (44%) and nitrogen, phosphorus and potassium contents of wheat produces, as compared to uncoated fertilizers. So, it can be summarized that polymer coated fertilizers can effectively improve growth, yield and fertilizer use efficiency of wheat crop.

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**Effect of Foliar Feeding of Micronutrients bioaugmented with *Enterobacter* sp. MN17 and  
*Burkholderia phytofirmans* PsJN on Wheat**

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Population of the world increasing day by day and has led to an increasing demand of food production and supply. Food security is becoming a major issue for the mankind which strongly depends upon arable land facing major problem i.e. land degradation and low soil fertility. These adverse and cumulative changes reduce the soil capacity to support plant growth and animals feeding that impair low yield and nutritionally unsecure produce. To overcome this problem, biofortification is considered better option to increase yield and nutritionally secure food to overcome low yield and malnutrition problems in developing countries. This research study is comprised of results of field experiment to examine the effects of foliar feeding of micronutrients along with endophytic bacteria on yield and flour quality of wheat. The results showed that foliar feeding of micronutrients along with microbe was not only effective in improving growth and yield parameters but also much more effective in enriching wheat grain with Zn and Fe. Foliar application on wheat crop increased agronomic parameters (growth and yield) and contents of Zn and Fe by 21 and 22% in wheat flour, respectively over respective control. These results elucidate that foliar feeding of micronutrients along with endophytic bacteria effectively increase yield and biofortified wheat grains. Furthermore, foliar feeding of micronutrients along with endophytic bacteria could be used as an easy, quick and cost effective approach to increase yield and enrich wheat flour with health essential micronutrients for correcting malnutrition.

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Response of Foliar Feeding of Micronutrients Mixture on Yield and Quality of Wheat  
under Late Sown Conditions

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Wheat (*Triticumaestivum* L.) is one of the most important cereals and used as staple food for millions people in the world. The most important yield limiting factors are no use of micronutrients, late sowing, non-judicious use of fertilizers, drought stress, salinity and high weed infestations. This research was conducted to evaluate the effect of commercial micronutrients mixture “UniMicropower” (Zn 4.7%, B 1.0%, Fe 2%, Mn 2%, and Cu 0.3%) foliar application (@1250 ml ha<sup>-1</sup>) on yield and quality of wheat under late sown conditions during winter 2015. Foliar application of micronutrients applied at tillering, stem elongation, booting, milking and their combination stages of wheat to improve its efficiency and productivity; while control plot were no Spray. The micronutrients deficient soils cause reduction in wheat quality and production. Micronutrients play a key role in physiological and biological processes of plant. Plants require macro and micronutrients for better growth and development. The result indicated that there was non-significant effects of micronutrients foliar application on number of total and fertile tillers; while significant improved the leaf area index, leaf area duration, net assimilation rate, crop growth rate, plant height, number of grains per spike, 1000-grain weight, biological yield, grain yield, harvest index, Grain protein and carbohydrate contents of wheat. Maximum growth parameters, yield and yield components and quality components were recorded when micronutrients foliar spray was applied at tillering, stem elongation, booting and milking. These results might be due to the involvement of micronutrients in physiological and biological processes for example enzyme activation, chlorophyll formation, membrane integrity, cell division, biological redox system, starch utilization, carbohydrates and protein synthesis and enhance the availability of other nutrients etc. In conclusion, “UniMicropower” foliar spray at tillering, stem elongation, booting and milking stages may be helpful to improve the yield and quality wheat.

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**Impact of Different Fertilizers on Yield and Yield Components of Maize**

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Organic manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients. Inappropriate crop nutrition management and poor soil fertility are the most important factors responsible for low yield. The field experiment was performed to evaluate the impact of different fertilizer (organic and inorganic) on yield and yield components of maize at Agriculture Research Station Swabi, Khyber Pakhtunkhwa during summer season 2014. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data was recorded on seven quantitative traits i.e. days to tasseling, plant height (cm), leaf area, grains cob-1, biological yield ( $\text{kg}\cdot\text{ha}^{-1}$ ), 1000-grain weight (g) and grain yield ( $\text{kg}\cdot\text{ha}^{-1}$ ). All treatments were significantly affected by the applied treatments except days to tasselling during the study. The treatment poultry manure gave maximum leaf area whereas minimum leaf area was obtained in control. Maximum plant height (cm), grains.cob-1, 1000-grain weight (g), biological yield ( $\text{kg}\cdot\text{ha}^{-1}$ ), and grain yield ( $\text{kg}\cdot\text{ha}^{-1}$ ) was obtained in compost applied treatment followed by poultry manure. Whereas minimum plant height (cm), grains cob-1, biological yield ( $\text{kg}\cdot\text{ha}^{-1}$ ), 1000-grain weight (g) and grain yield ( $\text{kg}\cdot\text{ha}^{-1}$ ) was obtained in control. The results reveal that organic fertilizer gave excellent response for yield and its related traits of maize crop as compared to inorganic fertilizer. The result of the study depicted that the impact of organic fertilizer on maize crop must be further evaluated before it is recommended to farmers.

**Sawdust and Corncobs Derived Biochar at Different Pyrolysis Temperature Influence Soil Properties**

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Soil organic carbon (SOC) is one of the most critical factors determining soil fertility and improves soil properties. The application of biochar to soils can maintain organic matter (OM) levels, improves soil quality and enhances crop yield. The biochar material was produced by the indigenous pyrolysis of sawdust and corn cobs under high temperatures (300 °C and 450°C). The biochar produced from both feed stocks at two temperatures was analyzed for pH, organic matter (OM), N, P and K. The impact of biochar on soil nutrients dynamics and physico-chemical properties was studied in laboratory closed incubation experiment. It was four factor factorial experiment in a Completely Randomized Design (CRD). The treatments were control (no amendments); SD450°C (sawdust pyrolysis at 450 °C); CB450°C (corn cobs pyrolysed at 450 °C); SD300°C (sawdust pyrolysis at 300°C); CB300°C (corn cobs pyrolysis at 300°C). The rates of application of biochar were zero, 1% and 3%. Upon incorporation of different rates of biochar in a soil (pH 7.40) the pH decreased up to 6.29 during incubation. The organic matter changed from 1.88% to 1.54% at end of incubation. The available Phosphorus, Nitrate nitrogen and extractable Potassium increased with incubation days and were statistically ( $p < 0.05$ ) higher at 300°C pyrolysis temperature. The results suggest that biochar addition mineralized the nutrients. The application of biochar has the potential to improve soil fertility, however, the mechanism how biochar addition to mineral soils stimulate nitrification, phosphorus and potassium availability needs rigorous investigation.

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**Growth Response of maize to Different Formulations of Boron Coated DAP**  
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Boron is an essential micronutrient which is highly important in plant growth. Though it is required in small quantity but its importance cannot be ignored. It has been proved in previous studies that boron is required for different processes of maize plant e.g. cell disjoining, leaf and flower bud creation, glucose and hydrocarbons metabolism and their transport, root growth, cell wall development and material moving between cells etc. Boron deficiency is a serious issue in Pakistan due to various factors e.g. low organic matter, high pH, continuous cultivation of crops, coarse texture and liming etc. Coating of micronutrients on major fertilizers like urea and DAP is an effective way to improve efficiency of fertilizers and maintain availability of nutrients for long time. Sufficient research work has not been conducted on micronutrient coated fertilizers. Keeping in view, a pot experiment was conducted at wire house of University of Agriculture Faisalabad to identify most suitable level of boron coated DAP for optimum growth of maize plant. Coating of DAP was carried out in collaboration with the Institute of Soil and Environmental Sciences, UAF. Following treatments were used in the study; T0 (Recommended rates of NPK with no B), T1 (Recommended rates of NPK with B), T2 (25% of recommended dose of 1% boron coated DAP), T3 (50% of recommended dose of 1% boron coated DAP), T4 (75% of recommended dose of 1% boron coated DAP), T5 (25% of recommended dose of 1.5% boron coated DAP), T6 (50% of recommended dose of 1.5% boron coated DAP), T7 (75% of recommended dose of 1.5% boron coated DAP). Effects of different formulations of boron coated DAP were analyzed in terms of growth parameters including plant height, root length, root fresh weight, root dry weight, shoot fresh weight, shoot dry weight and shoot length. It was concluded that the maize crop responds significantly to boron coated fertilizer and 50% of 1% boron coated DAP was performing good compared to recommended dose of DAP.

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**Effect of Polymer Coated Urea on Growth, Yield and Nitrogen Use Efficiency of Maize**  
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Low efficiency of nitrogenous fertilizer is one of the yield limiting factors in the agricultural production. Mismanagement of N fertilizer may lead it to loss from soil-plant system due to its dynamic nature. N fertilizer is vulnerable to leach, volatilize or denitrified through soil plant system. Control Released Fertilizers (CRF) can be the possible solution to mitigate these losses. A field study was conducted to test this hypothesis and evaluate the potential benefits of polymer coated and rock phosphate polymer coated urea. Two N rates (75% and 100% of recommended N) polymer coated Urea (PCU) and Rock phosphate polymer coated urea was compared to uncoated urea. Each treatment was replicated 3 times. All the treatments were assigned in Randomized Complete Block Design (RCBD). Morphological traits of maize studied including plant height, cob length, cob width, No. of grains per cob and grain yield were measured. Split application of PCU (100% of recommended N) results the maximum grain yield, plant height and cobs length while minimum values were recorded at control. This study also revealed that the N uptake by maize plant was significantly increased in PCU treated plots compared with uncoated urea. Results showed that plant height, cobs length, grain yield and N uptake was increased by 27, 34, 56 and 43.6% by polymer coated urea. In short coated urea enhance the maize growth and yield attributes so this technology might be of novel approach to get optimum yield of maize or successful maize production.

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**Soil C and N Dynamics and Wheat Performance as Affected by Different Allelopathic  
Mulches and Nitrogen Application**

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A 2-year study was planned to investigate the influence of different allelopathic mulches and nitrogen sources on soil C and N dynamics, and productivity of wheat in rice-wheat cropping system. The experiment comprised of different allelopathic mulches (control, plastic mulch, wheat straw mulch, rice residues mulch, sorghum residues mulch) applied (4 tons/ha) and nitrogen (N) sources (control, urea, calcium ammonium nitrate, ammonium sulphate) at 125 kg/ha used as experimental treatments. Results indicated that allelopathic mulches significantly improved SOM (24.2%), SOC (17.8%) and TN (24.5%) over control during both the years. Soil mineral N, (Nitrate-N and Ammonium-N) was enhanced over control. Using allelopathic mulches increased N uptake and protein percentage in grains was observed. Wheat biological and grain yield responded significantly to the applied crop residue mulches and enhancement in biomass and grain yield was observed. Application of nitrogen sources significantly improved morphological and yield related traits, while biomass and grain yield was enhanced during both the years. N uptake and grain protein was also favored significantly by nitrogen sources. Interactive effect of mulches and nitrogen sources was also found significant for morphological, yield and yield related traits and soil mineral N. Sorghum mulch in combination with CAN resulted highest net benefits. In conclusion, retention of allelopathic crop residue mulches in conjunction with N fertilizers may be opted to improve soil properties, to attain higher harvests and sustain productivity of soils in rice-wheat cropping system.

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**Mitigating the Effects of Drought Stress in Wheat through Potassium Application under  
Late Sown Conditions**

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Wheat is a vital cereal crop that is cultivated under various climatic conditions and source of staple food for millions of people in world. Now a day, due to climate variability and change in rainfall pattern, the events of drought stress occurrence increased in arid and semi-arid regions of the world. It is major abiotic stress that influenced various morphological, biochemical and physiological processes of plants such as water status of plants, photosynthesis, respiration, biochemical reactions, anatomical changes and altered hormonal relationof plants. All plant growth stages are intensively affected by drought stress and caused huge economical losses in term of complete failure of crop. To overcome the losses caused by drought stress, nutrient management technique is best one to mitigate the negative effects of drought in wheat crop under late sown conditions. Among the mineral nutrients potassium plays an important role to reduce deleterious effects of drought stress. Application of potassium sulphate at higher rate than recommended dose effectively increased the efficacy of various biochemical and physiological processes of plants such as photosynthesis rate, enzyme activation, energy balance, osmotic adjustment, cell division, maintenance of turgor pressure, reduced photo-oxidative damage, controlled transpiration as well as maintained pH of stroma of chloroplast that improved the abilities of plants to cope with drought stress conditions and performed well to show their maximum potential to give optimum yield. Potassium significantly increased nutrient availability, root growth as well as enhanced ability of plants to use water more efficiently to fix CO<sub>2</sub> and transform photo-assimilates to end product effectively under water shortage conditions. From this experiment, we concluded that application of K<sub>2</sub>SO<sub>4</sub> @ of 120 kg ha<sup>-1</sup> effectively increased crop performance under drought and gave maximum yield as well as net economic returns by promoting the activity of different biochemical processes under stress situations.

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**Nickel Availability and Its Effect On Growth of Maize in Texturally Different Soils**

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Nickel (Ni) is an environmental pollutant as well as micronutrient for plants. Ni toxicity in plants has been well documented. Accumulation of Ni at higher levels in the soil can cause toxicity to plants and thus affects plant growth. This experiment was conducted to study the availability of Ni in different textured soils. Soils (clayey and silt loam) were collected from different areas of Gujranwala and Faisalabad. Soil was spiked with Ni at rate of 0, 20, 40, 80, 120 and 160 mg kg<sup>-1</sup> by using salt Ni(NO<sub>3</sub>)<sub>2</sub>·7H<sub>2</sub>O. Maize crop was sown in the same pots previously used for maize crop to see residual effects of Ni. Experimental design two factor factorial Complete Randomized Design (CRD) was used with three replicates. Different agronomic, physiological and chemical parameters were recorded. Recorded plant parameters were shoot height, shoot and roots fresh weight, shoot and roots dry weight, chlorophyll contents, Ni concentration in shoot, roots and soil. After harvesting of maize crop sample preparation was done for Ni determination. Ni was extracted using Ammonium-Bicarbonate Diethylene Triamine Penta-acetic Acid (AB-DTPA). Ni determination was done for roots and vegetative plant parts. For Ni determination Atomic Absorption Spectrophotometer (AAS) instrument was used. The results were minimum in T5 and T6 for all growth parameters and Ni recovery was maximum in T5 and T6 for plant and soil. Results from T5 and T6 were significantly different from T1, T2, T3 and T4 for Ni treatments and different soil textures. Ni treatments effect was more prominent than different soil textures. It was concluded that Ni availability to plants and its behavior in soil were significantly affected due to different textures of the soils.

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**Sulfur: A Cheap Source of Calcareous Soil pH Manipulation and Micronutrient  
Bioavailability**

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Nutrient bioavailability in high pH calcareous soils is a common problem and crops grown on such soils are deficient in nutrients, especially micronutrients. With continuous increase in population, food demand is also increasing accordingly. Fe (30%) and Zn (60%) deficiency is most common in calcareous soils. Decreasing soil pH is considered, as an effective way to deal with this challenge micronutrients availability in calcareous soil. Different chemical fertilizers have been used in order to lower down the soil pH but it's costly. Elemental sulfur (S) is considered as cost effective approach in lowering of soil pH. Each mole of S gives two moles of hydrogen ions (H<sup>+</sup>) in the soil and reducing soil pH that leads to nutrient dissolution in rhizosphere. In a non-planted pots, different rates of S was used to lower soil pH up to 6.5 and 2.5 g S kg<sup>-1</sup> soil decreased soil pH up to 1.5 units and decreased level of soil pH was obtained. In S treated calcareous soil, it was noted that wheat plant dry mass increased up to 28% and grain yield increased up to 34% compare with control. Grain Fe, Zn and Mn concentration increased up to 30, 24 and 21% respectively compare with control. Further, experimental results showed that protein, fat, fiber and starch increased up to 41, 37, 33 and 54% respectively, compare with control. It was concluded that S has potential to lower calcareous soil pH and to increase plant growth, yield, micronutrient bioavailability and grain nutritional quality.

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**Ferritin Enriched Grains: A sustainable Solution to Combat Iron Deficiency in Humans**  
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Ferritin is a iron storage protein consisting of a 24- subunit shell around a 4500- atom iron core. Ferritin is stable protein and doesn't denature in human elementary tract. It is reported that it doesn't form complexes with other cations thus increase iron (Fe) availability to humans. Femalnutrition causes fatigue, poor work performance, reduce immunity, deficient oxygen supply to RBCs and in severe cases even death. In most part of the world, Fe deficiency particularly affects preschool children and women. Cereals crops such as rice, wheat and maize are the major food of 90% world population, and are poor in Fe that ultimately caused malnutrition. Different strategies are adopted to increased Fe concentration in cereals grain but gain no profit due to the increased proportion of phytate. Ferritin is a direct source of Fe for humans and a limited work is done to increase ferritin content in grains. In a pot experiment of rice, wheat and maize, it was concluded that combined application of biochar and Fe fertilizer, ferritin concentration increased up to 2, 3 and 2.2 fold, over control. In Ni contaminated biochar and Fe fertilizer amended soil, ferritin concentration increased up to 3 fold compare to un-amended control. Several studies suggested that rice, wheat and corn have low bioavailable Fe contents but biochar application with Fe fertilizer is a best solution to increase ferritin concentration in cereals grain.

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**Seed Inoculation with PGPR and Nitrogen Phosphorus fertilization Improves Yield and Quality of Forage Sorghum**

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Plant growth promoting rhizobacteria (PGPR) are used for seed inoculation in order to improve the growth and yield of different field crops. This study investigated the influence of seed inoculation with PGPR and different phosphorus (P) and nitrogen (N) levels on the forage yield and quality of sorghum. The study was carried out in randomized complete block design with factorial arrangement at Student Research Farm, Department of Agronomy, University of Agriculture, Faisalabad, with net plot size of 5 × 1.8 m. The experiment composed of N and P levels i.e., 0%, 50%, 75% and 100% of recommended doses ha<sup>-1</sup> and seed inoculation with PGPR1 (Azotobacter brasilense + Pseudomonas fluorescens) and PGPR2 (Azotobacter chroococcum + Pseudomonas fluorescens) with un-inoculated seeds as control. The results revealed that application of nitrogen, phosphorus and seed inoculation of PGPR considerably improved the yield and quality of forage sorghum. In case of nitrogen and phosphorus application the maximum forage yield (63.12 t ha<sup>-1</sup>), dry matter yield (14.51 t ha<sup>-1</sup>), crude protein (11.02%) and ash contents (8.97%) were recorded with 100% recommended dose of nitrogen and phosphorus. Similarly, seed inoculation with PGPR1 produced maximum forage yield (62.40 t ha<sup>-1</sup>), dry matter yield (14.09 t ha<sup>-1</sup>), crude protein (10.59%) and ash contents (9.07%). These results suggest that recommended dose of NP and seed inoculations with PGPR could be a wise strategy to increase the forage yield and quality of fodder sorghum.

