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BIOENERGY PROSPECTIVE AND EFFICIENT UTILIZATION PATTERN FOR RURAL ENERGY SUPPLY IN DISTRICT PAKPATTAN

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ABSTRACT

A study was conducted in district Pakpatan during the year 2013. In this research work bioenergy available in three villages of district Pakpatan was evaluated for self- sustainable development. The villages had great amount of biomass but the conventional methods being used biomass energy in rural area are inefficient, it results in incomplete burning producing carbon dioxide which is harmful for peoples and animal health. The left over biomass is burnt in open fields without considering its worse effects on environment as well as the worth of these assets. The electricity shortfall as well as environmental degradation can be managed using modern utilizations pattern of bioenergy. Through personal interviews and field visits biomass and biogas potential was estimated. In village Nosher Bodla, village 67 D and village 105 D the potential of biomass was found to be as 9,170, 2,971 and 5,607 tons, respectively, that could generate 3.42, 1.27 and 2.21 megawatts hour electricity. Also biogas potential was calculated and found to be as 160 m^3, 75 m^3 and 110 m^3 per day respectively. The long term trend is shown for next 10 years which describes that by utilizing these resources effectively, the electricity as well as domestic gas demand of these villages could be easily fullfilled.

KEYWORDS: Biogas; biomass; rural areas and environment; Pakistan.

INTRODUCTION

Pakistan is situated in South Asia covering total area of 796,096 square kilometers. It is an agricultural country having population of 140 million. More than 70 percent populations is involved in agriculture and had about 480 US dollar per capita income. Agriculture plays a vital role in the economy of this country. The average domestic energy demand increment in Pakistan had been calculated to be 24 percent per year. Almost 35 percent of export

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earning is needed for the import of petroleum products, which meet about 48.8 percent of total Pakistan energy demand. About 90 percent of total country's wood is used as fuel and 7,000 ha of land is deforested every year. Biogas and biomass technology had been proved to be very successful energy resources (4). The deficit of energy in Pakistan could be fulfilled with the help of renewable energy resources that are wind energy, biomass and solar energy. The rising demand of energy could also be fulfilled with bioenergy especially. Due to inefficient method of bio energy usage the carbon emission is high. At present biomass collecting and transport involve traditional methods. The solution of all these problems is only to use modern methods of biomass utilization (2). Ghaffar (3) reported that animal dung is wasted in collection. It proportion is about 25 percent and about 50 percent is used as fertilizer in fields. We can produce 0.19 m^3 biogas at 15 C^o from 1 kg of dung at (dry basis). The rate becomes double at 27 C^o. On the basis of these results, 1m^3 gas/day can be produced from 20 kg (wet basis) dung at 25 C^o. So, we can produce 23, 25 million m^3/day biogas daily. Bhatnagar et al. (1) stated that for production of 1 kWh electricity of electricity 1.85 kg of biomass is required. The overall efficiency of biomass based gasification system was taken as 12.42 percent. The wood gasification mode of power generation is quite feasible and offers immense scope for rural development.

The present study has focused mainly on how a village can generate its demand of electrical energy from natural resource and agro-based material as well. Renewable sources other than biomass and biogas can also be used to predict energy generation of the village.

MATERIALS AND METHODS

This study was conducted at district Pakpatan during rise and fall seasons of the year 2013. The amount of crop residues of different crops was determined and their energy potential was estimated. The selected villages named as "Nosher Bodla", "67 D" and "105 D" situated near district Pakpattan. The coordinates of the site was 30.34^o N, 73.38^o E. The total area of theses village is about 1500, 600 and 1300 acres, respectively. With a population 600, 250 and 475 persons, respectively. The major crops of these villages are maize, rice, cotton, wheat, potato and sugarcane. The other crops like potato and vegetables also have a great share in the cropping pattern.

Data for this study werecollected by visiting farmers and fields throughout the year. The village leaders as well as Agriculture Officer were asked for help in data collection. The following data were collected from the selected site.

- Total population of village.
- Total area of village.
- Total cropped and uncropped area.
- Annual crop rotation and land use for each crop.
- Average yield of each crop.
- Total numbers of animals and their type.
- Total electricity consumption of village.

