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Comparison of agricultural mechanization indicators between western and eastern region of Uttar Pradesh, India

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■ **ABSTRACT :** Uttar Pradesh (UP) is the most populous state in India with 16.16 per cent of India's total population (Census, 2011). In terms of area, it is the fourth largest state in the country. The western region is characterized as the food and sugar basket of Uttar Pradesh. The western region was far ahead in adoption of improved technology as compared to other regions in Uttar Pradesh. Eastern region of Uttar Pradesh is flood prone. Poverty is acute in this region. Therefore, household food security is the primary concern of the farm households in this region. Farm mechanization is essential for sustaining agricultural growth, especially in the context of diminishing agricultural labour. However, large communities of small and marginal farmers are still not in a position to take full benefit of farm mechanization. After selection of variables, a questionnaire was prepared to collect primary data from each agro-climatic zone of western and eastern region. In western region primary data were collected from 200 farmers from 20 villages of 5 districts and in eastern region 3 districts out of 27 districts were taken for the study and primary data were collected of 180 farmers from 18 villages in 3 districts. The mechanization indicators were higher in western region in comparison to eastern region but human energy was more in eastern region than western region. The average value of mechanization index, power availability, cropping intensity, irrigation intensity, annual farmers income, annual input cost, human energy mechanical energy, total energy in western region and eastern region of Uttar Pradesh were 0.958, 3.98 kW/ha, 176 per cent, 176 per cent, Rs. 263538, Rs.45609, 63.73 kWh/ha, 1132 kWh/ha and 1203 kWh/ha, 0.951, 2.61 kW/ha, 160.42 per cent, 160.42 per cent, Rs.177125, Rs.49586, 81.98 kWh/ha, 655.49 kWh/ha and 735.94 kWh/ha, respectively. Similarly, degree of mechanization was also higher in western region in comparison eastern region in most of unit operations.

■ **KEY WORDS :** Mechanization index, Farm power, Degree of mechanization, Cropping intensity, Human energy, Mechanical energy, Total energy

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Uttar Pradesh (UP) is the most populous state in India with 16.16 per cent of India's total population (Census, 2011). In terms of area, it is the fourth largest state in the country. Its geographical area is about 241000 square km. UP is the largest producer of agricultural products in India. About 17 per cent of the total food grain production of the country comes from this state. UP have vast rich fertile landmass and water resources. It plays a significant role in the country's food and nutritional security programmes.

Despite all these advantages, the situation of farmers in UP is not very good. Agriculture plays a vital role in India's economy, 54.6 per cent of the population is engaged in agriculture and allied activities (Census, 2011) and it contributes 17.4 per cent to the country's gross value added for the year 2016-17 (at current prices). Even with slow growth of mechanization, the total production of food grains in India increased from over 50 million tonnes in 1950-51 to 272 million tonnes in 2016-17. Food grain demand is expected to reach 355 million tonnes in 2030 as compared to 250 million tonnes in 2016.This is clearly reflected in the existing inter-state variation in income of agricultural households in India. The western region is characterized as the food and sugar basket of Uttar Pradesh. This region contributed about 45 per cent of all food grain production and nearly 60 per cent of sugar production in the state during the same period. Rice and wheat were the main food grain crops. The Western region was far ahead in adoption of improved technology as compared to other regions in Uttar Pradesh. Eastern region of Uttar Pradesh is flood prone. Poverty is acute in this region. Therefore, household food security is the primary concern of the farm households in this region. To meet the household food security, as high as 91 per cent of all agricultural land was allocated to food grain crops. Rice and wheat shared about 75 per cent of the GCA. Chickpea and pigeonpea were the main pulses in the region. Farm mechanization is essential for sustaining agricultural growth, especially in the context of diminishing agricultural labor. However, large communities of small and marginal farmers are still not in a position to take full benefit of farm mechanization because of adverse economies of scale, particularly in operations like land preparation and harvesting. Agriculture is a labour intensive sector and its shortage during peak season can derail growth. Therefore, farming systems need to be adequately mechanized and customized for the Indian scenario. Considering small size of farms across India, farm mechanization would have to be enhanced through promotion of custom hiring models.