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**Efficiency of Fenton-like Oxidation to Treat Naphthoic acid in Contaminated Soils and its  
Impact On Soil Quality**

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Soil contamination by petroleum hydrocarbons is a major environmental issue with serious health consequences. Present study describes the use of chemical oxidation to degrade 1-hydroxy-2-naphthoic acid (HNA) in soil slurry and its impact on soil's physicochemical and biological characteristics. The HNA was chosen as model pollutant because it is the first degradation product of one of petroleum derivatives and polycyclic aromatic hydrocarbon (phenanthrene). Batch experiments were conducted to evaluate the efficiency of magnetitecatalyzed Fenton-like oxidation (FL) of HNA in contaminated soil. Catalytic ability of magnetite was compared with that of soluble FeII at circumneutral pH. Obtained results indicate complete degradation of HNA after 24 h by FL oxidation. No toxic by-products were observed under our analytical conditions underscoring the complete degradation of the target pollutant. Soluble FeII was unable to catalyze chemical oxidation at circumneutral pH that might be correlated to its precipitation at neutral pH. Slight increase in oxidation efficiency was observed by increasing oxidant dose. A slight decrease in pH and CEC was observed after chemical oxidation. Content of metal oxides was not affected except for Fe that increased due to the presence of magnetite in post treated samples. However, magnetite catalyzed Fenton-like oxidation exerted slightly positive impact onto the microbial population of contaminated soils. This study has important implications to design *in-situ* remediation strategy for petroleum contaminated soils and sediments.

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**Impact of Potassium Fertilization on Crop Yield in Wheat-Maize Cropping System**

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Potassium (K) is third major nutrient necessary for plant growth and development. It plays an important role in activation of various enzymes, balancing the charge across the membranes, stomatal and osmoregulation. Plants get K from rhizosphere; nonetheless, the availability of K to the plant is highly variable, due to complex soil K dynamics. As extensive cultivation, high yielding maize hybrids and lesser K fertilizer inputs are resulting in its deficiency in the soils. Therefore K fertilization seems necessary for good agricultural yields in the wheat-maize cropping system. A field experiment was conducted at Ayub Agricultural Research Institute, Faisalabad. Recommended basal doses of N and P<sub>2</sub>O<sub>5</sub> were applied as urea and DAP. The treatments of wheat and maize experiments consisted of 0 kg K<sub>2</sub>O ha<sup>-1</sup>, 60 kg K<sub>2</sub>O ha<sup>-1</sup> as KCl (MOP) and 60 kg K<sub>2</sub>O ha<sup>-1</sup> as K<sub>2</sub>SO<sub>4</sub> (SOP). Each treatment was replicated four times according to RCBD and crops were harvested at maturity. Wheat grain yield and total biomass were improved with the application of K containing fertilizers. MOP had a more pronounced effect on wheat grain yield as compared to SOP; though total biomass production was more in the case of SOP which was 4%. Nevertheless, maize crop showed a better response to SOP as compared to MOP with regard to number of grains cob<sup>-1</sup> and 11% increase in grain yield. Maize is more sensitive to salts and Cl<sup>-</sup> in MOP may have any suppressive effect on maize yield. It is concluded that K fertilization has overall positive response in wheat maize cropping system. The economics of these experiments show that MOP and SOP both give economic returns; however MOP showed better results for wheat whereas SOP for maize.

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**Seed Priming with Micronutrients for Improving the Yield, protein and Zn uptake of  
Hybrid Maize**

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Seed priming is an effective and easy to accomplish pre-plant technique of crop production. It may prove as an alternate approach to soil and foliar application of micronutrients for improvement of quality and nutrient enrichment. In this study, the effect of micronutrient seed priming at different concentrations and combinations was evaluated on the productivity of hybrid maize (DK-6578). For priming maize seeds were soaked for 8 hours in solutions of zinc (0.5%), boron (0.01%), manganese (0.01%), boron + zinc (0.01% + 0.5%), boron + manganese (0.01% + 0.1%), boron + zinc + manganese (0.01% + 0.5% + 0.1%). For comparison seeds were also soaked in simple water (distilled) i.e hydro-priming; and untreated seeds were taken as control. Stand establishment was substantially improved by all combinations of nutrients in seed priming. Seed priming in all the treatments improved the growth and grain yield. The yield increase over untreated control was observed 23% more, after application with boron+zinc+ manganese (0.01% + 0.5% + 0.1%) through priming. The uptake of boron (77.60 mg kg<sup>-1</sup>) and accumulation of protein contents (10.82%) were also higher in this treatment. From this study, results suggest that, the combined application of boron, zinc and manganese (0.01% + 0.5% + 0.1%) through seed priming was observed effective and non-toxic treatment combination for improvement of yield, protein contents and Zn enrichment.

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**Evaluation of Struvite as Phosphatic Fertilizer and Role of Sulfur Oxidizing Bacteria on Phosphorus Bioavailability**

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Major portion of phosphatic fertilizer comes from the limiting natural resource, rock phosphate. The extinguishing rock phosphate reserves demands a timely alternative for phosphorus. Struvite precipitated from local sewerage water can be a good alternative for phosphatic fertilizer, a greenhouse experiment on wheat (*Triticum aestivum*) was conducted to evaluate the effectiveness of struvite as phosphorus (P) source for plants. Struvite precipitation was carried out from local waste water stream and the efficient strains of sulfur oxidizing bacteria (SOB) were isolated. The precipitated struvite was evaluated as a P source by comparing it with various P sources/fertilizers. For testing of P release, struvite was applied in five combinations, viz., control (no P source), all P from SSP fertilizer, all P from struvite, all P from struvite + sulfur (100 mg kg<sup>-1</sup> of soil), and all P from rock phosphate. Phosphorus was applied at 100 mg kg<sup>-1</sup> soil in all treatments irrespective of sources, except control. In addition all five treatments were repeated with SOB inoculation. Soil and plant samples were collected at tillering, booting and maturity stages, data was analyzed and recorded for different soil and plant parameters. Results revealed that SOB inoculation is positively correlated with the P availability in soil and P uptake by plants. Struvite proved to be an effective P source and results were comparable to those for SSP fertilizer. Struvite had high initial pH (10.5) which was countered by addition of sulfur and SOB. The treatment with struvite as P source + sulfur and with SOB proved to be best treatment in providing P to plants and for growth and production of crop. Its slow releasing nature helped to maintain adequate P level in soil throughout the growing season and also decreased the leaching and fixation losses which helped in better growth and yield of crop.

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Development and Characterization of Nitrogen-Fixing and Explosive-Detoxifying  
Microbial Consortia for Bioremediation of Explosive-Contaminated Sites

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Globally, a huge amount of cultivable land has been contaminated with explosive compounds such as hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and 2,4,6-trinitrotoluene (TNT). Although use of microbial consortia has been regarded a promising microbial resource for explosive degradation, their complete explosive mineralization has yet to be accomplished. The main objectives of the present work were to; (i) develop and characterize TNT- and RDX-degrading microbial consortia and (ii) evaluate the applicability of the enriched microbial consortia in soil under lab conditions. Thus, microcosm experiments were conducted using explosive-contaminated soil, RDX or TNT and starch. Explosives degradation and their products were monitored by HPLC, GC/MS or IC analysis. Total genomic DNA was extracted and bacterial 16S rRNA genes were PCR amplified using DNA samples for sequencing and community analysis. Two microbial consortia (MI and MIK with RDX and TNT biodegradation abilities, respectively) were successfully developed through sub-culturing in series with starch addition. Under N-fixing condition, explosive degradation was found to be stimulated by the co-addition of each target explosive and starch. Pyro-sequencing targeting bacterial 16S rRNA genes indicated that, in the consortia, the potentially novel explosive degraders stimulated by explosives and starch (*Rhizobium* for MI and *Methylophilus* for MIK) may have been involved in the improved explosive detoxification in association with nitrogen fixation. In the following lab soil microcosm experiments, applicability of the developed consortium (MI) in soil RDX bioremediation was supported. Findings suggest that the newly developed aerobic consortia are valuable microbial resources for bioremediation or rhizo-remediation of explosive-contaminated sites.

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Evaluation of Phenanthrene Biototoxicity in Soil by a Battery of Bioassays  
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A huge amount of arable land has been polluted with polycyclic aromatic hydrocarbons such as phenanthrene (Phe), worldwide. The Phe is highly toxic to biological system. Biological approaches to soil monitoring, such as the measurement of biochemical and cellular responses to pollutants (i.e., biomarkers) and on soil organisms (i.e., bioindicators), have become increasingly important in hazard assessment and remediation for determining clean-up end points. However, there are research gaps in the selection of appropriate toxicity indicators according to the level of soil contamination. The main purpose of this study was to examine the comparative sensitivity of bioassays for the evaluation of biototoxicity of Phe-polluted soil. Multiple species (viz. *Brassica rapa*, *Eisenia fetida*, *Vibrio fischeri*), representing different trophic levels, were used as bioindicator organisms to assess the ecotoxicological risk of soil spiked with a range of Phe levels (viz. 0.95, 6.29, 38.5, 58.7, 122, and 303  $\mu\text{g g}^{-1}$  dry soil) and aged for 69 d. All the bioassays including plant assay, earthworm survival, growth and comet assay, and bacterial Microtox test were performed according to the standard procedures. Results showed that among the acute toxicity assays tested, the *V. fischeri* luminescence inhibition (LI) assay was the most sensitive indicator of Phe biototoxicity. The sensitivity ranking for phenanthrene toxicity in the current study was in the following increasing order: LI > *E. fetida* survival > root elongation of Chinese cabbage > *E. fetida* fresh weight loss > *E. fetida* dry-weight loss. Here, we propose that Microtox test and comet assay are robust and sensitive bioassays, and could be appropriate monitoring tools for the risk evaluation of low to highly PAH-contaminated soil.

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**The Need of Balanced Fertilizer use for Achieving Food Security in Pakistan**  
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Pakistan is at an advanced stage in fertilizer use; as per hectare use was about 170 kg during 2013. The use of fertilizer is imbalanced and skewed towards nitrogen (138 kg/ha) followed by phosphate (31 kg/ha) and potash is negligible i.e. one kg/ha. Potash, the third major plant nutrient is at an introductory stage in Pakistan. Nation-wide research conducted to compare MOP and SOP during 1993-2004 under the ambit of PPIC/PARC and Potash PSDP projects. The results of the research under afore mentioned project and undertaken by other researchers have shown that MOP is as good source of K as SOP for the field crops, vegetables and fruits, except tobacco. Food security is an issue of both national and global importance. Pakistan's current population of about 181 million and it is expected to grow to 242 million in 2030. This means an increase @ 2.04 % an addition of 61 million people, about one third of the present population, in a period of 18 years. Against a population growth rate of 2.0 per cent, we are increasing staple cereals only at the rate of about 1.26 percent; it is a serious challenge for meeting the objective of food security and poverty alleviation. The scenario is grim in the coming years and need a serious consideration. Using chemical fertilizers alone will not result in appropriate increase in food productivity for long term sustainability consideration, unless integrated use of all sources of chemical and organic nutrients are exploited. Declining soil fertility has raised concerns about the sustainability of agricultural production at current levels. Thus, strategies for increasing and sustaining agricultural productivity will have to focus on using available nutrient resources more efficiently and effectively, than in the past. The integrated nutrient management (INM) is a viable approach for proper plant growth and productivity, together with soil resource sustainability for achieving food security.

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**Effect of Plant and Coal Derived HA on the Growth and Yield of Wheat under Field  
Conditions**

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Field experiment was conducted to study the wheat response to coal and plant derived humic acid (HA) application at different levels @ 0, 15, 25, 50 and 100 kg ha<sup>-1</sup>. Basal dose of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were applied @ 120, 80, and 75 kg ha<sup>-1</sup>. The results showed that plant height, yield and yield components positively affected with HA application derived from coal or crop residues. The maximum plant height was recorded with applied HA @ 50 kg ha<sup>-1</sup>. The difference between sources levels of applied HA was significant. The plant height was at par with applied HA @ 15, 25 and 50 kg ha<sup>-1</sup>. The macro and micronutrient concentration of plant also affected with the use of HA showing more absorption of nutrient from soil and their utilization in plant metabolism. The chlorophyll pigments increased with applied humic acid @ 25 kg ha<sup>-1</sup> and application of HA at higher 25kg ha<sup>-1</sup> rates did not cause any significant change in chlorophyll contents. The protein contents also affected positively with use of HA. These altogether curtailed in enhanced crops yield.

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**Effect of Biochar on Biological Nitrogen Fixation and Soil Water Retention under Rainfed Condition**

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Loss of soil fertility, reduction in soil productivity and water scarcity is the major limitation of rain fed area of Pakistan. Applications of biochar on low fertile and degraded soil may increase the soil fertility, nutrients uptake, water retention and improve soil productivity. Field study was conducted to examine the effect of biochar on biological nitrogen fixation (BNF) by mash bean (*vignamungo.L*) and soil water retention. Biochar was applied @ 0, 0.25 and 0.5 t ha<sup>-1</sup>. Soil samples were collected before application of biochar and after harvesting of crop and were analysed for soil pH, E<sub>Ce</sub>, CEC, total N, phosphorus, potassium, soil infiltration rate, aggregate stability, soil water content and soil water retention. BNF was determined through xylem sap method and sap was collected at pod filling stage. Soil treated @ 0.5 t ha<sup>-1</sup> showed maximum soil pH i.e. 7.9 and high soil E<sub>Ce</sub> (0.7 ds m<sup>-1</sup>). There was significant increase (50 %) in CEC (7.1 to 10.8 Cmolc kg<sup>-1</sup>) with biochar application. Biochar enhanced soil nutrients (N, P and K) availability. More stable soil aggregates and maximum soil infiltration rate (180 mm h<sup>-1</sup>) were found at soil treated with 0.5 t ha<sup>-1</sup> biochar. Biochar had no significant effect on soil water retention and soil water content. Biochar applied @ 0.5 t ha<sup>-1</sup> showed maximum increase in BNF (22.5 kg ha<sup>-1</sup>), grain yield (1.3 t ha<sup>-1</sup>) and biomass yield (2.35 t ha<sup>-1</sup>) of mash bean. The study concluded that sole application of biochar increases nutrients availability (N, P, K) soil infiltration and soil aggregate stability. Significant increase was observed as for as BNF (40 %), grain yield (77 %) and biomass yield (64 %) of mash bean is concerned. It is recommended that biochar improve soil productivity and BNF by mash bean.

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Bioassay of Extracts from Rhizospheric *Aspergillus* and Soil Borne *Penicillium* Species and  
Isolation of Pure Compounds

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Extracts of two fungal strains isolated from rhizosphere of *Mentha piperetta* and soil were screened for antibacterial, antifungal and cytotoxic activities. Antibacterial activities were performed against eight pathogenic bacterial strains while to test the antifungal ability the extracts of both fungi were tested against six pathogenic fungal strains. Cytotoxic activities were examined against brine shrimps eggs by hatching them in artificial sea medium. Results indicated that both ethyl acetate and *n*-hexane fractions of rhizospheric *Aspergillus* sp showed better activities as compared to soil borne *Penicillium* sp. In case of antibacterial activities ethyl acetate and *n*-hexane fraction of *Aspergillus* sp showed highest activity against *Bacillus subtilis* (47.5 mm) and *Salmonella typhi* (51 mm) respectively. Crude extracts of *Penicillium* sp showed highest inhibitory activity against *Proteus vulgaris* (34 mm). Ethyl acetate fraction of *Aspergillus* sp proved more effective against *Microsporium canis* (60.5%) while *n*-hexane fraction of this fungus was active against *Fussarium solani* (56.5%). Ethyl acetate fraction of *Penicillium* sp was also active against *M. canis* (63.5%) while its *n*-hexane fraction showed considerable activity against *Candida glaberata* (28.5%). Extracts tested against brine shrimps revealed that *Aspergillus* sp proved more toxic to brine shrimps with lethality rate of 98.33% as compared to 63.33% of *Penicillium* sp at 1000  $\mu\text{g mL}^{-1}$ . Using column chromatography technique a pure compound was isolated from the ethyl acetate fraction of *Aspergillus* sp. The mass of the compound was determined using LCMS and for structural elucidation of the compound a number of 1D and 2D NMR experiments were performed.

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**Boron Influence the Bio-Synthesis of Metabolites in Canola Seed**

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A 2-year field experiment was conducted to determine the effect of boron (B) levels on oil content and quality parameters of canola cultivars at Koont research farm of PMAS-Arid Agriculture University Rawalpindi under rainfed conditions. Experiment was comprised of four canola cultivars *viz.*, Faisal Canola, Pakola, PARC Canola hybrid and Rainbow and three levels of boron (0, 1, 2 kg ha<sup>-1</sup>). The interactive effect of canola cultivars and B levels showed significant effect on oil content, protein content, linolenic acid content and erucic acid content while non-significant difference were found in oleic acid content. The B application showed significant differences for oil and linolenic acid content. Oil content indicates the direct relation with B application, maximum oil content was recorded when B was applied 2 kg ha<sup>-1</sup> while; linolenic acid content showed the inverse relationship with B application. However, protein content, oleic acid content and erucic acid content showed non-significant differences for varying B levels. Amongst cultivars Pakola produced the maximum oil content while higher protein and linolenic content were found in Faisal Canola. It is concluded that Pakola have higher concentration of oil contents at 2 kg B ha<sup>-1</sup> application but less concentration of other metabolites under rainfed conditions.

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**Potassium Nutrition Improves Growth and Achene Yield of Sunflower under Water Deficit Conditions**

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Water deficit condition decreases the growth and yield of field crops; however, the use of potassium nutrition can overcome its hazardous effects. This study was conducted to determine the influence of potassium nutrition in improving the productivity of sunflower under different water deficit conditions. The purposed study was conducted at Student Research Area, Department of Agronomy, University of Agriculture Faisalabad, in randomized complete block design with net plot size of 3 m ×6 m. The experiment was composed of water deficit levels i.e., 75 mm (control) and 55 mm with foliar sprays of water, 0.5% and 1% potassium. The results revealed that foliar application of potassium under control and water deficit conditions improved the growth and yield of sunflower. However, the maximum achene yield was recorded with foliar spray of 1% potassium under normal conditions, meanwhile the application of 1% potassium under water stress conditions also substantially diminish the negative effects and considerably increased the achene yield. In conclusion, application of 1% potassium under well watered and water deficit conditions significantly improved the growth and achene yield of sunflower.