The second phase of the study was to estimate how much energy can be produced from that biomass and biogas. For this purpose, calorific value of all resources was taken from available literature. Then it was estimated that how much electricity and biogas can be produced. Energy consumption was calculated throughout the year for household as well as for irrigation pumping operations.

RESULTS AND DISCUSSION

Status of biomass sources in village

The biomass potential, demand, and energy consumption patterns across the village were calculated from the available data. Table summarizes information about the significant sources of biomass available in the village. It was observed that maize and cotton residues were the major sources of biomass.

Table 1. Total crop biomass available in the village Nosher Bodla.

Name of Crop	Type of residue	Total yield of crop (ton)	Crop to residue ratio`	Total biomass. (tons)
Wheat	Stalk	952	1.5	1,428
Maize	Stalks	1955	2	4,505
Cotton	Stalk	723	3.8	2,750
Rice	Straw	324	1.5	486
Total				9,170

Source :Dubey and Gangil (2009)

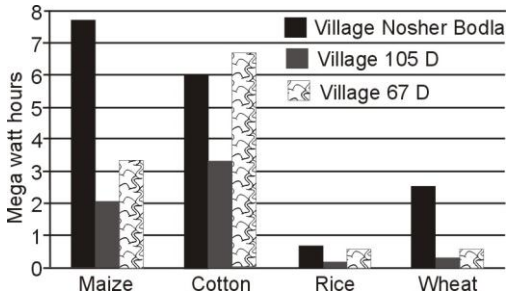

Fig. 1. Biogas available in the villages Nosher Bodla, 105 D and 67 D.

Biogas potential

The data showed that there was 1,963 tons of dung available in one year. The daily dung dropping was about 5.38 tons. Meena (7) reported that environmental conditions of Pakistan and India were almost same. One person needs about "0.227 m^3/person/day biogas for cocking purposes.

Daily 1 person require biogas	=	0.227 m^3
In village Nosher Bodla 600 person daily biogas needs	=	136.2 m^3
In village 67 D, 250 person daily biogas needs	=	56.75 m^3
In village 105 D, 475 person daily biogas needs	=	107.825 m^3
1 kg wet dung can produce = 0.03 m^3 biogas		
Biogas potential in village Nosher Bodla having 5380 kg	=	160 m^3 biogas
Biogas potential in village 67 D having dung 2500 kg	=	75 m^3 biogas
Biogas potential in village 105 D having dung 3700 kg	=	110 m^3 biogas

By calculations it was found that biogas is in excessive form for daily household needs (Fig.1). The excessive biogas can be utilized in other operations.

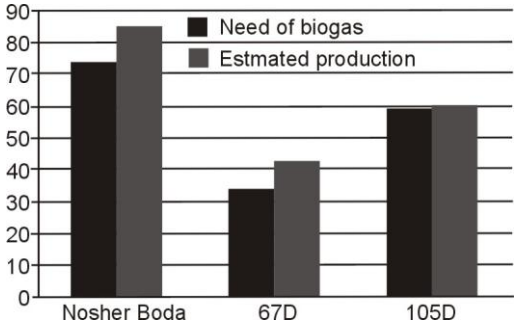

Fig. 2. Biogas need v/s estimated production of biogas.

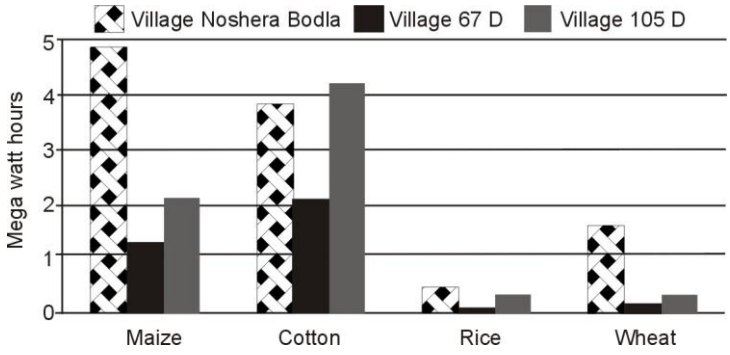

Fig. 3. Generation from biogas in all the selected villages.