The western plain zone of Uttar Pradesh has 9-districts *i.e*. Ghaziabad, Muzaffarnagar, Meerut, Saharanpur, Baghpat, Gbnagar, Shambli, Hapur and Bulandshar. This region has the highestland productivity in the state. The cultivated area is about 70 per cent land is under agriculture and another 5 per cent land is under forest cover 76 per cent of the net sown area is irrigated. Tube wells are the predominant source of irrigation. The zone receives, on an average 907 mm rainfall.

The south western semi arid zone of UP covers 8-districts *i.e.* Agra, Aligarh, Etah, Firozabad, Hathras, Mainpuri, Mathura and Kasanganj. In spite of a relatively high proportion of arable and irrigated cropped area, land productivity in the southwestern plains of Uttar Pradesh is low. This is largely on account of cultivation of low value crops principally wheat and *Bajra*. The region receives about 721 mm of rainfall. More than 74 per cent of the net sown area is irrigated and over 69 per cent land is cultivated.

The mid western plain zone includes 6-districts *i.e.* Badaun, Bareilly, Moradabad Sambhal, JP Nagar and Shahjahanpur districts. The average rainfall of this zone is 103 cm. The average food grain is 25.17 q/ha. It covers 30.36 lakh ha cultivated area. The irrigated area of this zone is 83.21 per cent only. The variation in temperature is from 4.5 to 45.4 ^{o}C.

The Bhabhar and Tarai zone includes three districts *i.e*. Bijnor, Pilibhit and Rampur. The average rainfall of this zone is 140 cm. The average food grain production in the zone is 25.07 q/ha. The irrigated area of this zone is 73.29 per cent only. The variation of temperature is from 5.5 to 38.4 ^{o}C.

The eastern plain zone includes Azamgarh, Mau, Balia, Faizabad, Ghazipur, Jaunpur, Chandauli, Barabanki, Sultanpur, Amethi, Sant Ravidas Nagar and Varanasi districts. The rainfall is adequate with a normal of 103 cm. Over 70 per cent of the land is cultivated and more than 80 per cent of the cultivated area is irrigated.

The north eastern plains zone includes the districts of Baharaich, Gonda, Balrampur, Basti, Gorakhpur, Sidharth Nagar, Shravasti, Sant Kabir Nagar, Lakhimpur Kheri, Maharajgunj, Kushinagar and Deoria. The rainfall is quite high at about 121 cm, 73 per cent of the land area is cultivated and about half of the cultivated land is irrigated. Tube wells are the major source of irrigation.

The Vindhyan zone includes Mirzapur, Santravidas Nagar, Sonbhadra districts of Uttar Pradesh. The average rainfall is adequate at about 114 cm. The climate is similar to the other parts of the eastern plains of Uttar Pradesh. The irrigated area is 52.85 per cent. The type of soil is black heavy, red granular and alluvial soil. However, the region has a very high forest cover of about 40 per cent

of the land. Less than a third of this land is cultivated and only a third of this is irrigated.

In modern era, agricultural mechanization draws a major controversy that it is considered as the application of mechanical power technology, particularly tractors. However, three main levels of mechanization technologies need consideration: human power, animal power and mechanical power technologies, with varying degrees of sophistication within each level (Rijk, 1989), on the basis of capacity to do work, costs and precision and effectiveness (Morris, 1985). Agricultural mechanization technology further varies from location to location and crop to crop. Thus, the quality of inputs of mechanization, and consequently land and labour productivity may differ considerably (Gifford and Rijik, 1980). So, mechanization planning requires the quantification of level of mechanization for each crop production. Several authors developed different methods to quantify the level of mechanization based on power or energy availability and its impact in agricultural and labour productivity.

Zangeneh *et al*. (2010) defined mechanization index (MI) and level of mechanization (LOM), to characterize farming system of potato in the Hamadan province of Iran. These indicators are defined mathematically as eq. (1) and (2), respectively. The MI elaborated here is an expression of the deviation of the actual amount of motorized farm work from the normal values at the regional level.

$$MI = \frac{1}{n}\sum_{i=1}^{n}\frac{M_{e(i)}}{M_{av}} * \frac{L_i}{TL_i} \quad ...(1)$$

where,

MI = Mechanization index for the production unit 'a', $M_{e(i)}$ = Overall input energy due to machinery in the production unit 'a', M_{av} = Regional-average energy due to machinery, L_i =Land area cultivated in the production unit 'a', TL_i = Total farm land ownership of production unit 'a', n = Number of farms.