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**Interactive Effect of Zinc and Nitrogen with Different Rates of Phosphorous on Yield and Quality of Wheat**

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Wheat is an important cereal crop feeding millions of the people around the world. In Pakistan, wheat is grown on soils having high CaCO<sub>3</sub> and low organic matter contents. Wheat production in the world, including Pakistan, is facing different challenges such as macro and micronutrients deficiencies in soils. Approximately over two billion people are affected by malnutrition, especially in developing countries. Among these, Zn deficiency badly affects plant growth, development and immune system of human beings. Bio-fortification has been emerged as a new technique to improve the nutrient contents of staple food. In this study, we evaluated the interactive effect of zinc and nitrogen with different rates of phosphorous on yield and quality of wheat, in a pot experiment, in the wire house, Department of Soil Science BahauddinZakariya University, Multan. There were eight treatments, T1= control, T2=Phosphorus @ 20 mg ha<sup>-1</sup> + Foliar application of nitrogen, T3=Phosphorus @ 20 mg ha<sup>-1</sup> + Foliar application of Zinc , T4=Phosphorus @ 20 mg ha<sup>-1</sup> + Foliar application of (Zn+N), T5 = Phosphorus @ 40 mg ha<sup>-1</sup>+Foliar application of distilled water, T6 = Phosphorus @ 40 mg ha<sup>-1</sup> + Foliar application of nitrogen, T7= Phosphorus @ 40 mg ha<sup>-1</sup> + Foliar application of Zinc, T8=Phosphorus @ 40 mg ha<sup>-1</sup> + Foliar application of (Z+N). The results showed that increase in the level of phosphorus @ 40 mg ha<sup>-1</sup> with foliar application of Zn+N improved the 27% shoot length, 30% spike length, 24% straw weight and 40% no of grains as compared to control. Foliar application of Zn+N enhanced the plant nutrient status, and it increased the phosphorus concentration in root and shoot of wheat. So, it is concluded that Zn+N foliar application could be used not only to enhance growth but also phosphorus level in the wheat.

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**Elevating Shoot Calcium Level Inhibits Leaves Senescence and Partially Mitigates Drought  
Stress in Maize Seedlings**

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Environmental stresses are the greatest impediment in improving world food production. To investigate the effect of foliar application of Ca<sup>2+</sup> and subsequent water application on maize seedlings CV Azam, an experiment was arranged in completely randomized design at the Institute of Biotechnology and Genetic Engineering, The University of Agriculture Peshawar. The results of this experiment demonstrated that foliar application of Ca<sup>2+</sup> decreased the excised leaf water loss, signifying better water relations and osmotic adjustment. Furthermore, water deficit decreased fresh biomass production (47%), shoot-root ratio (7%), transpiration rate (24.14%), relative water content (40.70%), chlorophyll content (57%) and the expression of Lhcb2 gene (50%). Similarly, there was a decrease in membrane stability (42.9%) and increase in the H<sub>2</sub>O<sub>2</sub> content (63.30%). Foliar application of CaCl<sub>2</sub> partially improved all these traits under drought stress, however they were still less than the regularly irrigated seedlings. Senescence is a type of cell death program that could be inappropriately activated during drought was also delayed in the supplemented seedlings as highlighted by a high RWC, chlorophyll content and expression of the Lhcb2 gene. The improved water relations and maintenance of growth and photosynthesis in the supplemented seedlings manifested the potential of CaCl<sub>2</sub> to improve crop performance under restricted water regimes without diminution of yield and ensure food production from arid and semi-arid lands.

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**Index Plant Tissue in *Sorghum Bicolor* for Soil Selenium Uptake**

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This study was undertaken to determine the relationship of soil selenium forms with selenium uptake through sorghum grown on loess, sandstone and shale parent material and the index tissue of sorghum for soil selenium uptake. Experimental study was conducted at Soil Chemistry Laboratory, Department of Soil Science & SWC, PMAS-Arid Agriculture University Rawalpindi, Pakistan during April to June, 2014. Samples of three replicated soils were selected at three different level of development in each of loess, shale and sandstone residuum were taken. Samples were analyzed for pH, texture, total organic carbon and total selenium. The variance in basic parameters, selenium fractions and selenium uptake at horizon level was analyzed by multivariate analysis of variance (MANOVA). Soil selenium was fractionated into carbonate bound, manganese-iron bound, organic matter bound, humic compounds bound, sulfide bound and residual selenium. The shale derived soils had the highest total selenium ranged from 374 to 670  $\mu\text{g kg}^{-1}$ , which had strong positive relation with sulfides bound ( $r^2$  0.91), recalcitrant selenium ( $r^2$  0.88) and humic selenium ( $r^2$  0.83) indicating their great contribution in total soil selenium. The maximum content of selenium fractions bound to carbonates, humic compounds and sulfide were in shale soil profile while content of Mn-Fe oxide bound, organic matter bound selenium fractions were more in loess soils. Sandstone soils were rich in residual selenium. The hypothesis that variance of two populations (top 1-2 inter rolled leaves and lower leaves and stem) are equal was rejected ( $p > F$  0.03) So, concluded that index plant tissue is top leaves part of plant. This study will help the understanding about the selenium status in soils and fodders to control the diseases caused by selenium deficiency in animals and humans.

**Constitutive and Adaptive Root Architectural Variation does Occur in Maize Genotypes in  
Response to Phosphorus Deficiency**

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Phosphorus (P) is very immobile and less available in calcareous soils due to its precipitation. Pakistani soils are alkaline and calcareous in nature where maize growth often decreased by P deficiency. Modifications in root architecture may have a better impact on P uptake by plants. To investigate the genotypic variation regarding root architecture and P uptake by maize, a rhizobox experiment was carried out in wire-house of ISES, University of Agriculture Faisalabad. There were two treatments: P0 (no phosphorus) and P1 (recommended phosphorus). Maize genotypes i.e. Faisalabad maize, S-2002, Maize-2018, DTC-46 and EV-77 were sown in rhizobox. Plants were harvested after seven days and their root and shoot fresh and dry weight was measured. Maize roots were scanned and Image-J software was used to digitalize the image for measurement of the root architecture traits i.e. the primary root length, number, density of lateral roots, number and length of seminal roots. Differential pattern in root architectural traits were observed among genotypes. At low P the number of lateral roots, number and length of seminal root showed differential response among various genotypes and were increased in some genotypes. The primary root length decreased at low level of P; whereas lateral root growth was increased in P deficient condition may be due to plant root's growth in search for P. Maximum P concentration was recorded in the roots of Maize-2018 at P0. Interestingly, number of lateral roots showed positive correlation with fresh shoot weight in all genotypes. Increase in lateral root number under P-deficient conditions can be a potential adaptive characteristic of maize plants to increase P uptake. It is concluded that root architectural variation exist in maize genotypes in response to P availability which can be a potential target for P efficient crop development.

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**Use of Different Potash Fertilizers for Maize Growth And Yield at Different Irrigation Levels**

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Maize (*Zea mays* L.) is an important food crop of the world. In Pakistan, it is cultivated on vast area of land with good annual production. To obtain optimum and sustainable crop yields, it is important to formulate a sound fertilization program. Potassium plays a vital role in growth and development of maize. Seasonal dryness is an important limitation factor in corn cultivation and it decreases maize annual yield as 17%. Potassium increase resistance capacity against drought by increasing growth of corn plant. Present study was carried out to assess the effect of different levels of potash on corn yield and quality at different irrigation levels. Maize variety (Monsanto 6714) was sown in two main plots each divided into five subplots. Irrigation was kept as main plot factor and fertilizer with five different combinations was kept as subplot factor. Experimental soil was evaluated for physical and chemical properties of soil before the experiments i.e. soil pH, EC and K contents. Treatments in the first plot were T0: no fertilizer, T1: SOP 70%, T2: SOP 100%, T3: MOP 70%, T4: MOP 100% and each treatment were repeated under both irrigation levels. The difference between both irrigation level was of 7 seven days at each supplemental irrigation. Data regarding different growth and yield related parameters was recorded. Analysis of variance and treatment mean comparison through LSD test showed that both irrigation level affected plant growth in the similar ways whereas K source has affected plant growth. Plants under treatments containing high K application showed more growth whereas those under low K application showed reduced growth. It was also observed that SOP has more positive effect on plant growth as compared to the MOP.

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**Effect of Organic and Inorganic Fertilizers on Growth And Yield of Two Maize (*Zea mays* L.) Varieties in Hazara Area**

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The present study investigates the effectiveness of different organic sources as well as inorganic fertilizers on the growth and yield of maize (*Zea mays* L). Research was carried out at the Research area of Awan nursery farm Haripur Khyber Pakhtunkhwa during spring, 2013. The experiment consisted of six treatments namely control, Fresh Cattle Manure, Kahoon organic fertilizers, Poultry Manure, Higo-organic fertilizers, and chemical fertilizers NPK. All organic fertilizers were used at a rate of 10 t ha<sup>-1</sup> while Chemical Fertilizers NPK was used at a recommended rate of 120-90-60 (NPK). There were two different varieties of maize namely Azam and Barani. Different plant growth and yield parameters were studied for each variety during the experiment. The Azam variety germinated earlier than the variety Barani while in all other parameters. The results showed that the parameters plant height, cob length, grains per cob, thousand grains weight and grain yield were significantly affected by the different organic and inorganic fertilizers treatments used. Kahoon organic fertilizer resulted in the highest plant height, while Higo organic fertilizer resulted the highest grains Weight, and chemical fertilizers NPK showed maximum cob length, grains per cob and grain yield. As maize grain yield from chemical fertilizers (NPK) was maximum followed by slight difference with application of Higo organic fertilizers, it can be concluded that organic fertilizers can perform better in comparison with inorganic NPK fertilizers. However, post-harvest soil nutrient differences and next crop yield data from the same plot may be useful in giving any recommendations. Among the varietal performance in the study, it can be concluded that Barani variety is the best for soils of Haripur district.

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**Yield and Quality Response of Cotton to Consortium of PGPR at Graded Fertilizer Levels.**

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Biofertilizers, formulations of rhizobacteria are eco-friendly, cost effective and have potential to sustain the yields in the intensive cropping system. Plant growth promoting rhizobacteria (PGPR) have proved their worth for promoting the yield and quality traits of various crops by producing phytohormones, siderophores, antibiotics, mobilizing nutrients and inducing systemic resistance. In a series of experiment, the consortium of PGPR of *Azotobacter* and *Azospirillum* sp were tested on the yield parameters of cotton with graded levels of nitrogen (N) at Cotton Research Station, Sahiwal. Three levels of N i.e. 60, 90 and 120 kg ha<sup>-1</sup> were applied while P was applied at 60 kg ha<sup>-1</sup> to all the treatments. Results revealed that the bacterial consortium affected the cotton growth and yield at all N levels as compared to un-inoculated control. The maximum seed cotton yield i.e. 2478 was observed at 120 kg N ha<sup>-1</sup> as compared to its respective control i.e. 2238 kg ha<sup>-1</sup>. The highest number of bolls plant<sup>-1</sup> (25), boll weight (3.34 g) and plant height (126.9) were also observed at the same treatment. Results also showed that consortium of PGPR had reduced cotton leaf curl virus (CLCV) incidence up to 36.0% as compared to 41.0% without inoculation. The highest ginning out turn (GOT) and staple length was observed with PGPR consortium inoculation i.e. 38.6% and 27.8 mm as compared to un-inoculated control i.e. 37.9 % and 27.5 mm, respectively at 120 kg N ha<sup>-1</sup>. Present study clearly demonstrated that consortium of PGPR had more assenting effect on the yield components of cotton. More combination of PGPR should be used in different ecologies to validate this approach and to compensate the mineral fertilizer for sustainable agriculture.

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**Growth and Yield Response of Legumes to Co-inoculation of Rhizobium and PGPR with  
and without Zinc Application**

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The contribution of microbial atmospheric N<sub>2</sub> fixation is almost double of total annual fixed nitrogen and converts atmospheric gaseous nitrogen into ammonium. Biological N fixation provides an economical and ecological way by reducing cost of mineral nitrogen. Micronutrients play vital role during legume-rhizobium symbiosis. Zinc is involved in the synthesis of auxins, photosynthesis and have regulatory role in efficient use of water. Pot studies were conducted at Soil Bacteriology Section to determine the role of co-inoculation of *Rhizobium* + PGPR in the presence and absence of Zn on the yield of mungbean and chickpea. Uniform fertilizer dose @ 30-60 kg NP ha<sup>-1</sup> was applied to mungbean and chickpea. Zinc was applied as ZnSO<sub>4</sub>·7H<sub>2</sub>O @ 2 kg ha<sup>-1</sup>. Results revealed that co-inoculation influenced the nodulation and yield positively as compared to their separate application and the effect was more pronounced with zinc application. Co-inoculation with Zn application to mung bean and chickpea produced highest number of nodules i.e. 16, 53 and nodular mass of mung bean 0.14 and 0.29 g pot<sup>-1</sup>, pod yield of mung bean 50.5 and 53.5 g pot<sup>-1</sup>, and dry matter yield of mung bean 56.0, 59.6 g pot<sup>-1</sup>, respectively. Results suggested that comprehensive experimentations on different legumes should be carried out for improvement of N<sub>2</sub> fixation process and yield on sustained basis.

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Characterization and Evaluation of Plant Growth Promoting Rhizobacteria from *Artemisia scoparia* in Mohmand Agency

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Rhizobacteria are a group of useful bacteria that inhabit roots of plant and enhance growth of plant by various mechanisms. Twelve bacterial strains were isolated from the soil and root of *Artemisia scoparia* collected from four different areas of Mohmand Agency. The characterization of the isolated bacterial strains was done on the basis of their biochemical, morphological and physiological features. The isolated bacterial strains were screened for their potential plant growth promoting activities. Most of the isolates were potential Phosphate solubalizers, maximum solubalization index was 1.7. Similarly most of the isolates were Indole acetic acid producers. Majority of isolates showed antifungal activity against phytopathogenic fungus *Helminthosporium sativum* and *Fusarium solani*. Maximum inhibition was 82% and 75%. An experiment was carried out in growth chamber where wheat plants were grown to evaluate the effects of bacterial isolates on growth of wheat. Most of the bacterial isolates significantly increase shoot length (28.75 cm), leaf length (21.5 cm) and leaf width (1.37 cm) of wheat seedling. Fresh Shoot, root weight and root length was significantly affected by inoculation. Therefore the present investigation indicated that the bacterial isolates from *Artemisia scoparia* have plant growth promoting characters –direct and indirect and may be used as biofertilizers for wheat growth and productivity.

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**Biochar: A Beneficial Multifunctional Organic Amendment for Soil and Plants**  
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Soil fertility declines due to low input of organic amendments and excessive use of chemical fertilizers. Conventional organic amendments such as compost, farm manure, crop residue and poultry manure mineralized rapidly and their major portion of nutrient is not available to plants. Instead of these organic amendments, biochar provide nutrients for longer period of time and improve soil health indicators for longer period of time, form hundred to ten thousand years. Biochar has large proportion of macronutrient but it's distinguish property from other organic amendment is to provide micronutrients by acting as an electron shuttle in redox-mediated reactions. Biochar applied @ 5% in degraded land increased water holding capacity up to 41%, soil porosity up to 29% and reduced bulk density up to 33%. Results of different pot studies in biochar amended soils showed that application of 1% (w/w) biochar increased photosynthesis rate up to 20%, transpiration rate 35% while 2% (w/w) applied biochar increased photosynthesis rate up to 29%, transpiration rate 43% in wheat crop. Plant dry mass and grain yield of maize increased up to 30 and 39% in 2% (w/w) biochar amended calcareous soil respectively. Protein and ascorbic acid of wheat grain increased up to 40 and 51% in 3% (w/w) biochar amended heavy metals contaminated soil. Hence it was concluded that biochar has strong positive effect on soil rehabilitation and plant growth and nutritional quality of grain.

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**Zinc Nutrition and Microbial Allelopathy Improve the Grain Yield and Zn Bioavailability  
in Bread Wheat**

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Zinc (Zn) is an important micronutrient and its deficiency hampers the crop yield, nutritional quality and ultimately the human health. Plant growth promoting Rhizobacteria (PGPR) transform unavailable Zn to available form for plant uptake, which enhance the plant Zn status and growth. To improve the productivity and grain biofortification of wheat; two year study was conducted at Agronomic research area, Department of Agronomy, University of Agriculture Faisalabad during 2013-14 and 2014-15. Zinc was applied to two wheat cultivars viz. Lasani-2008 and Faisalabad-2008 as soil application ( $10 \text{ kg ha}^{-1}$ ), foliar application ( $0.025 \text{ M}$ ), seed priming ( $0.5 \text{ M}$ ) and seed coating ( $1.25 \text{ g kg}^{-1}$  seed), while hydroprimed seeds were taken as control. Zn solubilizing bacterial strain viz. *Pseudomonas sp.* was also used in combination with different Zn application methods. Zinc application improved the grain yield and grain biofortification of bread wheat as maximum grain yield was recorded when Zn was applied in combination with PGPR through seed priming technique, followed by soil application of Zn + PGPR. Moreover, Zn application by either method increased the grain Zn concentration. However, soil and foliar application of Zn with and without PGPR impressively enhanced the Zn concentration in embryo, bran and endosperm of wheat. Zinc application improved the bioavailable Zn as minimum phytate concentration, phytate/Zn molar ratio and maximum bioavailable Zn was recorded for soil and foliar application of Zn + PGPR. In crux, soil application of Zn + PGPR was the most effective in improving the productivity and grain biofortification of wheat.

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**Biofortification of Rice through Zinc Solubilizing Rhizobacteria and Zinc Fertilization**

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Intensive farming to feed an ever increasing global population deplete soils macro and micro nutrients especially in wheat-rice cropping system. Pakistani rice grain contains zinc in the range of 10-15 ppm which does not meet the human requirement and causes severe deficiency. This Zn deficiency deleteriously affects the human health and development. It can be mended through biofortification, and can solve health problems in poorer areas of the world. A pot experiment (10 kg soil bearing three plants) was conducted at Soil Bacteriology Section, AARI Faisalabad to study the effect of PGPR (zinc mobilizing bacteria) on biofortification of zinc in rice. Treatments include Control, PGPR inoculation, 5, 10, 15 kg ha<sup>-1</sup> ZnSO<sub>4</sub>, PGPR Inoculation +5,10, 15 kg ha<sup>-1</sup> ZnSO<sub>4</sub>. Results indicated that PGPR along with 15 kg ha<sup>-1</sup> ZnSO<sub>4</sub>.7H<sub>2</sub>O significantly improved grain yield (49 g pot<sup>-1</sup>), 100 grain weight (2.31g) and zinc concentration in grain (20 ppm) as compared with its respective control (43g pot<sup>-1</sup>, 2.24g and 11.66 ppm). Zinc solubilizing rhizosphere bacteria enhanced the root and shoot growth due to nitrogen fixation, phosphate solubilization, auxin and organic acid production, as well as their ability to produce certain bacterial metabolites.