Electricity generation capacity from biomass:

After collecting all required data electricity was calculated as below:-

Table 3. Energy Generation from Biomass in all the selected village.

Biomass resources	Quantity (kg)	Calorific value (kcal/kg)	Total Energy availability (kcal)	Total electricity generation. (MWh)
Wheat	1428,000	3800	54,26,400,000	0.5088
Maize	4,505,600	3665	165,13,024,000	1.55
Cotton	2,750,440	4711	129,55,250,000	1.215
Rice	486000	3040	14,58,000,000	0.137
Total				3.4

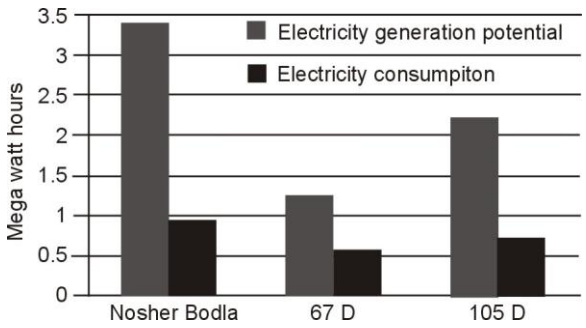

Fig. 4. Electricity consumption and generation.

It was also considered that electricity generation system based on gasification and biogas electrical energy generation project was good to produce the electricity for the villages. According to Bhatnagar (1) the biomass gasification system works on overall efficiency that is 12.42 percent. So the energy generation system can produce 3.99, 1.63 and 3.03 MWH electricity annually. This newly proposed project will not harm the biological life of that village.

Long term trend of biomass and energy:

Long term trend of biomass potential was estimated to know how much the study was feasible for future. For this purpose ten years data of biomass (maize, cotton, wheat and rice) was taken from the statistical department. After taking the data linear relationships were draw between 10 years biomass data v/s annual biomass. R^2 value is calculated to check the

strength of the linear relationship. If $R^2 > 0.5$, then the relationship will be considered to be perfect.

Village Nosher Bodlla

The ten year biomass data of "Village Nosher Bodlla" was taken and a linear relationship was drawn between year v/s biomass of each crop. In this village R^2 value of wheat biomass was 0.455, for maize biomass 0.205, Rice biomass 0.20 and for Cotton biomass it was 0.413 (Fig4. -7). This means that cotton and maize crop biomass showed stronger relationship then the other two.

The four graphs and their linear relationship is shown bellow.

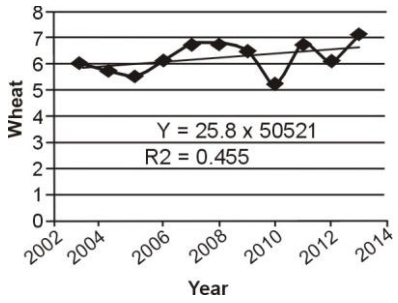

Fig. 5. Wheat biomass v/s year

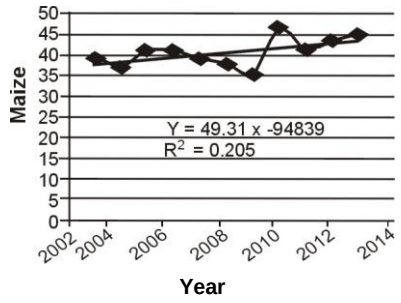

Fig. 6. Maize biomass v/s yea

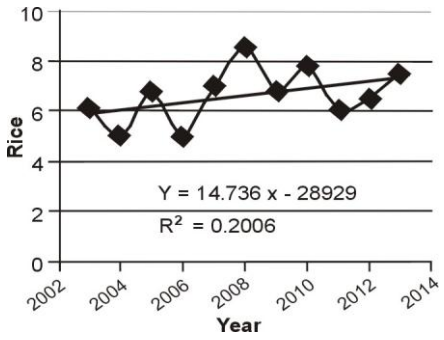

Fig. 7. Rice biomass v/s year

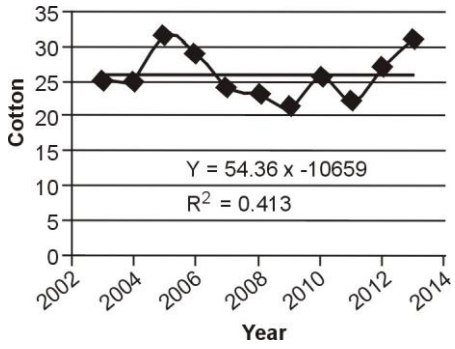

Fig. 8. Cotton biomass v/s year

To make R^2 more suitable the biomass values were extra plotted for next ten years on the bases of available trend. This trend showed that R^2 value of

