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Study of Major Sugarcane Disease, Pest Management Strategies and Its impact on Sugarcane Production in Bihar

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ABSTRACT

Sugarcane (*Saccharum officinarum, L.*) is thecommercial crop in the state of Bihar.With half of the sugar millin the state in the West and East Champaran Districts, these are the largest Sugarcane- producing Districts of Bihar followed by Gopalganj, Sitamarhi, Samastipur, Madhubani , Vaishali and Siwan.The area under sugarcane cultivation was 2.69 lakh hectare in 2013-2014 and it increased to 3.00 lakh hectare in 2015-2016, according to the Sugarcane Development Department . The sugarcane production was 176.10 lakh MT in 2013-2014 and 210.00 lakh MT in 2015- 2016. Sugarcane yields have been rigorously abridged in various parts of Asia as attacked by enormous number of insect pests and diseases. Changes in cropping patterns including the cultivation of high yielding varieties and hybrids have added to the problem in some areas. Plant breeding has been successful to some extent in keeping up with new and evolving diseases and pests. Innovation in agronomic practices, advent of chemicals for control, and more recently genetic engineering tools have been providing new opportunities for reduction of crop losses due to biotic pressures. Insect control is even more important as many viral diseases are transmitted by insects. The scenario of insect pests varies in subtropical and tropical belt of sugarcane. Top borer , shoot borer and stalk borer are found pre -dominantly in sub-tropical areas whereas internodes borer and early shoot borer are prevalent in tropical region.

1. Introduction

Sugarcane is an industrial crop with acreage of about 4 million hectares and production to tune of 300 million tonnes in India. Sugar is the largely ideal geological sweetener and energy mine worldwide . Cultivation of sugarcane in India dates back to the vedic period. The healthful reimbursement of sugar is a resource of persistent deliberation in the residential countries . It is a source of occupation to millions of people and is primary to the cost-effective expansion plan of sugar producing countries .About 80% of the world's sugar is consequent from sugarcane while the enduring 20% is from sugar beet (Beta vulgaris: Amaranthaceae) . Sugarcane (*Saccharum officinarum*; Poaceae) is one of the world's largest beneficial crops. Globally 121 countries escalate sugarcane and together with them India, Pakistan, Australia, Argentina, Bangladesh, Brazil, China, Columbia, Cuba, Mexico, Myanmar, Philippines, South Africa, Thailand and USA share 85% of field and 86% of production. In Bihar, it is the second foremost currency crop after cotton [4], contributing in charge new cultivation and GDP up to 2.3% and 0.6%, correspondingly . In supplement to sugar, sugarcane is also used to produce ethanol, bagasse, molasses and lobby mud (Solman,2011). Sugarcane provides raw materials as basic resource for industries like paper and chipboard manufacturing. This is an advantageously significant crop that has a profound economic impact on community and governmental issues in numerous countries around the globe (G.James,2004). It grows perfectly where there are stretched periods of sunlight (12-14 hrs.), hightemperature scope is between 22°C and 30 to 35°C and, moisture is high, 80-85% (DAFF,2018.)

Fig: A healthy sugarcane plant.

The sugarcane flora and fauna (phytobiome) comprises many weeds, arthropods and more than 50 plant pathogens(S.A.Ferreira and J.C.Comstock,1993). It is sustained duration crop; so a number of biotic and abiotic agents distress its productivity, including insect pests, viruses, bacteria, fungi, nematodes, invertebrates and weeds [16-19]. In general, diseases and insect pests obtain prospective to diminish its creation by 19 and 20%, respectively . Sugarcane crop is attacked by huge number of insect pests and diseases (R.L. Yadav,2009). Arthropod pests allied with the crop worldwide consist of complexes of branch feeders, sap sucking insects (e.g., aphids, thrips, mealy bugs), root feeders (e.g.,

white grubs, stem borers), and spider mites R.L.Yadav, 2009). Many farmers are in worry about their crops and decreasing production rate. This article offers information on sugarcane production, cultivation, effect of different environmental factors on sugarcane, some of the most important diseases and pests of sugarcane and converse every aspects of pest management strategies.