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**Effect of Zinc and Boron application methods on yield attributes of hybrid maize  
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Micronutrients deficiency is an important constraint not only for good crop production but also for human health. Zinc (Zn) and Boron (B) are important micronutrients whose roles are well documented for improving the growth and production of maize crop. Application of Zn and B could be a suitable option to fulfill the crop demand for Zn and B and also to increase their contents in grains. Therefore, a field experiment was conducted to check out the effect of different zinc and boron application methods on the productivity of maize hybrid DK-6714. The experiment was laid out in Randomized Complete Block Design with three replicates. Treatments included, T0: Control, T1: Soil application of zinc as ZnSO<sub>4</sub> @ of 12 kg/ha, T2: Soil application of boron as Boric acid @ 3 kg/ha, T3: Foliar application of zinc as 1% solution of ZnSO<sub>4</sub> at 9 leaf stage, T4: Foliar application of boron as 0.5% solution Boric acid at 9 leaf stage, T5: Soil application of zinc as ZnSO<sub>4</sub> @ 12 kg per hectare + Soil application of Boron as Boric acid @ of 3 kg/ha, T6: Foliar application of zinc as 1% ZnSO<sub>4</sub> solution + foliar application of boron as 0.5% Boric acid solution at 9 leaf stage. The statistical analysis showed that maximum grain yield, stem girth, cob length, cob girth, number of grains per cob and 1000-grain weight was obtained with treatment T6 and minimum growth and production was recorded when no Zn and B was applied (T0). In the lights of this study we can conclude that the soil application of Zn and B significantly improved the agronomic and yield contributing parameters of hybrid maize.

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**Combined Effect of Drought and Salinity on Plant Growth Parameters and Nutritional Status In Wheat Crop**

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Drought and salinity are the most threatening abiotic stresses, affecting growth and yield of various crops. Therefore, it is very important to investigate the combined effect of both drought and salinity, as salinity is known as chemical drought. A pot experiment was carried out to examine the combined impact of drought and salinity on the growth of wheat crop. The experiment was laid out in completely randomized design (CRD) using three replications. Wheat seeds were first germinated on moist filter papers in dark conditions and then seedlings were transferred into pots having 5 kg soil. Recommended doses of nitrogen, phosphorous and potassium (NPK) as basal fertilizers were applied at sowing time. All plants were grown at optimum moisture (70% WHC) for four weeks and then half of the plants were subjected to drought stress by maintaining 30% of WHC. While salinity stress was applied for both moisture levels by maintaining two (ECe) levels: 2 dS m<sup>-1</sup> (control) and 8 dS m<sup>-1</sup> (salinity stress). After four weeks of drought stress, plants were harvested. Growth parameters like shoot and root dry weights were significantly reduced due to combined treatment of drought and salinity as compared to individual treatments. Chlorophyll contents and nutrient uptake in plants were significantly reduced due to individual as well as combined treatment of drought and salinity. Sodium content in plant shoots and roots increased significantly where salinity treatments were applied. In conclusion drought and salinity reduced the plant growth and nutrient uptake (P and K) in wheat crop. While combined effect of drought and salinity was observed more harmful for plants as compare to individual effects of drought and salinity.

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**Interactive Effect of Zinc and Boron on the Performance of Transplanted Coarse Rice  
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Rice (*Oryza sativa* L.) is an important cereal crop of Pakistan which is mainly cultivated in rice-wheat cropping system of Pakistan. Rice, like other cereals, lacks in essential micronutrients especially zinc and boron. Zinc (Zn) and boron (B) are the most deficient micronutrients in soils worldwide that are essential for rice growth and yield. These nutrients can be supplied to plants in various ways such as, soil application, dipping of seedling and coating of seeds or by foliar application. A field experiment was conducted at Agronomic Research Area, University of Agriculture Faisalabad during kharif-2015 to investigate the role of Zinc and Boron towards yield enhancement in a coarse rice cultivar “KSK-133” sown through transplanting method. The experiment was comprised of seven treatments viz. dipping the seedlings in Zn solution (5% w/v solution), dipping the seedlings in B solution (1% w/v solution), dipping the seedlings in Zn + B solution, soil application of Zn @ 25 kg ha<sup>-1</sup>, soil application of B @ 2 kg ha<sup>-1</sup>, soil application of Zn + B (25 kg ha<sup>-1</sup> Zn, 2 kg ha<sup>-1</sup> B) along with control. Differences among the treatment means were compared by employing least significant difference (LSD) test at ≤ 5% probability level. Application of zinc and boron enhanced growth and paddy yield. Number of productive tillers, number of branches per panicle, number of kernels per panicle, 1000- kernel weight, biological yield, paddy yield, harvest index and normal kernels were maximum when zinc and boron @ 25 kg ha<sup>-1</sup>, 2 kg ha<sup>-1</sup> were applied in soil respectively. In conclusion, soil application of zinc and boron improved the paddy yield and quality of rice kernels.

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**Growth and Yield of Okra (*Abelmoschus esculentus* L.) as Influenced by Application of Poultry Litter and Dead Poultry Birds Compost**  
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Okra (*Abelmoschus esculentus* L.), an annual herbaceous and is more prevalent in the Indo-Pak subcontinent. It plays very important role in human diet, because it contains fats, carbohydrates, minerals, vitamin A, vitamin C and potassium. Poultry litter is a rich source of plant nutrients and is being used as organic fertilizer to improve soil health and crop productivity. The decomposed form of poultry litter and dead birds under controlled conditions (compost) may be more efficient way to use poultry litter as fertilizer. In a recent study a compost prepared by poultry litter and dead poultry birds was use to observe its effect on growth and yield of okra. About 20-30% inorganic fertilizers were replaced with poultry litter (including dead birds) compost in a field experiment conducted on research farm of Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad. Three levels of compost (0 kg acre<sup>-1</sup>, 500 kg acre<sup>-1</sup> and 750 kg acre<sup>-1</sup>) and recommended dose of chemical fertilizers were used as Urea, P2O5 and K2O as 60:40:25 kg NPK ha<sup>-1</sup>, respectively. However the amount of NPK fertilizers were reduced in compost treatments according the amount of NPK present in the compost. The results showed that plant height, fresh shoot weight, dry shoot weight, fresh root weight, dry shoot weight and chlorophyll contents were increased when higher compost level (750 kg acre<sup>-1</sup>) was used. In this experiment 18% total root length and 20% okra fruit yield were also increased where compost was applied at the rate of 750 kg acre<sup>-1</sup> as compared to control. It is suggested that application of compost improved the root length, nutrient uptake efficiency, soil health and plant anchorage. Thus the plant growth and fruit yield was improved.

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**Enhancing Phosphorus Use Efficiency through Polymer Coated Commercially Available  
Phosphatic Fertilizers**

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After green revolution agricultural production many fold increased as a result resources depleted very fast. In recent decade, natural resources becoming scarcest and need to improve resources use efficiency. Same situation is present in case of mineral resources especially rock phosphate. Rock phosphate is a major source of phosphatic fertilizers including single super phosphate and triple superphosphate. Different techniques have been used to enhance phosphorus use efficiency including agronomic practices, genetically efficient utilization of phosphorus varieties, microbial application but inconsistency results was obtained. Coating of fertilizer granules with polymer enhanced the use efficiency and slow release of nutrient for long period. A series of experiments were conducted for determine the polymer concentration (0.25, 0.50, 0.75, 1.0 and 2.0%) for coating on SSP and TPS in soil fertility laboratory Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad. Further experiments were carried out with concentration of 1% single, double and triple layer of coating at different moisture levels. It was concluded that 1% double layer release phosphorus slowly from both fertilizers compared to other treatments. To investigate the further effectiveness of 1% double layer a field trial was conducted on wheat at the research area of Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad. Field trial results shows that polymer coated SSP and TSP not only increased plant growth but also enhance economic yield compared to control (simple SSP and TSP). Statistical results showed that with the application of polymer coated SSP increased spikelet length, 1000 grain weight, plant height and phosphorus contents in grains upto 23.7, 31.4, 19.9 and 36.1% compared to control. Furthermore, polymer coated technique is nontoxic, environmental friendly, less expensive and reliable technique.

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**Phosphorus Release Pattern from Polymer Coated Diammonium Phosphate: Effect of Coating Concentrations, Layers and Soil Moisture**

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In spite of substantial increase in food production over the past half century, now a day, one of most important challenge facing society is how to feed the expected ten billion peoples by the mid of current century and eleven billion people by the close of this century. Phosphorus (P) fertilizer is one of the important elements of modern agriculture to get potential yield of crops to feed increasing population. However, application of P fertilizer granules in soil are subjected to a series of reactions with carbonates of calcium and magnesium which substantially retard P availability to crops. Coating P fertilizer granules with a polymer slows the release of nutrients over a long period of time for crops along with reduction in fixation. A series of laboratory experiments were conducted at Soil Fertility and Plant Nutrition Laboratory, Institute of Soil & Environmental Sciences, University of Agriculture, Faisalabad to check the effect of polymer coating concentration (0.25, 0.5, 0.75, 1 and 2%), layers (single, double and triple) and soil moisture (100, 75, 50 and 25% field capacity) on P release from diammonium phosphate. Results revealed that polymer concentrations coated on DAP 0.25, 0.50, 0.75, 1 and 2% released 90, 85, 80, 73, 45% P respectively from applied coated DAP up to two month. For next experiment 1% concentration was screened out and single, double and triple layer was coated on DAP to check the release rate of P. Results showed that 77, 66 and 55% P released from single, double and triple layers respectively. Double layer was selected for further experimentation for P release pattern under different moisture level but soil water content least affected on release pattern. So, polymer coated DAP enhanced P availability for long time by slow release mechanism and perform well under low soil moisture conditions.



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**CROP PRODUCTION**



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**Small vs. Large Scale Farming System: An Empirical Investigation from Central Punjab**  
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Difference in productivity and structure of agriculture under heterogeneous conditions is quite evident. However, production variability within narrow limits on farms under homogeneous conditions may also be there. This study was conducted to investigate the presence/absence of the inverse relationship between farm size and productivity. Farm level data regarding costs and returns was analyzed statistically to evaluate an economic relationship between farm size and productivity. For this purpose, a total of 120 farms are selected from Jhang District using stratified random sampling technique for the year 2012-13. The presence of a weakening inverse relationship is found in the sampled area. Relative use of inputs and resulting output differ along farm size. Mean farm size of the overall sample of farmers is about 14.27 acres with large farmers having about 292 percent more operational holdings than the small farmers. Family labour use is more on small farms than on large farms as the small farmers have surplus family labour and they employ relatively less hired labour. The land use and cropping intensities are higher for small farms. Small scale farmers are getting about 11 percent higher output than larger farmers from one acre indicating an opposite relationship between farm size and productivity. The presence of inverse relationship is confirmed when using value of output per acre as dependent variable and log of operational holding as independent variable. When tested for structural and technological variability using Chow's F-test, it is confirmed statistically that the two farm groups are not same rather these differ by size, structure, input use, output, technology, resources and profitability. Some policy measures in terms of land reforms, research orientation and socioeconomic setup are recommended to overcome productivity gap between the two farming systems.

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**The Role of Private Tobacco Companies on Tobacco Crop in Malakand Division, Pakistan**

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Economic stability is one of the significant elements in eradication poverty level of farmers' community. Therefore, the present study conducted to identify a role of private tobacco companies in tobacco crop. For this purpose, Malakand division was selected purposively by multi-stage sampling technique. Thus, a sample size of this study was (135) tobacco growers. Results of the present study reveal that maximum (82.96%) tobacco growers were young and middle age (up to 50 years). Mostly (72.59%) tobacco growers were educated up bachelor degree. Similarly, (85.18%) and (65.18%) tobacco growers well experienced in tobacco up to 20-30 years and were the small size of land cultivator up to 2.5 acres. Meanwhile, private tobacco companies provide maximum (85.18%), (85.18%), (75.55%) and (68.14%) tobacco growers' facilities related seed, nursery establishment, fertilizers, and pesticides respectively. Whereas, a response of tobacco growers regarding these facilities recorded good to excellent about seed facility and fair to satisfactory for remaining other facilities. Moreover, (98.51%) tobacco growers enclosed that they achieved information regarding tobacco crop by pamphlets and posters. While almost all tobacco growers applied mobile tool as electronic media for getting new information regarding tobacco crop. It is concluded on base of finding that tobacco growers should commercial growers and well experienced. Certainly, these growers would face major issues related quality seed, recommended dose of fertilizers, diseases and nursery establishment of tobacco crop. It is recommended on base of conclusions that private tobacco companies and other concern organization should train illiterate and traditional growers. Further, some specific extension technique like field demonstration, field trip, model farm service and farmer field school approach would apply for less knowledgeable tobacco growers. More than, it would be better that private tobacco companies or concern organizations launch telephonic, helpline and internet facilities for tobacco growers.



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**Viable Alternatives to Cotton-Wheat Crop Rotation for Semi-Arid Climatic Conditions**

**Hafiz Qamar Zia Ali, Fahmeed Ahmad Choudhary, Hafiz Zafar-ul-Qasim, Asad-ur-Rahman, Abaid Raza, Muhammad Usman Anees, Asad-ur-Rahman and Sumair Zafar**

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A study was conducted in the research area of Agronomy Department, University of Agriculture, Faisalabad during 2014-2015 to evaluate a sustainable and economical wheat-based rotation system under agro-climatic conditions of Faisalabad. Guar, maize, mash bean, mungbean, soybean, millet and some fodders (maize, millet and sorghum) were grown in Kharif season while wheat was the main crop in Rabi season. Wheat-fodder millet-grain maize gave the highest net benefits of Rs. 272062 but exhausted the soil. The maximum value of BCR (2.25:1) was achieved in the same rotation i.e. wheat-fodder millet-grain maize followed by wheat-fodder maize-mash bean with BCR of 1.86:1. Keeping in view the soil fertility plus economy, the later one i.e. wheat-fodder maizemash bean cropping system is economical for small landholders and can also improve soil fertility status.



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**Plant Growth Stimulants: Consequences on Allometry, Phenology, Physiology and Yield  
Traits of Autumn Maize**

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Phytohormones have a primitive role in crop growth and productivity. They can be used for crop enchantment when they are used in small amount. An experiment was conducted in agro-ecological conditions of Faisalabad (31.4187° N, 73.0791° E) to improve the performance of autumn maize through foliar application of plant growth promoters and allopathic aqueous extracts. Foliar spray of 0.1% salicylic acid, 0.02% thiourea, 3% sorghab and 3% moringa leaf extract were applied on two maize hybrids (Dekalb-919 and Dekalb-6789) at knee height and tasseling stages. Foliar application of 0.02% SA brought down electrolyte leakage (33%) when compared with control and foliar application of 3% sorghab and 0.02% SA enhanced relative water content 13.63% and 19.14% respectively. The maximum chlorophyll content (53.56 SPAD value) was recorded in Dekalb-6789 when applied with 3% moringa extract. The maximum leaf area index (5.25) was recorded when 3% concentration of moringa extract was practices foliarly. The minimum leaf area index (4.10) was recorded when plots were subjected to control treatment. Leaf area index at 55 days after sowing was enhanced 28% as compared to control by 3% foliarly applied moringa leaf extract. Leaf area duration at final harvest was enhanced 36.78% as compared to control by 3% foliarly applied moringa leaf extract. Application of these plant growth promoters enhanced the no. of grains per cob, thousand grain weight, plant height, biological and grain yield. Results suggested that the application of moringa water extract at 3% concentration was significantly better than other plant growth stimulants in improving the maize performance.

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**Yield response of Wheat (*Triticum aestivum* L.) to Zero and Conventional Tillage in Rice-  
Wheat Cropping System**

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Conventional tilled rice transplanting in puddle soils is widely practiced in rice-wheat cropping system in Asia, requires technical and large amount of labor and water. A field study was carried out to explore the performance of wheat sown with zero and conventional tillage in three rice field conditions i.e. flooded, alternate wetting and drying and direct seeded conditions during the years 2008- 09 and 2009-10 at Agronomic Research Area, University of Agriculture, Faisalabad. Zone disk tiller drill was employed for zero tillage while automatic rabi drill was used for conventional sowing of wheat during both years. Wheat variety Seher-2006 was used as experimental material @ of 125 kg ha<sup>-1</sup>. The results revealed that the number of fertile tillers and grains per spike were affected substantially while remaining yield contributing factors were with nonsignificant effect. Wheat grain yield 4.07 and 4.11 t ha<sup>-1</sup> was harvested in 2008-09 while 2.72 and 2.62 t ha<sup>-1</sup> for zero and conventional tillage technology, respectively. It was further concluded that the net of PKR. 50759/- and 47395/- was obtained by zero tillage during 2008-09 and PKR. 43528/- and 38285 in 2009-10, respectively. From this study of sowing wheat on zero tillage and conventional tillage in various rice field conditions, it is concluded that zero tillage is a resource conservation technology which gave the maximum net return and BCR during both the years.

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**Viable alternatives to Rice-Wheat Rotation for Maximizing the Agronomic Efficiency  
under Semi-Arid Climatic Conditions**

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Hafiz Qamar Zia, Muhammad Usman Anees, Asad-ur-Rahman and Sumair Zafar**  
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Agriculture is predominantly vulnerable to climatic changes. Fluctuating temperatures and changes in the pattern of precipitation are affecting yields of the crops. It also encourages the pest and weed proliferation that may result in crop failures and production losses. Most practiced cropping system in Punjab are rice-wheat, cotton-wheat and mixed-wheat cropping systems. These cropping systems seem deficient in giving its economic potential during kharif season. A research work was planned to evaluate sustainable wheat-based rotations under agro-climatic conditions of Faisalabad. Rice, sunflower, sesame, fodder maize, grain maize, mash bean, mung bean, soybean and grain sorghum were grown in kharif while wheat was the main crop in Rabi season. The maximum wheat yield ( $5.00 \text{ t ha}^{-1}$ ), TDM ( $12027 \text{ kg ha}^{-1}$ ), 1000-grains weight ( $41.19 \text{ g}$ ), grains per spike (49.27) and harvest index (44.65%) were observed in mungbean-soybean wheat rotation. Likewise, maximum organic matter (0.88%), nitrogen (0.055%), available phosphorus (8.27 ppm) and potash (151 ppm) were also recorded in mungbean-soybean-wheat rotation. Fodder sorghum-grain maize-wheat rotation gave the highest net benefit of Rs. 289954 followed by fodder maize -sunflowerwheat rotation having gross monetary returns of Rs. 233453. The maximum value of BCR (2.30:1) was achieved in fodder sorghum-grain maize-wheat followed by fodder maize -sunflower-wheat rotation with BCR of (1.86:1). Fodder millet-grain sorghum-wheat, fodder sorghum-mash bean-wheat and ricewheat rotations were found dominated by other rotations. Inclusion of legumes in wheat-based rotations is beneficial to get higher returns along with sustainability of soils. The wheat-fodder maize- mash bean cropping system can boost the economy of small landholders and improve soil fertility status.