wheat biomass was decreased from 0.455 to 0.393, for maize biomass it increased from 0.205 to 0.412, for rice biomass it increased from 0.20 to 0.411and for cotton biomass it was increased from 0.413 to 0.52. This means that the overall future prediction was more reliable.

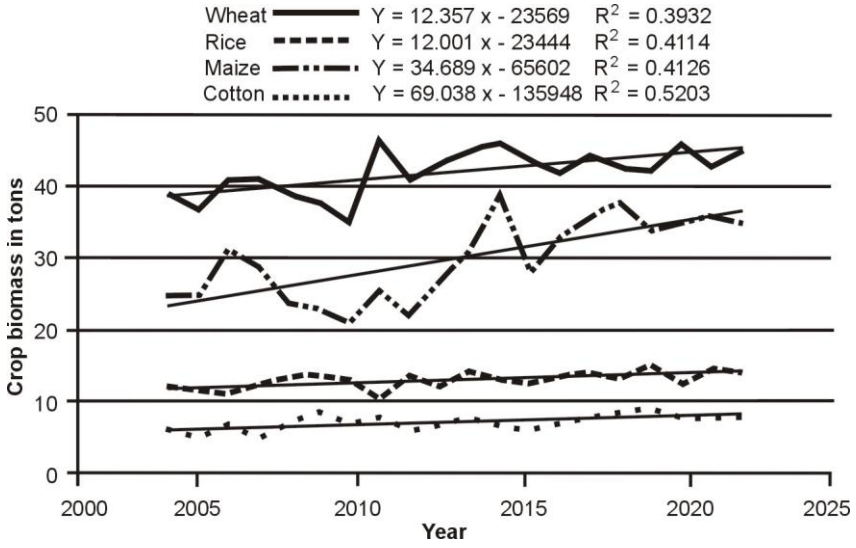

Fig. 9. Biomass v/s year graph by extra plotting.

On these extra plotted values electricity generation was assumed for next 10 year (Fig.9). The trend showed same relation as the above graph.

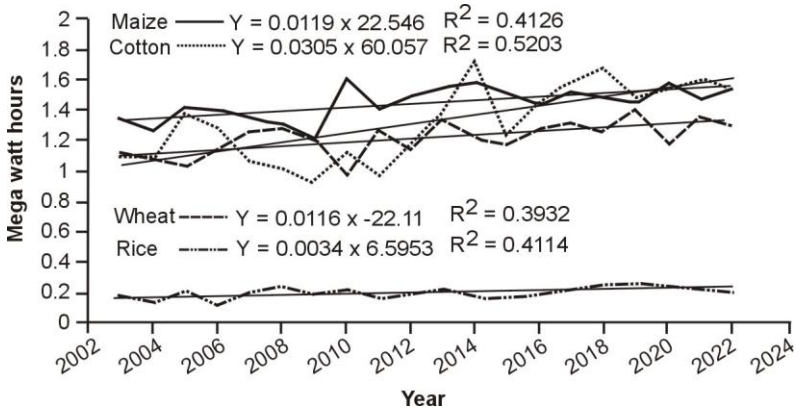

Fig. 10. Electricity v/s year graph by extra plotting.

Village 67 D

The linear relationship of wheat, maize and cotton biomass had a strong relationship with 10 years data because R^2 values are high. These were found to be 0.506, 0.512 and 0.474 respectively (Fig.10-13). For these three crops we can estimate the biomass quantity for any crop for future accurately. But the rice biomass had a weak relationship and the prediction for future will not be more accurate.