2. Important factors for cultivation of sugarcane in Bihar

(1) Suitable climatic conditions

Tropical or sub-tropical climate having about minimum 600 mm rainfall per year is more suitable for sugarcane cultivation. In Pakistan north western zone, central zone and southern zone are more popular for cultivation of sugarcane. Pakistani area of Sindh have hot and semi humid climate, so considered as more suitable and favourable for cane crop. Climate of Pakistan is good for best yield of sugarcane but weather conditions sometimes cause hindrance in growth of sugarcane .

(2) Photosynthetic effects on sugarcane

Sugarcane has ability to convert the 2 percent of solar energy into biomass and said to be as most effective photo synthesizer. It converts more solar radiations and carbon dioxide into fibre, food and fuel as compared to other crops (B.Natrajin, 2005).

(3) Productivity and utilization

A number of efforts have been done for best production of sugarcane but results are still low as compared other countries which produces sugarcanes. Many factors can be the cause of this like inappropriate methods of growth, infertile land, less production, improper management, poor methods of cultivation etc. while improper irrigation is the main factor of poor yield of sugarcanes . About 72.73% of total yield of sugarcane is utilized by the factories and when the overall production of sugarcane decreases then this percentage decreases to 61-67%. On the other hand Gur production from the sugarcanes is more profitable even in the low yield years.

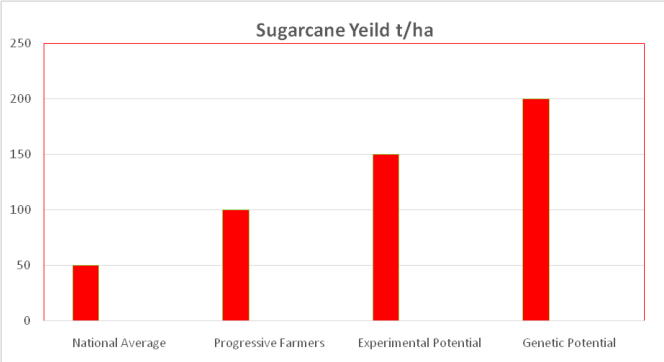

Fig: (1) National average and potential sugarcane yields

(4) Effects of temperature on sugarcane

Temperature has great effect on cane production. High temperature may leads to death of cells while low temperature can cause other damages [36]. High temperature can cause heat stress which can affect the enzymatic activity of sugarcane, germination of seeds, growth of sugarcane as well as yield of sugarcane (M.A.Kahlown,2002). Low temperature may reduce the metabolic activities of sugarcane and can cause osmotic stress (S.Chakraborty,1998).

(5)major factors affecting of sugarcane production in Bihar

(A) Verities of soil type

Sugarcane can be grown in all types of soil but for good production loamy clay soil is suggested to be perfect because water intake capacity increases here [39].

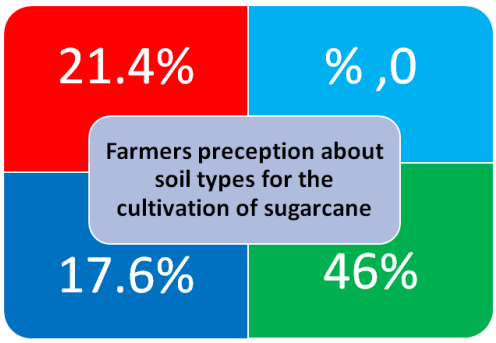

Fig: Farmers perception about soil types for the cultivation of sugarcane

(B)Sugarcane planting seasons pattern

Sugarcane planting usually done in two seasons Autumn and Spring but Autumn planting is more suitable because it gives higher yield as compared to spring. According to the months, October planting is more opulent but it have more chances of attack. A study reveals that approximately about 26.3 percent of growers planted sugarcane in February, 21.6 percent in October, 16.8 percent in March and 12.1 percent in September. While 27 per cent of the growers in the study area planted in spring (Feb-March) and in autumn (Sept-Nov) seasons respectively .