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**Sustainability through Agro-forestry- Implications for Agricultural Extension**  
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Every year we use 40% more resources that we can put back and this situation is pushing us to non-sustainability in every aspect of life. Agriculture sector has always played its important role to meet the dietary needs of masses across the globe. The area under cultivation is decreasing because of urbanization and on the other hand increased population is exerting pressure agriculture to fulfill the required needs of a large population. Saving the ecosystem and enhancing diversity can help us to a prolonged sustainable agricultural production. Agroforestry has not only helped the farming communities to get potential yield of their crops but it also has increased their economic, environmental and health status. The present study was conducted in district Khushab focusing on the farmers who were practicing agro-forestry. Majority (61.5%) of the respondents revealed that they were reluctant to practice agro-forestry in future because of less water availability and low economic outcome and willing to reduce area under tree production. The priority trees grown by the respondents were Sufeda, Shisham and Frash. The government should have to pay incentive to the farmers for practicing agro-forestry as it is being practiced in some other countries to use the resources in a sustainable way. The department of agriculture should not only have to bring awareness among the farmers but it must have to do some efforts to make the resources conserved.

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**Role of Humic Acid on Growth of Maize (*Zea mays* L.) under Drought Stress**

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Due to the worldwide problem of global warming, less and uncertain rainfall may lead to drought periods which may have unknown effects on agroecosystems. Water stress has been found to be the most environmental constraint reducing the leaf area, photosynthesis and plant biomass and ultimately reduce the grain yield. It has long been recognized that humic acid (HA) as soil conditioner has many positive effects on soil properties as well as on plant growth. So, humic acid can be a good option for drought tolerance of maize in rain-fed areas. To evaluate the effect of humic acid as a soil conditioner on plant growth under drought stress, a pot experiment was conducted. Humic acid from lignite source was prepared in lab and its three levels (0, 100, 200 mg kg<sup>-1</sup> of soil) were applied to both moisture levels i.e. optimum (70% of water holding capacity) and drought conditions (30% of WHC). In order to compare efficiency of laboratory prepared HA, same levels of commercial HA was applied for both optimum and drought stress treatments. Results showed that plant biomass, photosynthetic rate, plant height and nutrients concentration reduced significantly under drought stress but the application of laboratory prepared humic acid @ 100 mg kg<sup>-1</sup> significantly enhance the plant biomass, plant height, photosynthetic rate due to the presence of stable carbon fraction in the humic acid. While lab prepared and commercial HA @ 100 mg kg<sup>-1</sup> of soil significantly enhanced the nutrient concentration as humic acid enhances water retention and solute binding and release of nutrients. Under water deficiency, humic acid application lead to diminish of water stress effects on crop growth.

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**Influence of Sowing Methods and Harvesting Times on Forage Productivity and Quality of  
Sweet Sorghum**

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Optimum sowing method and harvesting time improves the forage yield and quality of fodder crops. This study was conducted to evaluate the influence of sowing methods and harvesting times, on the productivity and quality of sweet sorghum. The experiment was conducted at Agronomic Research Area, University of Agriculture and designed in randomized complete block design in factorial arrangement with net plot size of 1.8 m × 6 m. Chinese sweet sorghum was sown by broadcast method and in 30 and 45 cm apart lines, and harvested after 60, 75 and 90 days after sowing. All, the tested sowing methods and harvesting timing, remarkably influenced the growth yield and quality of sweet sorghum. However, sorghum sown in 30 cm apart rows produced statistically highest leaves per plant (13.09), fresh forage yield (38.1 t ha<sup>-1</sup>), dry matter yield (4.85 t ha<sup>-1</sup>), crude proteins (8.9%), ash contents (11%) and sugar contents (12.8%). Similarly, harvesting after 90 days of sowing, produced maximum leaves per plant (14.72), fresh forage yield (45.1 t ha<sup>-1</sup>), dry matter yield (5.60 t ha<sup>-1</sup>), ash contents (12.2%) and sugar contents (14.1%). In conclusion, sowing in 30 cm apart rows and harvesting after 90 days of sowing can increase the forage productivity and quality of sweet sorghum.

**Optimizing Row Spacing for Direct Seeded Aerobic Rice under Dry and Moist Field  
Conditions**

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Soil moisture condition at the time of sowing and row spacing are important factors that can affect stand establishment, quality, yield and yield-causative attributes of direct seeded aerobic rice. Farmer field based experiment comprised two soil moisture condition at the time of sowing (M1: dry sowing condition, M2: moist field conditions) in main plots, while three row spacing (S1: broadcasting, S2: 11.25 cm row spacing, S3: 22.50 cm row spacing) were assigned to sub-plots. The experimental results revealed that treatment S3(22.50 cm row spacing) took minimum time to start emergence (3.67 days), 50% emergence (7.50 days) and mean emergence time (9.50 days) under moist field condition. While, Final emergence count (177.33 m<sup>-2</sup>) was maximum in S2 (11.25 cm spaced rows) treatment. Statistically, maximum productive tillers (301.17 m<sup>-2</sup>), numbers of grains per panicle (93.66), 1000-grain weight (19.39 g), paddy yield (3.50 t ha<sup>-1</sup>) and harvest index (34.28%) were recorded in S3 (22.50 cm spaced rows) treatments. Plant height (71.59 cm) at physiological maturity, Straw yield (9.68 t ha<sup>-1</sup>) and opaque kernel (13.66%) was maximum under S2 (11.25 cm spaced rows) treatment. Percentage of sterile spikelet (9.50%), abortive kernels (9.67%) were highest in broadcasting treatments. Maximum net benefit (USD. 1095 ha<sup>-1</sup>) was obtained from S3 (22.50 cm spaced rows) treatment under dry field conditions and BCR 1.48 was recorded in 22.50 cm spaced rows. It is concluded that, S3 (22.50 cm spaced rows) are optimum for successful and economic direct seeded aerobic rice productivity under Faisalabad condition.



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**Sustainable Crop Production in the Punjab**  
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Sustainable agriculture is imperative to feed the rapidly increasing population and conserving the natural resources of the country. While higher growth rate of the population creates hindrance in sustainable crop production due to less per capita water and area availability, smaller farm size, soil depletion and poor soil health. According to Punjab Development Statistics-2015, more than 90% farms have less than 5 hectare land. Per capita land and water availability have been decreased up to 0.1 hectare cultivated land and 1000 m<sup>3</sup> water. Our soils have been depleted due to high cropping intensity and less use of organic and inorganic fertilizers. Lack of processing and value addition infrastructure is another factor in food availability. Research wing of the Punjab Agriculture Department is engaged in developing high yielding and climate resilient varieties of various crops. Different resource conservation strategies (ridge/bed planting, laser land leveling, improvement in water conveyance efficiency, high efficiency irrigation system, rain water harvesting, reduced tillage, and improving soil health) and high value crops/fruit (olive, grapes, exotic date Palm) have been introduced. Promotion of kitchen gardening especially in urban areas is another initiative of Punjab government to provide fresh and safe vegetables. Consistent research efforts and better policy measures are required to meet the future challenges of food security and sustainability.



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Plant Growth Promoting Characters of Rhizobacteria Isolated from Canola in Swabi,  
Khyber Pakhtunkhwa

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Rhizospheric bacteria are involved in nutrient recycling, production of phytohormones and inducing systemic resistance (ISR) against plant pathogens thus have been used in crop productivity from decades. Total 205 bacterial strains were isolated from rhizosphere, rhizoplane and endorhizosphere of Canola on their respective media. All of the isolates were phenotypically characterized on the basis of Gram staining reaction, cell morphology, colony size, color and shape. Selection of potential isolates was done on the basis of their P-solubilizing ability, production of Indole acetic acid (IAA), Hydrogen cyanide (HCN), Protease activity and Siderophores production. Out of these isolates ten strains were selected for different biochemical tests and evaluated their effect on different growth parameters of Canola cv (PARC Canola Hybrid). All of the isolates except strain D-ER-C-7 and D-RS-C-6 showed significant quantity of Indole acetic acid (IAA) ranging from 11.767  $\mu\text{g mL}^{-1}$ -28.233  $\mu\text{g mL}^{-1}$ . Out of ten isolates, four isolates E-ERS-C-7, F-RP-C-1, I-RS-C-5 and I-RS-C-5 were confirmed as PSB on the basis of halo zone formation in Pikovskaya agar medium as well as solubilization index. Among the ten isolates eight strains were proficient to produce HCN with the exception of D-ER-C-7 and G-RS-C-4. Among these strains with the exclusion of three isolates H-RS-C-3, I-RS-C-5 and C-RS-C-5, all strains showed positive results for siderophore production. Isolates D-ER-C-7, I-RS-C-3, C-RS-C-5, E-ERS-C-7 and G-RS-C-4 showed protease activity. Pot experiments in axenic condition and green house was conducted in a complete randomized design (RCD) with three replicates. Our results confirmed statistically that the isolated strains significantly increased growth of Canola cv as compared to un-inoculated or control.

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**Impact of Resource Conservation Technologies on the Productivity of Rice-wheat Systems**

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Conservation rice-wheat systems offers an ecofriendly option to reduce water, labour, and energy input, and improve soil health. This study was conducted to evaluate the the impact of sesbania brown manuring (SBM) in direct seeded aerobic rice (DSAR), and rice residue mulch (RM) in zero tilled wheat (ZTW) on soil health and system productivity. The experiment was conducted at Agronomic research area, University of Agriculture, Faisalabad and comprised of five RWCSs viz. (i) DSAR-ZTW, (ii) DSAR+SBM-ZTW, (iii) DSAR-ZTW+RM, (iv) puddled transplanted flooded rice (PudTR)-ZTW, and (v) PudTRplough tilled wheat (PTW). At rice harvest, minimum soil bulk density, highest total nitrogen (N), soil organic carbon (SOC) and soil microbial biomass carbon (SMBC) were recorded with DSAR+SBM-ZTW, which eventually improved the grain yield, water productivity and profitability of DSAR in this RWCS. At wheat harvest, highest total N, SOC, and SMBC were recorded with DSARZTW+RM, followed by DSAR+SBM-ZTW, which eventually led toward better wheat grain yield and profitability and improved system productivity in these RWCSs. The 2nd experiment was conducted for 2-years at two experimental sites (Nankana Sahib, Sheikhpura). During both years, rice was grown both as DSAR and PudTR; followed by PTW and ZTW after each rice production system at both sites. Overall, higher total N, SOC, SMBC, and SMBN were recorded in DSAR than PudTR, and DSAR yielded similar as the PudTR. Thus resource conservation technologies are recommended to sustain the yields in rice-wheat system with positive impact on soil health.

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**Foliar Application of Biostimulants Increased Growth and Yield of Vegetable Pea**

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Sustainability demands modern agriculture to be diverse, eco-friendly, economically viable and to be less dependent on synthetic inputs without compromising yield and quality. The use of biostimulants is becoming a common practice in modern agriculture, to lower cost of production and to enhance nutrient use efficiencies. In a field trial we tested, five biostimulants viz Raan (150 g/100 L), Seamax (300-500 mL/100 L), Megafol (200-250 MI /100 L), Rely (400 mL/100 L) , Moddus (250 mL/150 L) for two years with RCBD layout at Vegetable Research Institute, Faisalabad. Substantial positive effects of biostimulants were observed on shoot length, biomass, number of pods plant<sup>-1</sup>, 100 grain weight and green pod yield of vegetable pea. Maximum green pod yield i.e 8173 kg ha<sup>-1</sup>, shoot length 83 cm, 42 g 100 grain weight were observed with Seamax followed by Raan, Megafol, Rely, Moddus as compared to control (6587 kg ha<sup>-1</sup>, 58 cm, 30 g respectively). Hence, significant beneficial effect of all biostimulants used on plant growth were observed. The results presented above exemplify the promise and complexity of research involving biostimulants.

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**What Agricultural Technologies to Opt Meet Feeding Nine Billion Till 2050?**

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World has just touched on the harsh reality of food security and sustainability for issues facing global agriculture, global climate change, agri-water issues, rising populations and we know that future generations are going to be the ones that really suffer. Today we go into a grocery store and buy everything we desire – yet every 3.6 seconds someone dies of hunger. Its extremely important to share global vision and join for the quest to change agricultural technologies as for today 2016 with much of our world in a food security crisis, awash in toxic synthetic inputs and dwindling yields of genetically modified food, leading edge of hybrid agricultural inputs, to enter the future with actions which tackles all of these issues to the global market and ready to meet the demand. The sustainable advances and innovations in agricultural technologies have become much more complex and intricate and certain steps could lead the farming industry towards 2050, as next generation farms have to put science and technology to work to deliver a step change in yields, growing more from less. The simulated models to make informed choices based on current conditions of soil fertility, planting time, weather and moisture, variety response and historical data of a particular ecological belt have to be made available to the farmer rather than guesswork. Advanced technology based on exact numbers can only function properly if they are translated to help farmers to understand and control what's happening on their farm in real-time. The crop-needs-time-graph sensors will assure timely applications of inputs. The automation works together with math and sensors to make sure planting, inputs application, harvesting and other tasks are completed with as much precision as possible with less waste. Development of plants meant to thrive in high densities will help deliver a change in yield per acre as higher productivity is not luxury, its necessity now.

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**Comparative Performance of Chickpea (*Cicer arietinum* L.) Genotypes under Drought Conditions**

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Pakistan is located in semi-arid to arid region where scarcity water is a big problem which cause low average yield. Furthermore, the sudden rain and prolong drought period because of climate shift make the environment unfavorable to get desired yield even in irrigated areas. A field experiment with two sets, each was consist of 25 genotypes with three replication was carried out during Rabi 2015-16 in stress and non- stress conditions. The objective of the reported research was to study the response of chick pea genotypes in drought stress and to screen the appropriate genotype performing better in water deficit and irrigated conditions. Three genotype PGP-1426, GGP-1260 and PB-01 exhibited best drought tolerance efficiency (84.21, 83.78 and 81.57%), good harvest index (84.06, 83.23 and 81.14%) and minimum reduction in seed yield (15.78, 16.21 and 18.42%) in stress environment. With better yield susceptibility, these genotypes would be recommended as drought tolerant under stress environment.

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**Effect of Foliar Applied Nitrogen on Growth and Yield of Hybrid Maize (*Zea mays* L.)**

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In Pakistan due to constant rise in population, it is of dire need to improve the productivity of cereal crops in the country to meet the dietary requirements of the rising population. Plant nutrition has a key role in improving the productivity of a crop. Nitrogen is the key component in plant nutrition. Soil application of the nitrogen is practiced commonly but it is quite inefficient due to volatilization and leaching losses. This experiment was conducted to check out the impact of different doses of foliar applied nitrogen on growth, yield and economic attributes of maize. The experiment consisted of six treatments viz., T0: NPK 225:115:125 kg ha<sup>-1</sup>, T1: Water spray + basal dose of NPK 75:115:125 kg ha<sup>-1</sup>, T2: Foliar application of 2% nitrogen + basal dose of NPK 75:115:125 kg ha<sup>-1</sup>, T3: Foliar application of 4% nitrogen + basal dose of NPK 75:115:125 kg ha<sup>-1</sup>, T4: Foliar application of 2% nitrogen + basal dose of PK 115:125 kg ha<sup>-1</sup>, T5: Foliar application of 4% nitrogen + basal dose of PK 115:125 kg ha<sup>-1</sup> and each treatment was replicated three times. The statistical analysis showed that best results of growth and yield attributes comes under foliar application of 2% nitrogen + basal dose of NPK 75:115:125 kg ha<sup>-1</sup>. So finally we conclude that 2% nitrogen along with basal dose of NPK can be helpful in improving the growth and yield of hybrid maize (*Zea mays* L.).

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**Strategies for Sustainable Citrus Production in Pakistan**

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Citrus is one of the most important fruit in the global market including Pakistan. World area under citrus is more than 7.60 million hectares with total annual production of 105.4 MMT. Pakistan stands at 11th and 13th position in citrus with approximately 5 lac area and more than 2 million tonnes production, in the world. The average yield per acre in Pakistan is far less than real potential merely 11 tonnes/ha as compared to higher yielding countries average 30 tonnes/ha. The main reasons attributed to this low productivity are poor nursery plants, low and imbalance use of plant nutrients, intercropping, over and inappropriate irrigations, improper soil conditions, poor plant protection measures, traditional supply chain, poor marketing system. There is huge loss from field to fork due to non-adoption of modern techniques. These major problems are the main obstacle in higher yields and quality production and citrus industry is in stagnant conditions. Efforts have been made by Department of Agriculture with collaboration of extension and research wings through different interventions. Practical demonstrations of different management techniques like balanced plant nutrition, cultural practices including pruning and canopy management, judicious and proper use of chemicals against insect, pests and diseases have been made at growers' orchards. Lack of knowledge of modern techniques among common farmers community is another barrier in citrus quality production. A complete package of technology is available in prevailing resources in Pakistan to enhance production and quality of citrus.

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**Desiccator Technology for Crops stubble Management for Sustainable Agriculture**

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Crop residues are the different parts of the plants (roots, shoots, grain, tubers, etc) left in the soil when crop is harvested. In Pakistan, 40 billion tons stubbles are produced annually, share by cereal crops is 75% and 25% by others crops. Crop stubbles sometimes have been used as wastes but they require retention for disposal. Most of the farmers get rid from this precious source of soil organic matter and nutrients by burning (82%), used as fodder (7%), composting (5%), cooking fuels (2%), soil incorporation (1%) and other different uses (2%). Burning of fields after crops harvesting is very common practice which poses threats i.e. polluting the surrounding area (smog), nutrients losses, destruction of soil structure, killing of valuable microbes, and most important losses of precious organic matter. Farmers have no other option except for burning because incorporation of these crops residues break implements used for the incorporation of crop stubbles. Proper management of crop residues may improve soil organic matter level that in turn improves fertility and productivity of the soil. A field experiment was conducted at Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad provided heartening outcome on use of 'desiccator' to dry and brittle residues within days and then ploughed under the residues, followed by urea, molasses and bacteria application for quick decomposition of residues and converting into compost of wheat residues in the soil. Residual effect this treatment was tested on succeeding maize crops. The results revealed improvement in soil physicochemical properties and maize growth parameters as 44% in plant height, 36% in cob length and 31% in grain yield over burning treatment. Overall results suggested that application of desiccator in combination with urea, molasses and bacteria can properly manage wheat residues to enhance quality and health of soil for next crop.