The MI index, proposed by Andrade and Jenkins (2003) is an indication of the amount of machinery a given farmer uses for farm work compared with the average in the region. The second term in eq. (1) includes a ratio between the land area cultivated with wheat crop and the total land ownership. This term was introduced because it reflects the importance of land demand for cultivation. The LOM index is based on the premise that a mechanized farmer is the one that finds a way to utilize amounts of mechanical energy that are higher than the typical values using locally available technology.

$$LOM = \sum_{i=1}^{n}\frac{P_i * \eta}{L_i} \quad ...(2)$$

where, LOM = Level of mechanization, P_i= Power of tractors, η= Correction factor for utilized power (0.75).

Field capacity was multiplied by rated power so the quantification of energy expenditure was made in work units (kWh). The regional normal will be obtained after compiling a full dataset of all respondents and then it would be defined the mode for the number of passes for each operation as well as the mode in tractor size and field capacity.

The level of mechanization is calculated by the following formula (Almasi *et al.*, 2000).

$$\text{Mechanization level}\left(\frac{hp}{ha}\right) = \frac{\text{Total power}}{\text{Cultivated area}} \quad ...(3)$$

The total power of existing tractors (hp) = Average nominal power of one tractor x Number of working tractors.

Total real power of tractors= Total power of existing tractors x Conversion co-efficient (0.75).

Animal energy (hp-h) = Total existing animal power x Annual functional hours.

Annual functional hours = Number of functional days x Mean functional hours during a day.

Total existing animal power (hp) = Produced power of animal x Number of animals.

Human energy (hp-h) =Total exiting human power x Annual functional hours.

Annul functional hours= Number of functional days x Mean functional hours during a day.

Total existing human power (hp) = Produced power of human x Number of humans.

METHODOLOGY

After selection of variables, a questionnaire was prepared to collect primary data from each agro-climatic zone of western and eastern region. The selected district from each agro-climatic zone of western region and eastern region were Saharanpur from western plain zone, Firozabad and Etah from south western semi-arid zone, Badaun from mid western plain zone, Pilibhit from Bhabhar and Tarai Zone, Varanasi from eastern plain zone, Lakhinpur Kheri from north eastern plain zone and Mirjapur from Vindhyan zone eastern region of Uttar Pradesh. A stratified multistage sampling design was

applied considering district and village as strata. In western region, 5 districts out of 26 districts of were taken for the study, then from each district, 5 villages and then from each village, 10 farmers were selected using random sampling. In western region primary data were collected from 200 farmers from 20 villages of 5 districts *i.e.* 40 farmers from each district in western region. In eastern region 3 districts out of 27 districts were taken for the study then from each district 6 villages and then from each village, 10 farmers were selected using random sampling. In eastern region primary data were collected from 180 farmers from 18 villages of 3 districts *i.e.* 60 farmers from each district. As mechanization is a multi-dimensional concept, thus, the following indices were evaluated to study the mechanization status in target region. The many variables were selected based on requirements to estimate degree of mechanization, level of mechanization (power availability), mechanization index, cropping intensity, irrigation intensity, input cost and farmers income. The following variables were selected:

Degree of mechanization (MD):

It is one of the quantitative measure of mechanization, by which the degree of mechanization of different operations in a cropping system like land preparation, sowing, weeding, irrigation, spraying, harvesting, threshing, transportation of agri-cultural produce and can be assessed. It is the ratio of mechanization area accomplished to the area to be mechanized (Almasi *et al.*, 2000). The degree of mechanization of particular implements used in a particular agricultural operation can be given as:

Degree of mechanization=Mechanized area/Area to be mechanized ...(4)

Level of mechanization (power availability):

Farm power is an essential input in agricultural production system to operate different types of equipment for timely field completion of agricultural works to increase productivity and maintain sustainability of farm. In this study, power availability was also evaluated for western and eastern region of Uttar Pradesh. The main sources of mobile power were human, draught animal, tractors and combines whereas the sources of stationary power were oil engines, electric motors and threshers in the western and eastern region. The power availability was evaluated using formula given by eq. 5.