(C) Sugarcane planting pattern

The most common method of sugar cane planting is “overlapping”, “end to end” and “double set” methods. The cost for planting was recorded about 872 rupees per acre and investigated that any procedure or seed treatment was not followed before sowing the seeds of sugarcane (N. Adnan,2013) .

3. Major Sugarcane Diseases and Its Control

(A) Sugarcane Smut

This disease is mostly caused by the fungus Ustilago scitaminea (D.G.Robertson,1969) . It can be characterized by normally whip like surely sorus-bearing structures (E.J.Trione,1990). Slender stalks, remarkably small narrow leaves and size variation are also its characteristics (A.Sivanesan1986). After 2-5 months of cultivation, the diseased plant attain smut whip and shoot affects earlier (R.Antonie,1961). Globally, the most cane production affected by smut (A. Sivanesan and J.M.Walter,1986). Sucrose level, yield and juice quality is greatly affected due to sugarcane smut disease (Z.E.Mschichi and E.L.Keswani,1981) .

Fig: Sugarcane showing Smut.

Control Methods:

1. Rouging: remove or destroy soil before inserting the whip (T.L.Pearse,1989).
2. Plant deadly stems.
3. Hydrothermal treatment for 30 minutes at 52°C before planting.

(B) Red Rot Disease ofSugarcane

Cane erythema is caused by the fungus *Glomerella tucumanensis* (A.Sivanesan and J.M. Waller,1986). Red rot appears on the stem or spots with red spots and white centres and is recognized as a bundle of red blood vessels . Red rot is transmitted mainly from contaminated plant debris in the pores of water and soil. Agricultural and moisturizing agents, which typically infect insects, especially stems and termites, fungi and secondary invaders, accelerate the development of the disease red blood cells reduce sucrose in infected plants and increase processing costs due to impurities in the sap, while red artillery significantly reduces the germination rate of infected plants for planting (A.Sivannesan and J.M.Waller 1986).

Fig : Sugarcane showing Red Rot Disease

Control Methods:

1. Planting resistant varieties .
2. Loosen the injured mass during the growing season.
3. Protect the weed less field and avoid planting in contaminated fields where plants were previously affected.
4. 2-3 years of soybean harvesting practice (without grain).
5. A grid of healthy plants. It is necessary to remove dirt that indicates redness at the edges of the wound or part of a node or hole in the stem.

(C) Sugarcane Mosaic Virus Disease

Sugarcane mosaic virus disease has been identified as one of the most important and deadliest pipe diseases in the world. SCMV is transmitted by mechanical ways and aphids. Diagnostic symptoms include young leaf spots and brightgreen or yellow-green leaf spots (A.Sivanesan and J. M. Waller, 1986)

Fig: Sugarcane showing Mosaic virus Diseases

Control Methods:

1. Plant-resistant varieties
2. Equalize systematically contaminated stocks by season.
3. Get rid of aphids and alternatives such as ivory, corn and sorghum.
4. Healthy plants should be selected

(D) Sugarcane Leaf Blast Disease

Sugarcane leaf eruption caused by the fungus *Paraphaeosphaeria michotii*. This is a mild disease that survives straw and leaf debris (A.Sivanesan and J.M.Waller,1986). It attacks both leaves and stems. It affects leaf leaves, initially forming long yellow narrow spots with long axes parallel to the vessels. Spots can merge, and all leaves are red, dry and die from top to bottom.

Fig: Sugarcane showing Leaf Blast Disease

Control Methods:

The best way to control this disease is to use only resistant varieties of a desire plant (V. A. Awoderu, 1978).

(E) Curvularia Leaf Spot Disease

It is believed that the disease is a leaf region caused by *Curvularia lunata* [42]. The initial symptom is a slight pale yellow ribbon lesion on the first five leaves. Red changes occur around the lesion, and the affected tissue eventually dies (A.C. Wada,1995).

Control Methods:

To control this disease use resistant varieties only.