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**Nutritional and Medicinal Composition of Sun Mushroom (*Agaricus sylvaticus*)**  
**Anam Zahid<sup>1\*</sup>, Muhammad Muzammil Jahangir<sup>1</sup>, Hassan Munir<sup>2</sup>, Fozia<sup>1</sup>, Muhammad Saeed Ahmed<sup>1</sup> and Asif Ali Khan<sup>1</sup>**

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*Agaricus sylvaticus* fungus are most familiar with the name of Sun Mushroom. *Agaricus sylvaticus* fungi, belongs to the family Agaricaceae, are used in dietary plan of patients. Edible mushroom contains abundant amount of protein, lipids, carbohydrates, dietary fiber, minerals, fat soluble vitamins and Vitamin C. In edible mushroom (*A. sylvaticus*) consists of different minerals of calcium, magnesium, sodium, potassium, zinc, cobalt, manganese etc. Sun mushroom contains high biological value and presents all the essential amino acids. It consists of higher values of moisture content (6.31%), lipids (6.60%) and protein (41.16%). Sun mushroom consists antioxidants, phenolic compounds such as phenolic acids, flavonoids and tocopherols. It is useful against different diseases like diabetes, atherosclerosis, hepatitis, hypercholesterolemia, cardiovascular diseases.

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**Nutritional and Medicinal Composition of Bitter gourd**  
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Bitter gourd (*Momordica charantia*) is an important medicinal plant; it belongs to Cucurbitaceae family. It is also known by the names of bitter apple, balsam pear, bitter melon and wild cucumber. Bitter gourd is one of the most important vegetable in Pakistan and in some other countries such as Bangladesh, Taiwan, China, Vietnam, Malaysia, Thailand and India. In bitter gourd fruit bitterness is due to the presence of three pentacyclic triterpenes momordicinin, momordicin and momordicilin. Bitter gourd contains moisture (93.20%), ash (7.36%), lipids (6.11%), fiber (13.60%), protein (27.88%), Carbohydrates (34.31%), Energy (241.66 kcal/100 g). It consists of Calcium, Sodium, Potassium, Iron, Manganese, Copper, Phosphorus and vitamin C. It is helpful for different diseases such as inflammatory, leukemic, diabetic, mutagenic, mycobacterial, microbial, tumor, ulcer, aphrodisiac, viral, astringent, carminative, cytotoxic, hormonal, depurative, hypo-tensive, , immune-stimulant.

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**Institutional Efforts in Capacity Building of Farmers for Utilization of Resources in Sustainable Way**

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Being an agricultural country, Pakistan's economy mainly depends on agriculture. Agriculture shared its contribution of 19.3% in GDP during 2015 which was 21.4% in previous year showing a steady decline due to some external and internal factors. The important reason behind the situation is excessive utilization of resources in a non-sustainable manner which increased population rate. Proper policy design by public administration is lacking pertinent to felt and unfelt needs of farmers. Developed countries have focused on sustainability in utilization of renewable resources. These countries utilize their assets according to their felt needs in sustainable manner. For sustainable agriculture in Pakistan, the agricultural institutions should be updated according to modern techniques and changing environment. The study was conducted in cotton growing areas of the Punjab-Pakistan. A large majority (75.3%) of the respondents unveiled that private sector helps them when they are willing to use their products while they are ignored if unwilling to use their products. Public and private organizations have to re-design their due role for sustainability of agriculture in terms of education and motivation of the farming community for food security. Currently extension organizations are not focusing on sustainable utilization of the natural resource for crop and animal production. The private sector focuses in the capacity building of those farmers who use their products while public sector helps the farmers in increasing their agricultural production without their self interest. There is dire need of legislation for private sector to limit their role in agricultural production because insecticide and pesticides use pose a threat to sustainable agriculture.

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**Effect of Gypsum and Seed Priming for Sustainable Productivity of Rice-Wheat under Saline-Sodic Field**

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Scarcity of fresh water coupled with escalating food demand due to unrestricted increase in population has provoked the farmers to use low quality underground water. This alternate irrigation source has globally alarmed the risk of salinity-sodicity problems. An increased concentration of salts in soil solution restricts water availability along with specific ion toxicity which affects physiological and metabolic process of plants and thus reduces ultimate yields. In order to obtain sustainable crop yields of wheat and rice from these soils, pre-sowing seed treatments along with gypsum application can be an efficient strategy under dynamic field conditions. A field experiment was conducted at Proka Farm-II, University of Agriculture Faisalabad on a saline-sodic soil with treatments as control, T1 (farmer practice), hydro-priming for 24 h + application of gypsum @ 50% SGR (T2), Priming with 1% KCl solution + 50% SGR (T3) and Priming with 5% gypsum solution (saturated) + 50% SGR (T4). At wheat harvest maximum straw yield ( $5.76 \text{ t ha}^{-1}$ ) was recorded with T1 and maximum grains yield ( $4.08 \text{ t ha}^{-1}$ ) was recorded with T2 while maximum straw ( $6.48 \text{ t ha}^{-1}$ ) and paddy yields ( $1.80 \text{ t ha}^{-1}$ ) of rice were obtained with T4. Post-wheat soil analysis showed that at 0-15 cm, maximum decrease in E<sub>Ce</sub> (53.90%) was recorded with T4 followed by T1>T3>T2, while maximum percent decrease in SAR (77.91%) was resulted with T3 followed by T2>T4>T1. Post-rice soil analysis revealed that at 0-15 cm, lowest E<sub>Ce</sub> was observed with T4 (83.165) followed by T1, T3 and T2 respectively, while maximum percent decrease in SAR (87.30%) was obtained with T2 followed by T4, T3 and T1 respectively. Economic analysis of applied treatments showed that maximum net income for wheat (Rs. 86968) and rice (Rs. 32388) was obtained with T2 and T4 respectively. Consequently, application of gypsum (50% SGR) along with gypsum solution and hydro priming improved yield of both crops and reclamation efficiency of saline-sodic soil.



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**Organic and Modern Foods: Critical Analysis**

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The purpose of this presentation is sensitization of the academia and stakeholders about the concepts, perceptions and statistics of organic and modern (*inorganic*) foods. Food is any nutritious substance that people or animals eat or drink or plants absorb in order to maintain their life and growth. It is usually of plant or animal origin, and contains essential nutrients, such as fats, proteins, vitamins, or minerals. The substance is ingested by an organism and assimilated by the organism's cells to provide energy, maintain life, or stimulate growth. Organic food is the product of traditional farming (based on natural agroecosystems) without modern interventions in the form of using synthetic fertilizers, insecticides, pesticides, etc. Modern foods are the products of inorganic methods/farming introduced after the industrial revolution to cope with the increasing food demands and human population. Soon after introduction of modern/inorganic agricultural practices, however, an organic movement began in the 1940s as a reaction to agriculture's growing reliance on synthetic fertilizers/pesticides and associated serious side effects. By and large, topic of organic and inorganic agriculture is controversial in view of compulsive compromise on the wholesomeness and quality of food to meet the food demands of increasing human population in the 21st century. This presentation reviews the historical timelines of the organic and modern foods, the current statistics of the organic agriculture, the socio-economic aspects, status of organic standards (*legislation*) and future of organic farming in Pakistan in the backdrop of concepts of *one-health* and *projected food demands* in the 21st century.



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**Impact of Saline Irrigation Water on Growth of Sunflower Plant and Soil Health**  
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Sunflower is a short duration crop. Pakistan is producing only one third of its edible oil requirements and the rest is fulfilled through imports. Salinity is a major abiotic stress that limits plant growth and development. Sunflower growth is badly affected by high salt concentrations as it has various adverse effects on plant growth including osmotic stress. Therefore a research study was conducted at University College of Agriculture, University of Sargodha to evaluate the possible effects of brackish water on germination, growth and yield of sunflower using different ratios of canal and brackish water. Soil basic analysis (EC, pH, SAR and ESP) was carried out. 8 Kg sieved soil was filled in each pot. Hysun-33 ICI variety of sunflower was sown in pots. Recommended basal dose of NPK as Urea, SSP and SOP was applied. Canal and brackish water ratio was as followed; T1 (1:0), T2 (3:1), T3 (2:1), T4 (1:1), T5 (1:2), T6 (1:3) and T7 (0:1). Experiment was design according to CRD with three replications. Crop was harvested after 45 days of germination. It was found that EC, pH, SAR and ESP of soil was gradually increased with increasing brackish water ratio. Maximum and minimum water uptake by crop was found in T1 and T7 respectively. Likewise maximum plant height was obtained in T1 where only canal water was applied and minimum was in T7 where only brackish water was applied. Similar pattern was observed with stem girth, fresh and dry weight of root and shoot. Results confirmed that increased level of salinity adversely affect the yield of sunflower as well as soil health.

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**Relative Effect of Plant Growth Promoting Rhizobacteria (PGPR) on Yield of Lentil  
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Plant Growth Promoting Rhizobacteria (PGPR) are free living or associative with plant roots and improves the plant growth by releasing plant hormones or by producing plant hormones from its precursor. Inoculation of PGPR is beneficial for plant growth directly by improving the plant hormones level or indirectly by acting as a bio control agent by preventing diseases and reducing the pathogens attack. The pot experiment was conducted in the research area of University College of Agriculture, University of Sargodha, to evaluate the relative effects of Plant Growth Promoting Rhizobacteria (PGPR) on yield and nutrient uptake efficiency of Lentil (*Lens culinaris L.*) crop under saline conditions. Different two strains of PGPR (P5 & P10) was inoculated in the plants individually and in combination. This experiment was consisted of four treatments T1; Control, T2; *Pseudomonas fragi*, T3; *Pseudomonas jessenii*, T4; Combination of *Pseudomonas fragi* and *Pseudomonas jessenii* with three replications. All the pots were filled with 5 Kg soil and arranged according to Completely Randomize Design (CRD). All these treatments were applied and seed were inoculated. Crop was harvested on maturity and collected from every pot. Plant yield attributing parameters viz. root and shoot length, fresh and dry weight of plant, grain yield were measured. Results showed that the maximum yield was obtained in case of T4 as compared to other. Growth characteristics as root and shoot length, fresh and dry weight under T4 were even higher. PGPR also increased the number of pods per plant, dry matter yield and grain yield by 40%, 23% and 27%, respectively, as compared to control.

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Hirsutization of Asiatic Cotton (*Gossypium arboreum* L) for Insect Pests Complex  
Morphological, Agronomic and Quality Traits

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For developing better quality and high yielding cotton varieties, screening and identification of better quality cotton germplasm is necessary. This objective of this research was to examine the variability and potential of cotton germplasm regarding yield and fiber technological properties for future contribution in plant improvement efforts. One hundred and twenty nine varieties/accessions with 3 check varieties were studied for agronomic and fiber quality descriptors. Because large number of entities, Augmented Design (AD) was used with six replications. Cluster, principle components (PC) and correlation analysis were employed to obtain suitable parents that can be further exploited in a breeding programme. All the parameters manifested highly significant correlation with seed cotton yield except fibre traits highly significant correlation ( $r=0.929^{**}$ ) was observed between seed cotton yield and Symphodia. . It was observed that boll weight showed significant contribution towards fibre fineness with highly significant value ( $r=0.230$ ). The findings of present study lead towards the improvement in the yield and fibre quality in Arboreum cotton and selected genotypes can be utilized for selecting genes involved in quality traits in Arboreum cotton.

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**Drought induced Biochemical and Growth Adaptations in Cotton Cultivars**  
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Scarcity of water severely affects the cotton cultivation all over the world especially in arid and semi-arid regions. Development of high yielding and drought tolerant cotton varieties are necessary to fulfill demands of ever growing population of the world. Utilization of physiological and biochemical traits are being used to identify the drought tolerant cotton germplasm and to understand the mechanism and genetic variability in genotypes. In the present study, cotton (*Gossypium hirsutum* L.) germplasm was evaluated under two irrigation regimes i.e., well watered and limited water conditions. Before physiological maturity, cotton leaves were collected and analyzed for Chlorophyll contents soluble sugars and proline accumulation. At maturity, data regarding yield and yield parameters were recorded. Significant reduction in yield parameters was observed under W2 condition in all the tested genotypes except soluble sugars and proline accumulation which significantly increased due to drought stress. The cotton genotypes which maintained higher yield had positive correlations with biochemical traits. The results showed that genotypes that adapted drought stress biochemically produced higher yield which confirmed that biochemical alternations in genotypes were regulated genetically and as well as environmentally in these genotypes. The findings of present study further suggested that biochemical adaptations can be used to screen cotton germplasm for drought tolerance and developing high yielding drought tolerant cotton varieties.



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**CROP PROTECTION**



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**Monitoring of Insecticide Resistance in *Amrasca devastans* (Dist.) to New Chemical  
Insecticides in Punjab, Pakistan**

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*Amrasca devastans* (Dist.) is an economically important pest of solanaceous and malvaceous crops like Cotton, okra and brinjal with a potential of developing resistance against most chemical insecticides. Four different populations were collected from four different locations of Punjab, Pakistan (Multan, Khanewal, Muzafargarh and Lodhran) and tested for monitoring the resistance against six new chemical insecticides by leaf dip method. After comparison with lab susceptible population the resistance ratio level were in range of tolerance to moderate level of resistance for imidacloprid, moderate to high resistance for spirotetrament, moderate to very high, for nitenpyram, tolerance to very high for acetamiprid, tolerance to moderate for chlorfenapyr and no resistance to tolerance for fipronil. Current monitoring study suggest us to follow regular insecticide resistance monitoring, rotation of insecticides with different mode of action based on action threshold and economically, socially and environmental friendly use of insecticides with optimum rate of application. These methods are required to delay resistance development in *A. devastans*, for minimizing injudicious use of insecticides and also to save other living organism like natural enemies.

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**Bioactivity of Venom of *Aenasius bambawalei* (Hayat) (Hymenoptera: Encyrtidae) against Cotton Mealybug**

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*Aenasius bambawalei* (Hayat) (Hymenoptera: Encyrtidae) is a nymphal endoparasitic wasp of cotton mealybug, *Phenacoccus Solenopsis* (Tinsley) (Hemiptera: Pseudococcidae). The present study was conducted to check the bioactivity of venom of the wasp was performed by artificial microinjections of both crude and treated venom (heat and proteinase) of the wasp containing 0.3 and 0.5 ul in non-parasitized and synchronized 3rd instar hosts (mealybugs). The mortality data was recorded after 24, 48, 72 and 96 hours exposure periods while mealybugs receiving saline injections were acted as control. The main effects for artificially envenomated mealybugs were observed for their mortality and survival. The biological activity of crude venom was also evaluated by heat and protease treatment. Here, we demonstrate that maximum mortality (84±1.69%) was achieved by microinjections containing higher volume (0.5µl) of crude venom followed by minimum mortality (71±4.0%) was achieved with lowest volume of venom (0.3ul) while in control treatment mortality was only (9.0±1.22%) after 96 hour exposure period. Results also showed that mortality increases with the increase in volume of crude venom and exposure period. On the other hand heat and proteinase treated venom did not show any significant mortality of the host insect. Our findings suggest that bioactive components of the crude venom are proteins which lost their activity upon heat and protease treatment that's why treated venom (Heat and Proteinase) did not show any significant mortality. This basic information regarding biological activity of the venom of *A. bambawalei* is very useful for the successful management of cotton mealybug (host) as well as in host regulation process.

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**Effect of Allelopathic Bacteria on Growth, Yield and Suppression of Rice Associated Weeds: A step towards Sustainable agriculture**

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Weeds are those pests that cause huge losses due to their intervention in agroecosystems. Due to herbicidal impacts on human health and on environment over all the efforts are made to reduce the heavy dependence on chemical weedicides that are used to control weeds in the field. In this favor the process of biological weed control is beneficial in an ecosystem with the purpose of controlling one or more kinds of weeds. Non-pathogenic allelopathic bacteria which release phytotoxins in the rhizosphere of certain weeds and suppress their growth (called allelopathic bacteria) were isolated and characterized from the rhizosphere of rice and its associated weeds. The bioherbicidal activities of competent strains (which suppress one or more weeds with no harmful effects on rice) were selected. Pot trial was conducted on rice and associated weeds (*Cyperus rotundus* and *Echinochloa colonum*) by applying strains T42, T70 and T19 and their consortium. The data collected from pot trial showed that all the bacterial strains performed better as compared to control. Inoculation with T42 maximum increased the fresh biomass, root weight, root length, spikelet length, and grain yield of rice about 48.06, 52.49, 42.54, 15, 63.65% respectively. Similarly, bacteria also reduced the plant biomass, root weight, root length and number of tillers of weeds upto 47.54, 36.90, 41.25 and 29.87% as compared to their respective uninoculated control. Allelopathic bacteria also improve physiological parameters in rice and reduced the in case of weeds. My results declared that no harmful effects of bacteria were observed on growth of rice over weed free conditions.

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**Occurrence, Manifestation and Impact of Various Management Practices on Downy  
Mildew of Cucurbits in High Tunnels**

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Downy mildew of cucumber caused by *Pseudoperonospora cubensis* is serious problem for tunnel farming in Pakistan. In current study, disease incidence was recorded from nine high tunnel farms at different locations of District Vehari. The disease occurrence was correlated with different farm management practices. Our results revealed that downy mildew incidence was 24-80% in the tunnels and it was dependent on time of sowing, crop varieties and fungicides used. Sowing of crop on 15 November showed significant results in disease reduction. The diseases was more sever at flowering stage. Among fungicides, Antracol and Cabrio Top produced the best results against the disease. Farms having less disease incidence showed 8-15 % higher crop production. Good farm management practices are highly effective in disease reduction.