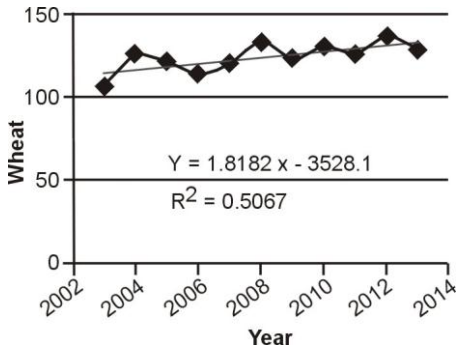

Fig. 11. Wheat biomass v/s year

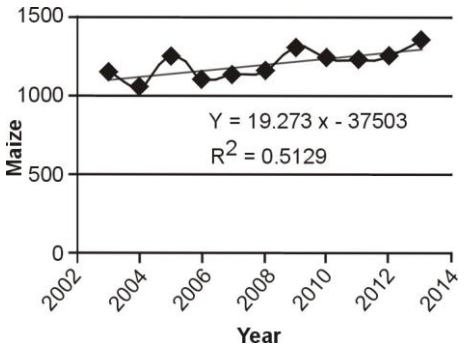

Fig. 12. Maize biomass v/s year

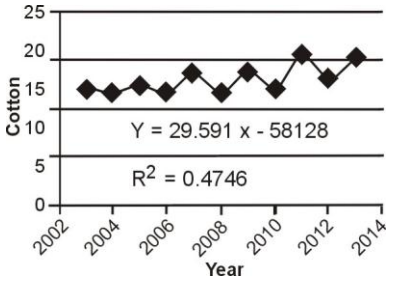

Fig. 13. cotton biomass v/s year

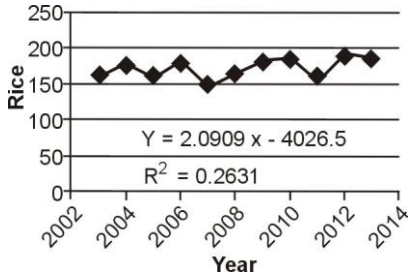

Fig. 14. Rice biomass v/s year.

By extra plotting the R^2 value of wheat biomass increased from 0.506 to .539, for maize biomass 0.512 to 0.647, for Cotton biomass 0.409 to 0.518 and for Rice Biomass it increased from 0.263 to 0.361 (Fig.1). This relationship showed that all the crop biomass were reliable sources for future energy generation. The graph is shown bellow.

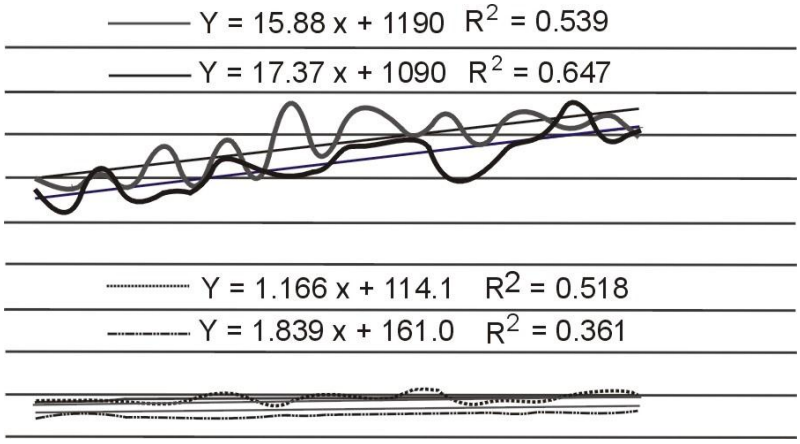

Fig. 15. Biomass v/s year graph by extra plotting.

Extra plotted graph for electricity generation gave same trends as above graph of biomass.