4. Pests of Sugarcane

(A) Stem Borer Disease of Sugarcane

The larvae of several butterfly barrels are among the most important sugarcane pests. The stalk attacks the shoots, which are the parts that grow. They dry up and die, creating a "dead heart." In addition, if young reeds are attacked before the inside is formed, their inventory will decrease, leading to their extinction. When the larvae of the inner stem create an internal tunnel, the weight of the stem decreases, the quality of the juice decreases, the stem breaks and the residence time decreases. If a serious infection occurs, the stem dries or rots, resulting in late processing of unwanted shoots. *Sesamia nonagriodesbotanephaga*, *S. calamistis*, *Eldana saccharina* and Chilotrea spp. This is the main stalk of sugarcane .

Fig: Sugarcan stem showing infection (Stem Borer)

(B) Early Shoot Borers

Adult moths stain in straw and lay eggs in groups of 10-30 eggs on the surface of the leaves along the edges of the centre. Borage infections are serious before the rainy season (April to June). A plant infects plants when lead growth begins before the formation of the inside. Caterpillars penetrate laterally through reeds through one or more holes in the stems (shoots) just above the ground, split up and down, killing growth points and creating

gaps in the field. Caterpillars can destroy three or four buds before germination. The advent of monsoons significantly reduced drilling activity (F.R.Goebel,2010).

Fig: Sugarcane showing Early Shoot Borers

(C) Internode Borers

The old butterflies are straw and rather tall. Larvae meet walnut plants three months after sowing (June -December). Immediately after the formation of the node, damage to the plant and its activity continues until harvest. They are inserted into the pipe near the node, the entrance is clogged with dust and spirals. Larvae detect damage in the pipe from one to three segments (D.Meenakshi,2018)

Fig: Sugarcane plant Showing Internode Borers

(D) Root Borers

Adult larvae are milky white. They are called root plants, but they do not eat roots, they drill holes in the root surface. Only the underground part of the trunk is attacked by pests. Boring attacks mostly occur on young sugarcane plants, causing total loss of crop and serious damage in the first week of September (I.B.Bhatti,2008).

Fig: Sugarcane Root Borers

(E) Sugarcane Leaf Hoppers

Raise adults and nymphs by sucking cell juice from the bottom of sugarcane leaves, (*Pirilla purpusila*). With the continuous removal of hair in various containers, the upper leaves of the affected stems dry out and the side shoots begin to bloom. The container releases a sticky liquid known as honey dew. Promotes fast and rich growth of the sponge, therefore it is completely covered with fungal leaves. This affects plant photosynthesis and plant growth (D. Meenakshi, 2008).

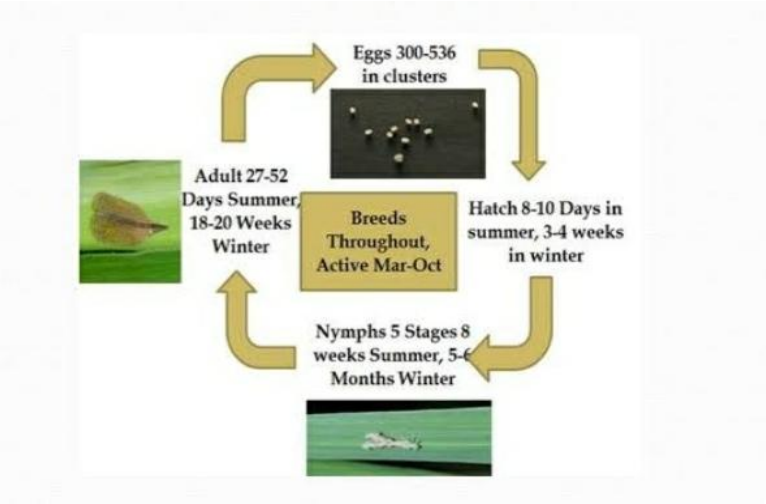

Fig: Sugarcane pest,*Pirilla purpusilla* , Showing life cycle .