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Pathogenesis of Chickpea Wilt due to *Fusarium oxysporum* F. SP. *Ciceri* Muhammad

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Pathogenesis study of *Fusarium oxysporum* f. sp. *ciceri* was made to correlate epidemiological factors with chickpea wilt. It was observed that seedling mortality increased with an increase in inoculum load, at the inoculum load of 3 g, seedling mortality was minimum and at 20 g it was maximum. Similarly, when *Fusarium* wilt was observed in different types of soils, it was found that the disease developed sever in sandy soil and least in clay soil. Soil moisture also played an important role in disease development. It was observed that seedling mortality was maximum (91%) when the soil moisture level was low (16.2%) and minimum (0.00%) when it was high (35.67%) Studies of disease development on sap extract of leaves and roots showed maximum growth of *F. oxysporum* f. sp. *ciceri* on root sap then leaves. Colony growth of *F. oxysporum* f. sp. *ciceri* was 3.2 to 5.9 cm at leaves sap and was 3 to 9 cm on root sap.

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**Circular Molecules of Diverse Origins Associated with Cotton Leaf Curl Disease**  
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Many economically important crops are prone to geminiviruses infection. Insect transmitted geminiviruses have circular, single-stranded DNA genomes among which the whitefly transmitted genus Begomovirus includes the viruses of most economic significance. In this study it has been observed that diverse circular molecules are amplified upon cotton leaf curl begomovirus infection. Amplified molecules included the usual viral components found in infected plants, but in addition to this certain molecules of non-viral origin were also detected. Different circular molecules are known to occur in plants. These include plant viruses, plasmid like molecules of chloroplast and mitochondrial origin, helitrons, repetitive sequences etc. Although plant DNA viruses have been extensively studied, their origin, diversity and exact mechanism for induction of circular molecules have not been investigated thoroughly. Phi29 DNA polymerase that amplifies circular DNA molecules was used to amplify these molecules found in infected plants. Among amplified molecules, the prominent ones were plasmid like molecules of chloroplast origin, transposons and sequences of cotton origin. Some molecules were recombinants of known and unknown DNA sequences. Further these molecules are amplified upon viral infection only as these could not be detected in the samples taken from healthy plants. The role and importance of these molecules with respect to leaf curl disease is still to be investigated.

Computational Analysis of Family of Resistance Genes from Chickpea against *Fusarium oxysporum*

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Chickpea (*Cicer arietinum*) is the second best commonly grown legume crop. Resistance genes are also known as R-genes are present in most of the plant genomes. These R genes confer resistance to plant diseases against specific pathogens by producing R proteins. Resistance genes give resistance to plants against specific pathogen and also show a high level of similarity on DNA and proteins structure among different plant species. In this study, *in silico* characterization of R genes from chickpea was done by using different bioinformatics tools. A comprehensive genome wide analysis of R genes and proteins was done including gene structure analysis, multiple sequence alignment, chromosomal localization and phylogenetic analysis of these resistance genes, was carried out to determine the functional homology in chickpea. The results of these analyses revealed high level of motifs and introns conservation in the proteins and genome DNA of most of the genes in the family. Different numbers of genes were found on different chromosomes on chickpea. Moreover, we also performed computational analysis of expression for R gene family in response to *Fusarium oxysporum*, the causal organism of Fusarium wilt in chickpea. On the basis of *in silico* characterization resistant and susceptible genes against Fusarium wilt was selected and these selected genes were amplified having nucleotide binding site and leucine rich repeats domain (NBSLRR-type RGAs) from chickpea genome. The results concluded that the patterns of R genes and proteins are conserved in different classes of R genes. Similarly it was concluded that a few R genes are upregulated in response to *Fusarium oxysporum* infection in chickpea.

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FEEDING 9 BILLION THROUGH SUSTAINABLE AGRICULTURE

Comparison of Various Weed Control Measures in Weed Dynamics and Profitability of  
Direct Seeded Fine Rice

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Water and labour scarcity pushes researchers to explore alternate sowing methods for rice like direct seeded aerobic rice, the most conservational and economical but weed infestation is the major hindrance to adapt this production system. In our study, mechanical, chemical and cultural approaches were employed as weed control measures. Weed dynamics and yield parameters were recorded and economic analysis was performed. The results revealed that all the weed control options significantly reduced the total weed density and total dry weight over control and improved harvest index. Highest reduction in total weed density (90.72%) and total weed dry weight (73.61%) was achieved by hoeing followed by post emergence application of Penoxsulam. The order of treatment groups in decreasing total density, total weed dry matter production and increment in harvest index was as cultural < chemical < mechanical. However, substantially highest net returns (Rs. 44,049/-) and benefit cost ratio (BCR) (1.53) of Penoxsulam followed by hoeing with hoe with net returns of Rs. 42,271/- and BCR 1.47. Interculture, mulching technique and sesbania intercropping scored 1.19, 1.13 and 1.21 BCR, respectively. Thus, hoeing with hoe (25 and 45 DAS) and post emergence application of Penoxsulam were most effective, economical and highly beneficial weed control options.

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**Plant Derived Smoke: A Potentail Pesticide Alleviator**

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Use of pesticides has resulted to increase agricultural production worldwide but some persistent pesticide residues have great potential of adverse impact on the environment and human health. Application of pesticides in modern agriculture has boosted farm productivity. Plant derived smoke solution is widely known for its promotry effects on plant growth. In this study, effect of pesticides (Lamdacyhalothrin) concentrations (30, 60, 120 and 240 ppm) were find on maize plant growth and alleviation of inhibitory effects of pesticide with the help of plant derived smoke solution. It was observed that inhibitory effects of *Lamdacyhalothrinon* maize seed germination, seedling length, seedling mass and pigmentation were concentration dependent and increased with the increase of concentrations (30, 60, 120 and 240ppm).It was found that seed germination percentage was 23 % in control, 36 % in snoise dilution, 13, 6, 6 and 0 (%) in 30, 60, 120 and 240 ppm respectively after 24h. Alleviation solutions of smoke and pesticidesignificantly reduced the inhibitory effects of Lamdacyhalothrinon seed germination, seedling length, seedling mass and pigmentation. It might beconcluded that smoke dilution might block the way of pesticides uptake or stop the channels of pesticides absorption.

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**Physiological and Biochemical Responses of Maize to Plant Derived Smoke Solution**  
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The ability of plant-derived smoke as a plant growth regulator is well known. Smoke solution has positively affects plant growth and developmental processes. This study highlights the presoaking effects of smoke solution on physiological and biochemical growth of maize. Maize seeds were presoaked in control, concentrated and 500 times diluted smoke solution (1:500) for 0, 6, 12 and 18h. Faster seed germination and improved seedling length and mass were observed in seeds presoaked for 6, 12h and 18h in smoke dilution. Similar effects were found on seedling length and biomass of maize seedling treated with smoke dilution as compare to control. Amount of chlorophyll pigments (*a* and *b*) and total carotenoids were significantly increased in maize seeds presoaked for 6, 12, and 18h seed. Total soluble proteins were increased in seedling treated with smoke dilution (1:500). Inhibitory effects of concentrated smoke solution on physiological and biochemical maize growth parameters were increased with the increase of presoaking hours. It is concluded that plant derived smoke solutions have positive effects on plant physiological and biochemical growth parameters. The results also suggest that smoke solution has the potential to be used in agriculture because it is economical and environment friendly.

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Identification of Guava Fruit Volatiles for the Management of Peach Fruit Fly, *Bactrocera zonata* Saunders

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Peach fruit fly, *Bactrocera zonata* (Diptera: Tephritidae) is a polyphagous insect pest of various fruits. Present study was conducted to identify the volatiles emitted from guava fruits that may have any significant role in attraction, oviposition behaviors and further on fitness parameters of *B. zonata*. Choice experiment of *B. zonata* on 3 uninfested and fruit fly infested guava varieties, Gola, Larkana large surahi (LLS) and Larkana small surahi (LSS) was done through two arm Y-tube olfactometer to examine the attraction towards potential ovipositional host. Significantly,  $***P < 0.001$  and  $*P < 0.05$ , more female flies were attracted towards uninfested and infested fruits compared to the control (blank). Fresh Gola vs LSS was found more attractant ( $*P < 0.05$ ) as compared to all other in Y-tube olfaction experiment. Head space samples collected from fruits of three guava varieties were analyzed by gas chromatography- mass spectrometry (GC-MS). Moreover, oviposition behavior and fitness parameters were examined in cage experiment to observe the oviposition preferences. Among oviposition behavior parameters: number of fly visits on fruit, number of successful oviposition attempts and time spent by individual flies in choice and no choice experiment were recorded. Numbers of visits on Gola compared to LSS were significant as compared to all other varieties. Interestingly, no significant difference of fitness parameters of *B. zonata* was observed on experimental varieties. The result suggested that attraction of *B. zonata* to different guava varieties is highly associated with volatile but oviposition and fitness parameters are not significantly influenced by the volatiles. These findings confirm that the identified aldehyde compounds of kairomonal characteristic from guava fruit have an impact to attract this quarantine pest.

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**Weed Dynamics and Productivity of Wheat as affected by Allelopathic Crop Residue  
Mulches and Nitrogen Sources**

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Weeds pose serious threat to wheat productivity. Use of allelopathy in recent years has emerged as a pragmatic approach for sustainable weed management. Returning of allelopathic crop residues as mulches to soil may be one of the best management strategy to manage weeds and sustain the productivity on long term basis. This study was conducted to investigate the influence of mulches of residues of different crops known for having allelopathic potential under different nitrogen sources. The experiment consisted of four mulches viz. plastic mulch, wheat straw mulch, rice residues mulch, sorghum residues mulch, each applied at 4 tons/ha, and three nitrogen (N) sources viz. urea, calcium ammonium nitrate, ammonium sulphate, applied at 125 kg/ha. Results indicated that, maximum suppression in weeds density and dry biomass was observed with plastic mulch. Amongst the allelopathic mulches, maximum suppression in broad leaved and narrow leaved weed density and dry biomass was observed with wheat mulch followed by sorghum than control. Moreover, maximum reduction in total weed density and dry biomass was observed with wheat mulch over control followed by sorghum and rice mulch. Maximum improvement in grain yield was observed with sorghum. Nitrogen sources also affected grain yield significantly. Maximum yield improvement was observed when calcium ammonium nitrate was applied. We observed a strong negative correlation of grain yield and water soluble phenolics with the density and dry biomass of weeds. In crux, the use of allelopathic crop residue mulches in combination with the mineral nitrogen fertilizer might be a pragmatic option to control weeds and improve the wheat productivity.

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Host Assessment of Various Ornamentals in Response to *Meloidogyne incognita* and its  
Management through Endophytic Bacteria

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The economic significance of ornamentals has been growing in numerous countries, and worldwide demand has quickly increased. Different species of nematodes including root knot nematode, *Meloidogyne* spp. affect ornamental plants. In this experiment, 10 ornamental plant species including *Ophiopogon japonicas*, *Ficus benjamina*, *Cordyline fruticose*, *Ficus elastica*, *Hibiscus syriacus*, *Rhapis excelsa*, *Artemisia stelleriana*, *Murraya paniculata*, *Carissa macrocarpa* and *Duranta repens* were assessed against the attack of root knot nematode *Meloidogyne incognita*. The results revealed that *Ficus elastica*, *Artemisia stelleriana* and *Duranta repens* were recorded with maximum number of root galls, egg masses, number of females, number of egg masses, number of juveniles and minimum canopy area, dry root weight, fresh root weight, roots length, fresh shoot weight, dry shoot weight and shoot height, these were found highly susceptible varieties against the attack of *Meloidogyne incognita*. *Murraya paniculata* and *Ficus Benjamina* were observed with susceptible response against the of *Meloidogyne incognita*. *Cordyline fruticose*, *Hibiscus Syriacus* and *Carissa macrocarpa* were observed moderately susceptible. *Ophiopogon japonicas* and *Rhapis excels* were found moderately resistant with minimum number of egg masses. Ornamental plant species *Murraya paniculata*, *Duranta repens*, *Ficus elastica* and *Artemisia stelleriana* were managed by using endophytic bacterial strains *Pseudomonas putida* and *Pantoea agglomerans* against the attack of root knot nematodes. The results concluded that *Murraya paniculata*, *Duranta repens*, *Ficus elastica* and *Artemisia stelleriana* plants treated with endophytic bacterial strain *Pantoea agglomerans* showed minimum number of root galls and maximum root length, shoot weight and canopy and minimum root weight.

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Potential of Biocontrol Agents for Management of Causal Agents of Aflatoxin in Maize  
Grains

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Maize (*Zea mays*) is staple food of many countries of the world. In Pakistan its stand 3rd after wheat and rice among cereals. Maize also used in poultry and livestock sector for formulation of feed. *Aspergillus* species especially *Aspergillus niger* and *A. flavus* produce aflatoxins in cereal crops like corn, groundnut and rice under storage conditions. Five morphologically different isolates of *A. niger* and *A. flavus* were collected from different labs of Dept. of Plant Pathology, University of Agriculture, Faisalabad. These isolates were cultured on PDA (Potato Dextrose Agar) in petri plates for aggressive analysis. Took one of the most aggressive isolate for further study and cultured it on PDA (Potato Dextrose Agar) The antagonistic Fungus *Trichoderma Harizianum* and moringa plant extract were evaluated against most aggressive isolate of *A. niger* and *A. flavus* in petri plates that is a eco-friendly strategy to control these fungi. Two concentrations of moringa plant extract were taken for evaluation purpose. It was revealed that *Trichoderma harizianum* successfully restrict the growth of *Aspergillus niger* and *A. flavus* in petri plates and made inhibition zone in petri plate. It was also noticed that maximum control of *Aspergillus niger* and *A. flavus* was found by moringa plant extract at 15 ml per 200 ml of PDA. Fungus *Trichoderma Harizianum* and moringa plant extract are environment friendly, so can be used antagonistic in future research for control of *Aspergillus niger* and *A.flavus*.

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Combined Insecticidal Effectiveness of three Locally Grown Plant Essential Oils and Phosphine Gas Towards Lesser Grain Borer (*Rhyzopertha dominica*)  
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Need of the day is to search the plants derived natural products as an alternative to conventional and synthetic insecticides to overcome environmental hazards and ever-increasing pest resistance against these pesticides. Keeping in view, the current studies were carried out to evaluate the percentage mortality of three locally grown plant essential oils (*Melia azadarach*, *Azadirachta indica* and *Datura stramonium*), phosphine gas and their combinations against the adults of Lesser grain borer (*Rhyzopertha dominica*). The respective concentrations viz, 5, 10, 15% and 100, 200, 300 ppm concentrations of essential oils and phosphine gas respectively were assessed along with their combinations. Mortality in test insect was observed in time interval and concentration dependent manner. In essential oil alone experiment, *A. indica* showed maximum mean mortality of 25.45% with highest concentration after 72 hrs of exposure, while 64.41% mortality was observed in phosphine alone experiment with 300 ppm of concentration after same exposure period. Combined application of these two increased mortality significantly as 89.66, 86.44% and 75.71% was observed in 300ppm+15% *M. azadarach*, 300ppm+15% *D. stramonium* and 300ppm+15% *A. indica* respectively after 72 hrs. The current information is useful as a safe alternative for the successful management of stored grain insect pest.

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**Effect of Different Host Plants in Modulating the Susceptibility of *Amrasca devastans* to  
New Chemistry Insecticides**

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*Amrasca devastans* (Dist.) is the destructive pests of malvaceous and solanaceous crops like cotton, okra and brinjal in Pakistan. Experiment was conducted to determine the susceptibility of *A. devastans* reared on three different host plant species to five new chemical insecticides. All insecticidal bioassay were performed by leaf dip method. Okra population was taken as a reference strain. The results showed that *A. devastans* strain reared on cotton was more susceptible to chlorfenapyr, nitenpyram, imidacloprid, and spirotetrament compared with reference strain. However, the susceptibility level of same strain against acetamiprid was less than control. Conversely, *A. devastans* strain reared on brinjal showed highest susceptibility ratio against spirotetrament but lowest against nitenpyram and imidacloprid. In crux, changes in susceptibility of *A. devastans* to different insecticides are due to different host plant diets. Thus, there is a need to use all these insecticides in rotational pattern on particular host to avoid the fast development of insecticide resistance in *A. devastans*. It is also important to not cultivate similar host plants in one habitat for proper management of *A. devastans*.

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**Amount and Form of Nitrogen Affect Burnt Leaf Length of Onion Seedlings**  
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Burning of plant leaves reduces surface area for light and CO<sub>2</sub> absorption and can cause a great loss of economical yield of crop plants. In February 2016 vegetable growing areas of central Punjab were visited and leaf tip burning of onion seedlings was found common in the area. Investigations are in progress to know the actual cause of the disease/disorder. Besides the diagnosis of the problem, experiments were also conducted to know the effect of amount and form of applied nitrogen on tip burning of onion seedlings cultivated in hydroponics. Both amount and form of nitrogen affected the leaf length and burnt leaf tip length of the seedlings. Tip burning was decreased with nitrogen concentration in Hoagland solution and found minimum at 4 mM N, and then increased with further increase in N concentration up to 8 mM. Nitrogen at 4 mM was also found the best in improving biological and bulb yield of tip burnt onion. It was further noted that ammonium replacement of solution nitrate up to the extent of 50% or more significantly increased the tip burning compared to that of reference treatment (100% nitrate-N). Biological and bulb yields were found maximum with NO<sub>3</sub>: NH<sub>4</sub> ratio 3:1. In conclusion, optimum dose of nitrogen in 3:1 = NO<sub>3</sub>: NH<sub>4</sub> ratio is helpful in reducing tip burning of onion seedlings.

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Effect of different Nitrogen and Potash Application Levels on Bacterial Leaf Blight of Rice  
(*Oryza sativa* L.)

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An experiment was conducted at Rice Research Institute, Kala Shah Kaku in 2010 during kharif season to study the influence of nitrogen (N) and potash (K) on severity of Bacterial leaf blight (BLB) of rice (*Oryza sativa* L.) aimed at improving productivity. The experiment was laid out in RCBD factorial arrangement with three replications. Treatments comprised of; 0 kg N ha<sup>-1</sup>, 75 kg N ha<sup>-1</sup>, 100 kg N ha<sup>-1</sup>, 125 kg N ha<sup>-1</sup> and 0 kg K ha<sup>-1</sup>, 50 kg K ha<sup>-1</sup>, 75 kg K ha<sup>-1</sup>, 100 kg K ha<sup>-1</sup>. Data on disease severity yield and yield related parameters of rice were recorded using standard procedures. Yield and yield parameters were affected significantly by various combinations of N and K. In case of BLB, minimum diseased leaf area was observed when nitrogen alone was applied at 75 kg ha<sup>-1</sup> in contrast to fertilizer applied at 125 kg N ha<sup>-1</sup> + 50 kg K ha<sup>-1</sup> which showed maximum diseased leaf area. Maximum paddy yield (4.32 t ha<sup>-1</sup>) was recorded when rice was fertilized at 75 kg N ha<sup>-1</sup> + 100 kg K ha<sup>-1</sup> as compared to sole fertilization of 75 kg K ha<sup>-1</sup> that produced minimum paddy yield (2.40 t ha<sup>-1</sup>). Optimum fertilization at 75 kg N ha<sup>-1</sup> + 100 kg K ha<sup>-1</sup> improved harvest index up to 20.32 %. Minimum harvest index of 15.61 % was obtained where K alone was applied at 100 kg ha<sup>-1</sup>. Maximum gross income, net returns and BCR were obtained where rice crop was fertilized at 75 kg N ha<sup>-1</sup> and 100 kg K ha<sup>-1</sup>.