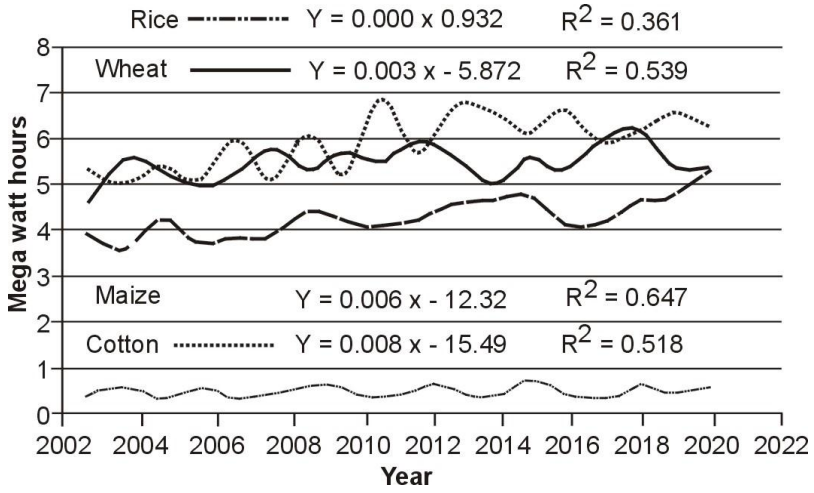

Fig. 16. Electricity v/s year graph by extra plotting.

Village 105 D

In this village, wheat had strong relation but other crops were resulted in weak relationship. The prediction of biomass for these crops will not be suitable. The R^2 value of wheat biomass was found to be 0.421, for maize 0.45, for cotton .531 and for rice it was 0.256.

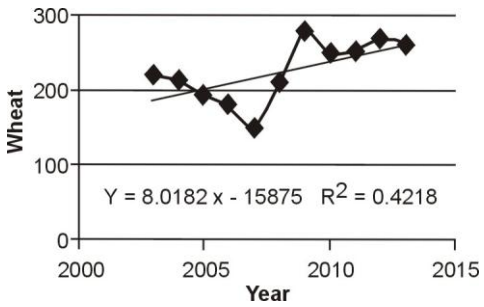

Fig. 17. Biomass v/s year graph

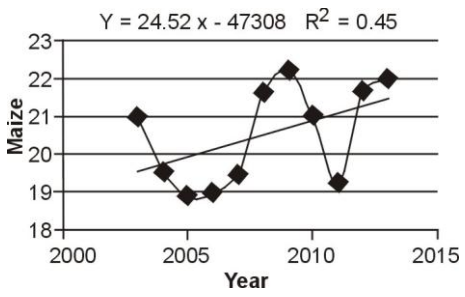

Fig. 18. Biomass v/s year graph

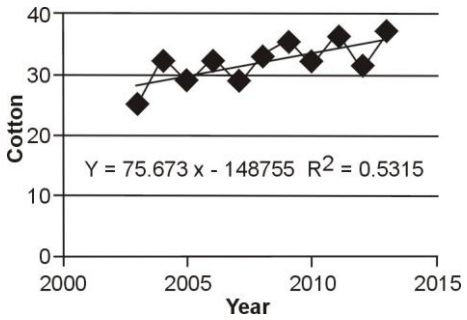

Fig. 19. Biomass v/s year graph

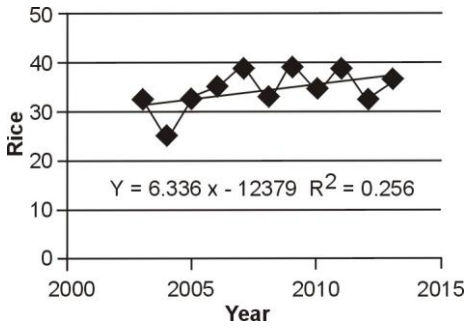

Fig. 20. Biomass v/s year graph

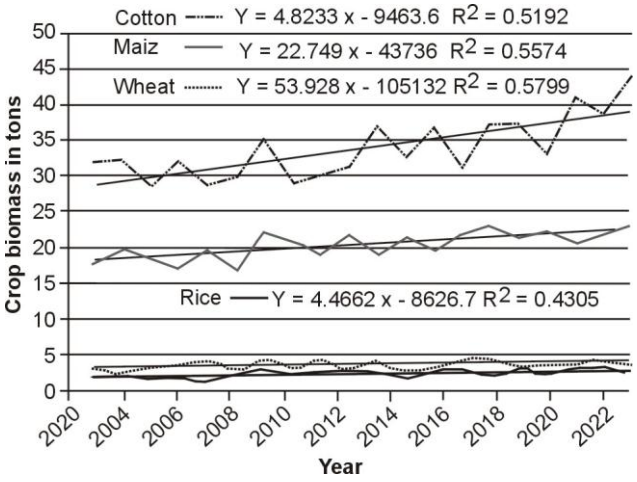

Fig. 21. Biomass v/s year graph by extra plotting.