Fig: Male *Pyrilla purupsilla*

Fig: Female *Pirilla purpusilla*

(F) Sugarcane Woolly Aphids

Wollblattlaus (SWA), *Ceratovacuna lanigera* Zehntner (Homoptera: Aphididae) is one of the most important sugarcane pests in Southeast Asia. Severe C. lanigera infection was reprinted to achieve a significant reduction in re-

care properties and a 15% reduction in sugar levels (R.J.Rabindra,2002).

(G) Nematodes

Nematodes (blackheads) are filiform animals that are invisible to the naked eye, attack sugarcane, cause discoloration of the roots, cause infectious diseases, infect viruses, grow, produce giant cells and reduce the amount of nutrients. , In severe cases, nematodes cause growth disorders, yellowing and subsequent death of infected plants [64, 65].

(H) Scale Insects

High temperature and high humidity contribute to the accumulation of Scale insects. Seeds are the way of spreading them into new areas. Scales are usually attached to an internal assembly covered by a leaf cover. The trees of diseased canes give you an idea about secret code of tip drying and unhealthy pale fresh colour and with never-ending plague junction yellow. De-sapping leads to non-opening of plants jaunt blonde and ultimately emotionless up. Nodal area is extra infected than intermodal region. Contaminated crop enlargement is small and the intermodal measurement lengthwise is cheap drastically (C.D.Mc Allister,1986).

(I) Termites

The termites incident setts, shoots, canes and stubbles. The termites collect submission through the graze split ends or through buds of the setts and give to eat on the silky tissue. The tunnel excavated is packed with the soil. This affects germination and like so the first crop plunk and finally the staff yield. The germination collapse can be up to 60% (P.Allsopp,2010).

(J)Whitefly

Waterlogging and nitrogen malnourishment source plain eruption of whiteflies. Varieties with broad and lengthy foliage are new susceptible to this pest. The nymphs of pallid flies (white flies)suck the sap away from the under rise of foliage which results in colour changes like yellow and pinkish and in serious case it results in drying of the leaves. Arduous infected trees are roofed by the dirty mould caused by the fungus, which adversely affects photosynthesis. The whitefly plague retards hit intensification and reduces honey please (D.Meenakshi,2018).

5. Pest Management Methods or Practices in Sugarcane

With respect to sugarcane cane Crop production following are the Pest manage-ment Methods which can be adopted.

(A) Cultural Method

The practices like manipulation of date of planting, Trash mulching, Detrashing, Earthing-up etc are cultural method of pest management in sugarcane crop.

(B) Physical or Mechanical Method

Mechanical and physical controls kill the pests directly or make environment unsuitable for it. Although the mechanical practicesare constraints by non-availability of human resource and operational economic.

(C) Varietal Management Method

Some Pest resistant varieties are available; the proper verity of the crop should be planned for cultivation.

(D)Biological Method

The biological methods include the principles like develop the native natural enemies of targeted pest or colonizing pests in the invaded areas. This method is mostly recommended by entomologist now a day.

(E)Chemical Method

Chemical practices are largely used by the farmers to control Pests. Insecticides or pesticides prevent the rapid buildup of pest population to economic injury levels. Despite the minimal usage there is a need to select appropriate insecticide and formulation and adopt proper method and time of application for different seasons and situations. It is not compulsory for the keep in check of bit people that integrated mosquito management tradition must be followed from the sowing time up to harvesting. Awareness is supposed to be shaped amongst the growers all the same augmentation people and schooling workshops about other sugarcane borers, their excitement cycle, time of hurt and habit of management practices. Resistant varieties must be adult to underestimate monetary losses (A. Mohammad and S.Ahmad,2014).

1) Planting sugarcane as remote left as on the cards from maize, millet and sorghum and eliminating elephant meadow from the vicinity of the walking stick farm.
2) Planting of good and vacuum setts should be done which are free from bit plague (no bored holes).
3) Handpicking and larvae Killing and adults and burning the diseased parts of the plant.
4) Planting should be in October or at the newest November to avert borer.
5) Practicing 2-3 day rotation with leguminous crops.
6) Avoiding planting in fields beforehand cropped to sugarcane, which will dole out as a lake for the borers.