Power availability (hp/ha) = Total power/Net cultivated area ...(5)

where,

Total power = Total mobile power + Total stationary power

Net cultivated area = Net cultivated area of target region villages wise number of tractor, combine harvester, bullocks, agricultural workers, power tiller, diesel engines and electric pump.

■ RESULTS AND DISCUSSION

The graphical representation of variation of mechanization index, power availability, total energy, cropping intensity, irrigation intensity, human energy, degree of mechanization, annual input cost, mechanical energy and annual farmers income western region of four agro climatic zones *i.e.* western plain zone, south western semi arid zone, mid western plain zone and Bhabhar and Tarai zone and eastern region of three agro climatic zones *i.e.* eastern plain zone, north eastern plain zone and Vindhyan zone are shown in Fig. 1 to 18. The farm mechanization indicators and their variability among different agro-climatic zones of western and eastern region were studied. It can be seen that western plain zone is more mechanized in terms of mechanization index and farm power availability and South western semi arid zone is least mechanized. Similarly, it can be seen that eastern plain zone is more mechanized in terms of mechanization index and farm power availability and vindhyan zone is least mechanized. From the Fig. 1 to 18, it is also clear that south western semi arid zone and mid western plain zone is almost same mechanized as per mechanization index and farm power point of view. The farm power value in western plain zone is 36.4 per cent more than south western semi arid zone From the Fig., it is also clear that north eastern plain zone is more mechanized than vindhyan zone as per mechanization index and farm power point of view. The farm power value in eastern plain zone is 13.66 per cent more than north eastern plain zone. Similarly mechanization indicators and other parameters of western region are also high in comparison to eastern region as shown in Table 1 except human energy, which was more in eastern region. The degree of mechanization of different farm implements in different unit operation is also shown in Fig.5 and 6. From the Table 2, it is also found that the degree of mechanization in western region is more than