After extra plotting the graph value of R^2 became higher and it showed strong relationship between biomass and year (Fig.20). The value of wheat increased from 0.421 to 0.519, maize increased from 0.45 to 0.557, cotton increased from 0.539 to 0.539 and Rice increased from 0.256 to 0.430.

The electricity generation on extra plotted graph values shown same trends as above graph.

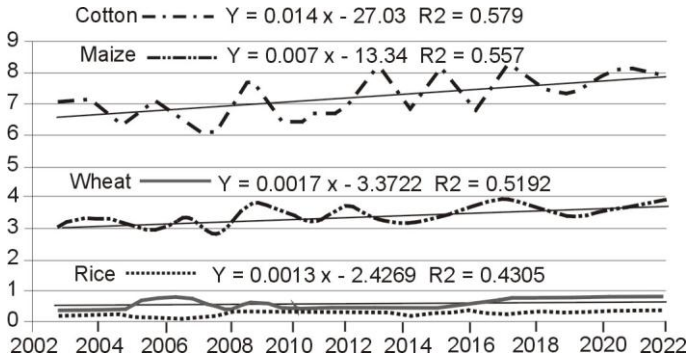

Fig. 22. Biomass v/s year graph by extra plotting.

The results showed that study areas are enriched in bioenergy sources. If this energy is utilized efficiently, the crisis in power sector can be overcome easily. The annual production of residue at the farm level is increasing with the cropping pattern as well as cropping intensity in the rural areas. These crop residues can be utilized for the energy production. Jiang *et al*.,(5) also studied the bionergy potential from the crop resides in China. They concluded that annual production of residues was found to be 103.8 million ton for rice, 75.6 million tons for wheat, 223 million tons for maize and 13.3 million tons for cotton and other crops similarly had a share of 89.8 million tons. The total production was found to be 505.5 million tons which had equivalent standard coal of 253.7 million ton.

CONCLUSIONS

Based on the study the following conclusions are drawn:

- In the study area the computation of available and demand of bioenergy showed that the village produces surplus energy for its resources.

- The annual theoretical electricity production to annual electricity demand ratio for village Nosher Bodlla is 3.8, for village 67 D 2.6 and for village 105 D is 3.2.
- The annual theoretical biogas production to annual biogas demand ratio for Village Nosher Bodlla is 1.2 m, for Village 67 D 1.32 and for Village 105 D is 1.02.
- On the bases of last ten years data, graph is plotted for each village and for each crop to show the long term trends. That graphs show the linear equation to predict the future values and also R^2 values to check the strength of relationship. In village Nosher Bodlla the R^2 value of wheat biomass is 0.455, for maize biomass 0.205, for rice biomass 0.20 and for cotton biomass it is 0.413. This means that cotton and maize crop biomass show stronger relationship than the other two.
- To make R^2 more suitable, biomass values are extra plotted for next ten years on the bases of available trend. This trend shows that R^2 value of wheat biomass is decreased from 0.455 to 0.393, for maize biomass it is increased from 0.205 to 0.412, for rice biomass it increased from 0.20 to 0.411and for cotton biomass it is increased from 0.413 to 0.52. This means that overall future prediction becomes more reliable.
- In village 67 D the R^2 value of wheat biomass increase from 0.506 to .539, for maize biomass 0.512 to 0.647, for cotton biomass 0.409 to 0.518 and for rice biomass .263 to 361. This relationship shows that all crops biomass are reliable sources for future energy generation.
- In Village 105 D the R^2 value of wheat biomass increase from 0.421 to 0.519, for maize biomass 0.45 to 0.557, for rice biomass 0.256 to 0.415 and for cotton biomass it is 0.531 to 0.430. By prediction it is clear that future prediction becomes more reliable.
- Analysis of the sector wise contribution in the energy surplus showed that animal dung, maize and cotton residue contributes the main bio resources in the villages.
- By adopting modern bioenergy production technologies shortfall of electricity as well as environmental problems can be minimized.

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M. Azhar Ali	**:**	**Helped in data analysis**
M. Usman Farid	**:**	**Helped in write-up**