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References

[1] C. H. Ruxton, E. J. Gardner and H. M. McNulty, “Is sugar consumption detrimental to health? A review of the evidence 1995–2006.” Critical Reviews in Food Science and Nutrition, 50(1), pp. 1–19. 2010.
[2] T. M. Hess, J. Sumberg, T. Biggs, M. Georgescu, D. Haro-Monteagudo, G. Jewitt, M. Osdogan, M. Marshall., P. Thenkabali, A. Daccache, F. Marin and J. W. Knox, “Sugarcane, water and agricultural transformation in Sub-Saharan Africa.” Global Environmental Change, 39, pp. 181–194. 2016.

[3]FAOSTAT,"Sugarcane.http://www.fao.org/faostat/en/#search/Sugar%20cane." 2018.
[4] S. Qureshi, "Significance of sugar industry in National Economy." Econ. & Socl. Rev., 2, pp. 17-21. 2004.
[5] B. Natrajin, "Sugar and sugarcane international and national scenario and the role of sugarcane breeding institute in varietal improvement in India." Int. Trg. Oct. 12-26th Coimbatore India. pp. 10. 2005.
[6] Anonymous, "Sugarcane encyclopedia." Internet source. 2005.
[7] S. Solomon, "Sugarcane by-products based industries in India." Sugar Tech, 13(4), pp. 408–416. 2011.
[8] G. James, Sugarcane. Second edition. Blackwell Publishing, London. 2004.
[9] S. K. Shukla, L. Sharma, S. K. Awasthi and A.D. Pathak. "Sugarcane in India: Package of Practices for Different Agroclimatic Zones." Indian Instituite of Sugarcane Research, Lucknow, India, pp. 1–64. 2017.
[10] S.A. Ferreira and J. C. Comstock, "Diseases of Sugarcane (Saccharum Spp. Hybrids)." The American Phytopathological Society, Minnesota, 1993.
[11] R. S. Verma, "Sugarcane Projection Technology in India." International Book Distributing Co, Lucknow, India. 2004.
[12] J. E. Leach, L. R. Triplett, C. T. Argueso, and P. Trivedi, 2017. "Communication in the phytobiome." Cell, 169, pp. 587-596. 2017.
[13] A. Rasool, M.U. Hassan, A. Suhail and S.T. Sahi. "The impact of some physiomorphic characters of sugarcane genotypes on their resistance against sugarcane pyrilla, Pyrilla perpusilla Wlk. (Lophopidae: Homoptera)." Pak. J. Agri. Sci., 47, pp. 339-344. 2010.
[14] M. Zafar, A. Tanveer, Z.A. Cheema and M. Ashraf, "Weed-crop competition effects on growth and yield of sugarcane planted using two methods." Pak. J. Bot., 42(2), pp. 815-823. 2010.
[15] A. T. Showler, "Selected abiotic and biotic environmental stress factors affecting two economically important sugarcane stalk boring pests in the United States." Agronomy, 6(1), pp. 10. 2016.
[16] S. Tukaew, A. Datta, G.P. Shivakoti and D. Jourdain. "Production practices influenced yield and commercial cane sugar level of contract sugarcane farmers in Thailand." Sugar Tech., 18, pp. 299-308. 2016.
[17] S. A. Ferreira and J.C. Comstock. "Diseases of Sugarcane, Major Diseases." Elsevier Science Publishers, pp. 211-229. 1989.
[18] P. Rott, A. Bailey, J. C. Comstock, B. J. Croft and A.S. Sauntally. A Guide to Sugarcane Diseases. Centre de Cooperation Internationale en Recherche Agronomique pour le Development (CIRAD) and International Society of Sugar Cane Technologists (ISSCT) Montpellier, France. 2000.
[19] R. L. Yadav, S. K. Shukla, A. Suman and P.N. Singh, "Trichoderma inoculation and trash management effects on soil microbial biomass, soil respiration, nutrient uptake and yield of ratoon sugarcane under subtropical conditions." Biology and Fertility of Soils, 45, pp. 461–468. 2009.
[20] R. L. Yadav, D. V. Yadav and S. K. Shukla, "Bio intensive Agronomy: a paradigm shift in agronomic research." Indian Journal of Agronomy 54, pp. 105–112. 2009.
[21] G. Dittrich, D. E. Conlong and A. Mitchell, "Molecular identification of South African sugarcane white grubs (Coleoptera: scarabaeidae)." Proc. S. Afr. Sugar Technol. Assoc. 80, pp. 264-268. 2005.