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Leaf Rust Disease Affects Various Morpho-Physiological and Yield Attributes in Bread  
Wheat

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Leaf rust of wheat caused by *Puccinia triticina* is one of the most important diseases in the Pakistan and cause both yield and quality reduction. To investigate the effect of leaf rust of wheat on morph-physiological processes and grain yield, a field experiment was conducted in different wheat lines and varieties. The morpho-physiological attributes of the infected plant leaves were badly affected by the leaf rust of wheat. The experiment comprised two treatments, one was inoculated with leaf rust spores manually and Morocco as a spreader while other keeping as a control. The results showed that there was -42.92, -23.72, -23.01, and -11.42, % decrease in chlorophyll content, flag leaf area, specific flag leaf area and relative water content in leaf rust (diseased) plot while 21.24, 160.16% increase in relative dry weight and relative membrane permeability in the leaf rust plot and vice versa. The results also revealed that leaf rust of wheat also reduce the yield components like number of grains per spike, spike length and 1000 grain weight (-52.38, -43.37 and -45.50 respectively). Thus, it could be concluded that leaf rust of wheat affect the morph-physiological process and badly reduce the yield as well.

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**Microbial Endophytes for Growth Promotion and Yield Enhancement in Wheat**  
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Increasing human population places pressure on agriculture. To feed this population, two time increase in the current wheat production is needed. Today agriculture is becoming input intensive with more reliance on synthetic fertilizers and agrochemicals to fulfil the feed demand of the growing numbers. Use of synthetic fertilizer since last few years is impacting the soil quality. In this scenario, the use of beneficial endophytic microbes is an attractive strategy to overcome the use of synthetic products. To investigate the effect of consortium application of endophytic bacteria and fungus on plant growth, grain yield moisture status, a pot experiment was conducted in different wheat lines. It comprised four treatments like control, application of bacterial strain *Bacillus subtilis*, fungal strain *Trichoderma harzianum* and their consortium (*B. subtilis* + *T. harzianum*). The effect of consortium application was more prominent and significantly different from the sole application of the endophytes. The results showed that with a consortium application of endophytic bacteria and fungus, there was 28.6, 4.3, -6.3 and -3.7% increases in flag leaf area, chlorophyll content, relative membrane permeability and water content respectively. Consortia of endophytic microbes also resulted in the yield enhancement through the betterment of various yield attributes like number of spikelet's, grains per spike and grain yield per plant (32.2, 25.8 and 30.8%, respectively). So, it is concluded consortia of endophytic microbes can greatly promote the progress of plants into the fundamental mechanisms of symbiosis and increased the yield in an environmentally sustainable way.

**Variability among *Ralstonia solanacearum* Strains from Different Agro-ecological Zones of Pakistan**

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Bacterial wilt incited by the bacterium *Ralstonia solanacearum* is a serious threat to economically important solanaceous crops in Pakistan and the bacterium has shown great morphological, pathogenic and genetic diversity in different regions of the world. As such information is lacking in Pakistan, therefore, in the present studies variations in hypersensitivity response, growth and virulence were observed among 114 strains of *R. solanacearum* collected from eight agro ecological zones of Pakistan. Of all the 114 isolates of *R. solanacearum*, 88 showed positive HR and mucoid growth while 26 isolates gave negative HR with non mucoid growth. Out of 114 strains of *R. solanacearum* consisting of biovar 3 and 4, 22.8% were found avirulent, 25% weakly virulent, 29.3% virulent and the remaining 21.9% were highly virulent. Among 92 *R. solanacearum* biovar 3 strains, 21.7 % were identified as avirulent, 25% weakly virulent, 34.4% virulent and 22.8% were highly virulent in the eight agro ecological zones of the country. Similarly, out of 22 *R. solanacearum* biovar 4 strains, 27.3% each were detected as avirulent, weakly virulent and virulent while 18.2% strains were found highly virulent. Relationship was also found between growth and virulence among the *R. solanacearum* strains of the isolates. The strains having non-mucoid growth have been found avirulent while those with mucoid growth were weakly virulent to highly virulent. Similarly, strains showing positive HR were virulent while those with negative HR were found as avirulent.

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Wheat Breeding for Durable Rust Resistance

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Wheat rusts have resulted in serious economic losses by affecting the wheat crop and even causing famine situation in different parts of the world. After green revolution of 1960s introduction of semi dwarf wheat varieties with race specific resistance have averted the situation and helped in attaining self sufficiency in food production. The varieties with race specific resistance have shorter life whereas varieties like Lerma Rojo-64, Yaqui-50 and Lyalpur-73 developed in early part of green revolution have longer life which is attributable to adult plant resistance (APR) type of resistance mechanism based on major and minor genes combinations. Emergence of new rust races like *Yr9* and *Yr27* virulence's and devastating stem rust race Ug99 and its mutants enforced the wheat breeders to revise their strategy. Now, minor genes accumulation or combination of major and minor genes having APR type of resistance is considered to be the durable solution. The minor genes/APR genes, *Sr2/Yr30*, *Lr34/Yr18*, *Lr46/Yr19*, *Lr67/Yr47* etc are being used in wheat breeding programs of different parts of the world. Our studies using 325 genotypes by using 250 SSR markers revealed that 1DS, 4AL, 4BL, 5AS, 5DS, 6AL, 6BS and 6DS are important genomic regions for rust resistance. Germplasm with APR type of resistance has shown resistance consistency over space and time. Breeders now deploy top cross/back cross scheme and advancing segregating populations by selected bulk method and some breeders are also using MAS for improving their efficiency. Number of varieties with this type of resistance has been released in Pakistan and different parts of the world. In Pakistan, wheat varieties Seher-06, Faisalabad-08 and Lasani-08 having this type of resistance are still under cultivation after 8-10 years their release.

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One New Species of Genus *Spodoptera* (Hadeninae: Noctuidae: Lepidoptera) from Multan,  
Punjab, Pakistan

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The present work incorporates thorough investigations on Taxonomic studies of the Genus *Spodoptera* belonging to family Noctuidae, damaging agricultural crops (cereals, vegetables, fruits, oilseeds fodders, medicinal plants and forest range plantation) at different localities of Multan. A comprehensive and a comparative taxonomic account of new species of the genus *Spodoptera* i.e. *Spodopterahirsutosis* provided herewith. This specie is very similar to the *Spodopteralittoralis* but easily distinguish on the basis of different characters of genitalia. Specimens of this genus have been identified on the base of their Genitalic characters. The species *Spodopterahirsutus* were collected from the different agro forest and crop area of the Multan region with the help of light traps and areal nets. The abdomen of specimen was detached from the body and dipped in 10% KOH solution for twenty four hours or boiled for 2-3 minutes. Dissected abdomen and removed the male Genetalia. The dissected male Genetalia after washing 2-3 times with distal water was mounted permanently with Hoyer's medium. The photograph of male Genetalia was prepared with the help of Olympus digital camera (DPX 200). Diagnostic characters and dichotomous identification key of species have been provided. This species has been reported for the first time from Multan, Pakistan and new to science.

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**Varietal Response of Maize against *Aspergillus flavus*, the Causal agent of Aflatoxins**

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Maize is an important food crop of the Pakistan and stands fourth most cultivated crop after wheat, cotton and rice. Its contribution towards value addition is 2.1% in agriculture and 0.4% in Gross Domestic Product (GDP). Maize is a staple food of both developed and developing countries. Aflatoxin contamination is the main problem in maize as it is highly toxic to both human and animals. Aflatoxins are secondary metabolites namely B<sub>1</sub>, B<sub>2</sub>, G<sub>1</sub>, G<sub>2</sub> produced by *Aspergillus flavus*. Thirty six varieties/ lines of maize were screened out against *Aspergillus flavus*. *Aspergillus flavus* were isolated from infected fields by surveying different fields of maize. The inoculation was done by using side needle technique. It was revealed from experiment that almost all varieties showed moderately susceptible or susceptible response when inoculated with *A. flavus*, while two varieties Sahiwal-2002 and XMA-9 showed resistant response. These varieties show no symptoms of *A. flavus* infection after harvesting. Susceptible varieties showed disease severity more than 15% while moderately susceptible varieties showed disease severity less than 15%. It was noticed from the result that side needle technique is the best inoculation technique. The exact nature of resistant varieties is not clear but it was hypothesis that there are many field factors along with their genetic makeup made them resistant against *A. flavus* infection. These varieties could be used in future for further experiments against *A. flavus* infection: producer of aflatoxin.

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**Sunflower Allelopathy: Impact on Weeds, Soil Health and Productivity of Mung Bean**

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Weeds are the most notorious category of agricultural pests, which not only cause drastic decline the crop production but also effect negatively on soil health. However, continuous use of herbicides to control various weeds is posing severe threat to soil and human health. In this scenario, the strategy of using the allelopathic crop residues and water extracts seems to be an attractive option to reduce dependence on synthetic herbicides. Besides controlling weeds, residues of allelopathic crops affect the soil properties through influencing the soil microbes and soil enzymes. Thus, a two-year study was planned to check the effect of sunflower residues incorporation on soil properties, weeds and productivity of mung bean. This study comprised of five treatments viz. control, sunflower water extracts at 10 and 20 L ha<sup>-1</sup>, sunflower residues incorporation at 4 and 6 t ha<sup>-1</sup>. Sunflower water extracts reduced 5-26% density and 9-31% dry weight but, in case of residues incorporation 44-57% reduction in density and 58-70% in dry weight of weeds were taken place as compared to control. At mung bean harvest, better soil properties in terms of N (86%), OM (74%), soil microbes, and soil enzymes [alkaline phosphatase (186 µg NP g<sup>-1</sup> soil h<sup>-1</sup>) and dehydrogenase (38 µg TPF g<sup>-1</sup> soil h<sup>-1</sup>)] were recorded with when sunflower residues was incorporated at 6 t ha<sup>-1</sup>. In conclusion, sunflower residues incorporation may be opted to improve soil health, suppress weeds and harvest better yield and profitability (339 \$ ha<sup>-1</sup>). This method may provide a possible alternative for achieving sustainable weed management in mungbean with substantial improvement in soil properties.

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Determination of the Incidence of Yellow Wheat Rust in Relation to Different  
Environmental Factors

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Wheat rusts are the significant diseases of wheat crop and a potential threat. Among all major wheat diseases occurring in all wheat growing areas of Pakistan, stripe rust caused by *Puccinia striiformis* f. sp. *tritici* is a big hazard when it occurs in severe condition. Disease modeling based on the information regarding different environmental factors is an important tool to avoid and devise various strategies to combat plant diseases. To develop a relationship between rust incidence and different environment factors, we used ten wheat varieties/lines (Galaxy, Lasani-2008, V102, V121, Millat 2011, V120, Faisalabad-08, V130, V-127 and Punjab 2011). These varieties/lines were screened against yellow rust disease under field conditions. Moreover, the incidence of disease was correlated with environmental factors (temperature, relative humidity, rainfall and wind speed). The overall results demonstrated three varieties/lines (121, Millat 2011 and 120) with moderately resistant (MR) reaction to stripe rust of wheat while rest of seven varieties/lines (Galaxy, Punjab 2011, 127, 130, Lasani 2008,102 and FSD-08) showed moderately resistant moderately susceptible response to this disease. The correlation matrices showed clear response of disease development to environmental factors. Among environmental factors minimum temperature and relative humidity showed significant positive correlation with disease development while wind speed and rainfall showed non-significant correlation with disease development and maximum temperature showed negative correlation with disease development. The study concluded that there is sufficient degree of resistance against yellow rust in the most recent cultivars in addition to advanced lines. Moreover, the results concluded that minimum temperature and relative humidity are important determinants of occurrences of the disease.

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**Caterpillar Mushroom Use to Curing the Different Diseases**

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Caterpillar fungus (*Cordyceps sinensis*) also known as summer plant, winter worm or club or finger shaped mushroom grows mostly on the mountains, snowy grass of China and Asia. It is helpful against different problems associated with humans such as kidney failure, asthma, bronchial and lung inflammation, nephrotoxicity, liver disorders and also to control the cardiovascular diseases. It is use for diabetic patients. Caterpillar fungus contains nutritional and medicinal properties in relation to human health. Caterpillar fungus is unique collection for the human beings due its curing properties and have intensity, climate change for sustainable resource management. Caterpillar mushroom is used as anti-viral, anti-tumor, anti-cancer, immuno-modulating effects, antioxidants, anti-aging and reduction of cholesterol, increase of stamina and libido. For Cordycepin, active ingredient of Cordyceps, anti-cancer activities and anti-inflammatory abilities. It is myco-medicinal mostly utilize in all over the world like Chinese and East Asia communities. Furthermore its use become sa fashionable luxury product, often given as a gift and used as a culinary status symbol.

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Evaluation of Wheat Lines against Barley Yellow Dwarf Virus

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Barley yellow dwarf viral disease is globally most important disease of wheat. It has a worldwide distribution and infects a wide range of Poaceae family including major cereal crops mainly wheat, barley and oats. Occasionally this BYDV disease also affects rice and maize. The experiment was started with one hundred and fifteen advanced wheat lines. The transmission of barley yellow dwarf virus was carried out through aphid *Rhopalosiphum padi*. PAV-strain of BYDV was efficiently transmitted by *Rhopalosiphum padi*. Infected plants of oats showing typical symptoms of reddening were used as a source of barley yellow dwarf virus inoculum. Wheat plants were grown in the field in rows alternated by the rows of susceptible oats. The whole experimental area was isolated by border rows of oats. At the beginning of tillering stage, the inoculation by *Rhopalosiphum padi* aphids was lasted from 5-7 days, and then the aphids were killed by an insecticide. The wheat plants were keenly observed for the appearance of symptoms after two weeks of transmission. The whole experiment was conducted under field or natural conditions. All the tested wheat lines exhibited typical symptoms of flag leaf yellowing. Hence one hundred and fifteen advanced wheat lines were screened against barley yellow dwarf virus under field or natural conditions for the incorporated resistance due to *Bdv1* and *Bdv2*. These wheat lines were tested by DAC-ELISA and found that all the lines had different levels of virus concentrations. This indicated the level of resistant, tolerant, susceptible and highly susceptible wheat lines. On the basis of ELISA readings out of 115 lines 28 lines were resistant, 43 lines were tolerant, 8 lines were susceptible and 36 lines were highly susceptible. The isolated resistant wheat lines will be further tested for the identification of resistant genes. These resistant genes will be further characterized for their transformation in the less resistant cultivars of wheat.

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Insecticidal Activity And Chemical Composition Of Essential Oils Of Plants Collected  
From Hazara Division Against Red Flour Beetle (*Tribolium castaneum*)

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The red flour beetle (*Tribolium castaneum*) is economically very important insect pest of stored grain products. It feeds mainly on rice, wheat and flour thus destroying the quantity and quality of food products. It is estimated that about 10-40% of the overall production is damaged by this pest. Synthetic insecticides are normally used to control this pest. The continuous use of synthetic insecticides has created resistance in this pest in addition to the toxic effect on environment. The plants produced compounds could be used as an alternative to synthetic insecticides. In order to search plant based natural insecticides, essential oils (EOs) were extracted from fresh aerial parts of *Tagetes minuta*, *Conyza sumatrensis*, *Eucalyptus globulus* and *Chenopodium ambrosioides* through steam distillation. Bioactivity of the essential oils was tested against adult *T. castaneum* using a fumigant assay. The EOs were also analysed on gas chromatography-mass spectrometry (GC-MS) to identify their chemical composition. The EOs of *T. minuta*, *C. sumatrensis* and *C. ambrosioides* showed 90-100% mortality in tested beetles whereas *E. globulus* did not show any activity. The major compounds identified in *T. minuta*;  $\beta$ -ocimene, verbenone, and tagetone, *C. sumatrensis*; limonene,  $\beta$ -cubebene and lachnophyllum ester, *C. ambrosioides*;  $\alpha$ -terpinen, p-cymene and germacrene D and *E. globulus*;  $\alpha$ -pinene,  $\beta$ -pinene, eucalyptol, aromadendrene. The tested plants EOs had the potential to be used for the control of *T. castaneum*.

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Weed Population Dynamics Associated with Wheat Productivity under Different  
Herbicides Application

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Weed infestation is a serious problem in wheat which causes severe damages to the crop yield especially in pothowar region. To find out the remedy of the said issue a field experiment was conducted to investigate the effect of different herbicides on weeds population dynamics and yield of wheat advance line AUR- 0809. The experiment was conducted during Rabi season, 2015-2016 laid out in RCBD with split plot design with controlled and treated plots. Different herbicide formulations i.e. Ally max, ClearView, Starane M and Buctril super 60 EC were used to check effect in studied experiment. Minimum values for all studied traits were observed in treated plot where Ally max herbicide was applied. It was observed that treated plot Ally max showed maximum readings for all traits plant height, biological yield, grain yield, spike length, tillers, weed control efficiency. The treatment Ally max is suggested to use in further experiments for improving wheat yield by minimizing weeds infestation.

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Identification of *Begomovirus* Infecting Chillies Grown in Tunnels

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About 50 plants of *Capsicum annum* were grown in NARC, Islamabad in a green house. Chillies were grown in tunnels during spring 2016. Plants were allowed to grow for about seven weeks. Diseased plant samples (leaves) showing the sign and symptoms of infection caused by *Begomoviruses* were collected. These morphological characters were leaf curls, yellowing and retarded growth of plants. *Begomovirus* was detected in one sample of chillies out of total 10 samples collected on the basis of morphological and PCR based studies. The genus *Begomovirus* is from the *Geminiviridae* family. These *Begomoviruses* have been emerged as severe constraints through worldwide and pass on disease to different field crops in which weeds, ornamental plants and vegetables are included. Molecular detection of this virus was done by using degenerate primers. The degenerative primers that were designed for the amplification of specific DNA fragments. Polymerase chain reaction based assays were performed with the help of these degenerative primers. So *Begomovirus* was found as a causal agent of leaf curl disease in sample of chillies.