[22] A. L. Barker, D. E. Conlong, M. J. Byrne, 2006. "Habitat management using Melinis minutiflora (Poaceae) to decrease the infestation of sugarcane by Eldanasaccharina (Lepidoptera: Pyralidae)." Proc.S. Afr. Sugar Technol. Assoc., 80, pp. 226-235. 2006.
[23] G. W. Leslie, "Estimating the economic injury level and the economic threshold for the use of FASTACR against Eldanasaccharina (Lepidoptera: Pyralidae)." Proceedings of the South African Sugar Technologists Association 81, pp. 319–323. 2008.
[24] G. W. Leslie, "Estimating the economic injury level and the economic threshold for the use of acypermethrin against the sugarcane borer, Eldanasaccharina Walker (Lepidoptera: Pyralidae)." Int. J. Pest Manag. 55, pp. 37-44. 2009.
[25] F. R. Goebel and N. Sallam, "New pest threats for sugarcane in the new bioeconomy and how to manage them." Curr. Opinion Environ. Sustain, 3, pp. 81-89. 2011.
[26]T. A. Goble, D. E. Conlong and M. P. Hill, "Virulence of Beauveriabrongniartii a B. bassiana against Schizonychaaffinis white grubs and adults (Coleoptera: scarabaeidae)." J. Appl. Entomol., 139, pp. 112. 2014.
[27] South African Sugarcane Research Institute (SASRI), Pest and Disease Guide. SASRI, South Africa. 2014.
[28] M. S. Nazir, K. Jamil, A. Jabbar and S. Nawaz. "Differential genotypic performance of autumn planted sugarcane." PSJ Vol. XV, 2, pp. 8-11. 2000.
[29] Muhammad Usman, Nimra Akram, Sundas Imtiaz, Syed Muneeb Haider, American Scientific Research Journal for Engineering, Technology and Sciences (ASRJETS), pp. 126-139
[30] S. Chakraborty G. M. Murray and P. A. Magarey, "Potential impact of climate change on plant diseases of economic significance to Australia." Australasian Plant Pathology, 27, pp. 15-35. 1998.
[31] N. Adnan, A. J. Ghulam and A. J. Mumtaz, "Factors Affecting Sugarcane Production in Pakistan." Pakistan Journal of Commerce and Social Sciences 2013, 7 (1), pp. 128-140. 2013.
[32] A. Sivanesan and J. M. Waller, (1986) Sugarcane diseases. eMI Phytopathology Paper No. 29. CAB International, Slough. 1986.
[33] R. Antonie, Sugarcane Diseases of the World, Elsevier, 1, pp. 327-345. 1961.
[34] A. M. Whittle, "Yield loss in sugarcane due to culmiculous smut infection." Tropical Agriculture, 59, 240-241. 1980.
[35] Z. E. Mschichi and E. L. Keswani, "Effect of sugarcane smut yield and yield components of sugarcane varieties in Tanzania." Tropical Agriculture, 59, pp. 243. 1981.
[36] R. S. Byther and G. W. Steiner, "Comparison of inoculation techniques for smut disease, testing in Hawaii." Proceedings of the International Society for Sugarcane Technology 15, pp. 280-288. 1974.
[37] K. L. Trenor and R. A. Bailey, A preliminary report on the inci- dence of red rot in the South African Sugar Industry. In: Proceedings of the 63rd Annual Congress SASTA held at Durban and Mount Edgecombe, 5-8 June 1989. SASTA, SASA Experiment Station, Natal, pp. 111-116.
[38] Bailey, R.A. and G. R. Betchet, Progress in screening for resist- ance to sugarcane diseases in South Africa. In: Proceedings of the 5th Annual Congress SASTA, 5-12 June 1982, held at Mount Edgecombe, Natal. SASTA Experiment Station, Natal, pp. 143-149. 1982.
[39] V. A. Awoderu and B. A. Okusanya, The state of knowledge of sugarcane pathology in Nigeria. In: Proceedings of an International Symposium on Sugarcane in Nigeria. August 28-September 1. NCRI, Moor Plantation, Ibadan. NCRI, Ibadan, Nigeria, pp. 177-189. 1978.
[40] A. C. Wada and A. Schilder, (1995) Curvularia leaf spot: A new disease of sugarcane in Nigeria. In: Nigeria Society for Plant Protection (NSPP) 24th Annual Conference held at Umdlike, Nigeria, 28-31 May 1995. NSPP Book of Abstracts p. 2.
[41] M. L. Jareth, "Seasonal abundance and distribution of sugarcane stemborers in Nigeria." Journal of Economic Entomology, 61, pp. 593-594. 1968.

[42] F. R. Goebel, E. Tabone, D. T. H. Khanh, E. Roux, M. Marquier and J. Frandon, “Biocontrol of Chilo sacchariphagus (Lepidoptera: crambidae) a key pest of sugarcane: lessons from the past and future prospects.” Sugar Cane Int, 28, pp. 128-132. 2010.
[43] D. Meenakshi, V. S. Naveen, Manisha and Y. Jayant “Insect Pests of Sugarcane and Their Management.” Biomolecule Reports - An International Newsletter, 2018.
[44] M. N. Sallam, “A review of sugarcane stemborers and their natural enemies in Asia and Indian Ocean Islands: an Australian perspective.” Ann Soc Ent France, 42, pp. 263-283. 2006.
[45] I. B. Bhatti, D. P. Panhwar, G. S. Umar, M. Chohan, N. Gujar, M. A. Panhwar and M. A. Unar, “Incidence and intensity of borer complex infestation on different sugarcane genotypes under agro climatic condition of Thatta.” Pak. J. Sci., 60(3), pp. 103-106. 2008.
[46] F. R. Goebel and M. Way, “Crop losses due to two sugarcane stem borers in Re´ union and South Africa.” Sugar Cane Int, 27, pp. 107-111. 2009.
[47] R. J. Rabindra, J. Poorani, S. K. Jalali, S. Joshi and S. Ramani, “Ceratovacuna lanigera Zehntner (Homoptera: Aphididae) a serious pest of sugarcane in Maharashtra and attempts at its management by biological means.” J. Biol. Control., 16(2), pp. 171-172. 2002.
[48] R. Kfir, W. A. Overholt, Z. R. Khan and A. Polaszek, “Biology and management of economically important lepidopteran cereal stem borers in Africa.” Annu Rev Entomol, 47, pp. 701-731. 2002.
[49] O. A. Fademi, “Nematodes as pests of sugarcane.” Lecture delivered at the One-week Intensive Sugarcane Production Training Course at National Cereals Research Institute, 2-7 November 1986.
[50] C. D. Mc Allister, J. W. Hoy and T. E. Reagan, “Temporal increase and spatial distribution of Sugarcane Yellow Leaf and Infestations of the Aphid vector, Melanaphis sacchari.” Plant Dis, 92, pp. 607-615. 2008.
[51] P. Allsopp, “Integrated management of sugarcane whitegrubs in Australia: an evolving success.” Annu Rev Entomol, 55, pp. 329-349. 2010.
[52] A. Mohammad, S. Ahmad, A. Khan, N. Ahmed and S. Ahmed, “Infestation of sugarcane borers and remedy by farming community at Dargai Malakand.” Pak. Entomol., 36(2), pp. 119-121. 2014.
[53] Mr. Nripesh Kumar Nrip, Dr. Anil T. Gaikwad, “A Study of Various Pests in Sugarcane Crop of India.” 2(11), pp. 2456-5040. 2017.