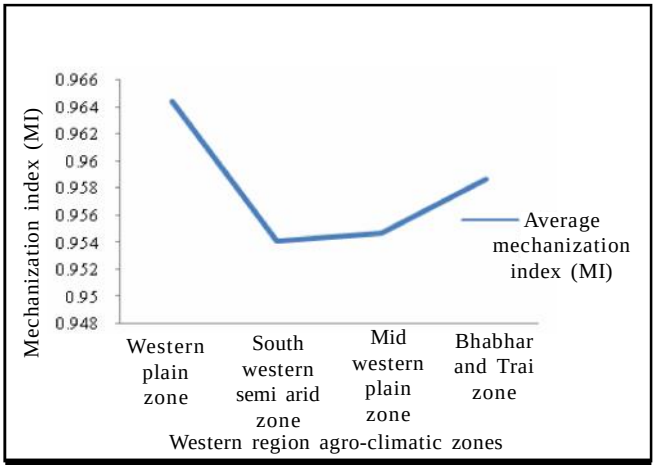

Fig. 1 : Variation of mechanization index with Western argo- climatic zones

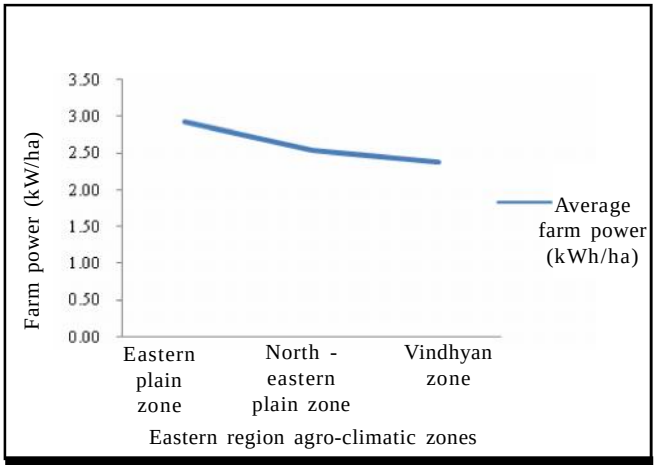

Fig. 4 : Variation of mechanization index with Eastern argo- climatic zones

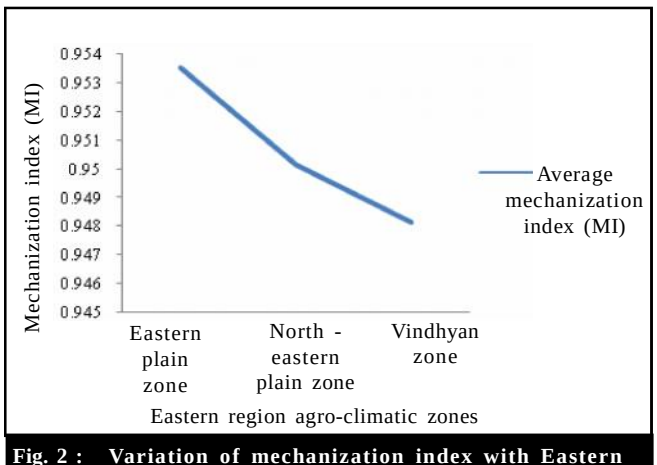

Fig. 2 : Variation of mechanization index with Eastern argo- climatic zones

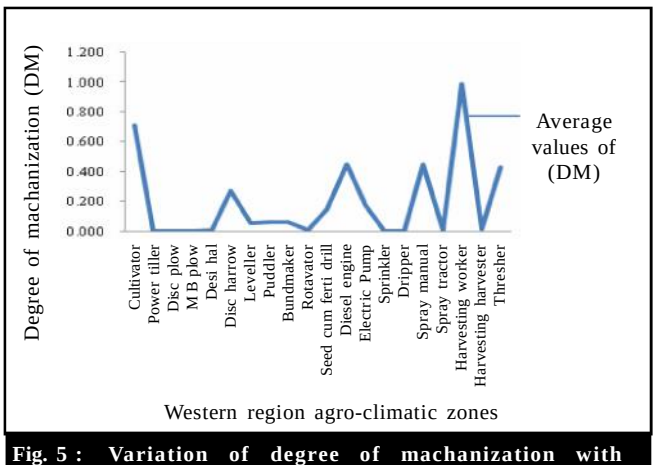

Fig. 5 : Variation of degree of machanization with Western argo- climatic zones

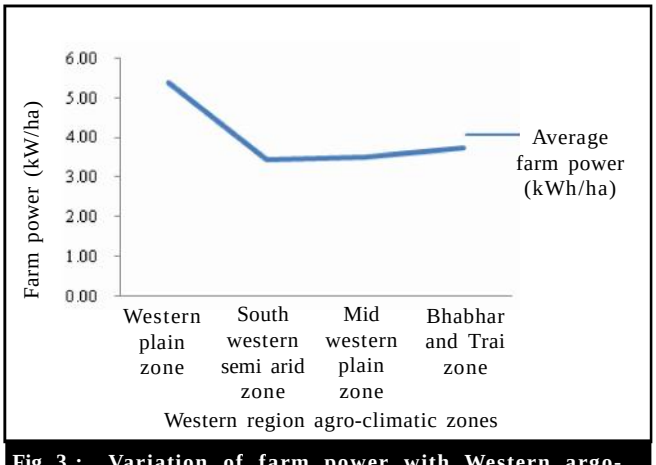

Fig. 3 : Variation of farm power with Western argo-climatic zones

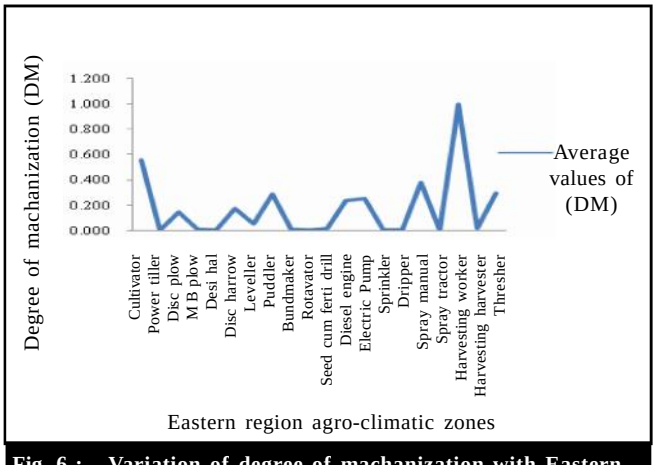

Fig. 6 : Variation of degree of machanization with Eastern argo- climatic zones

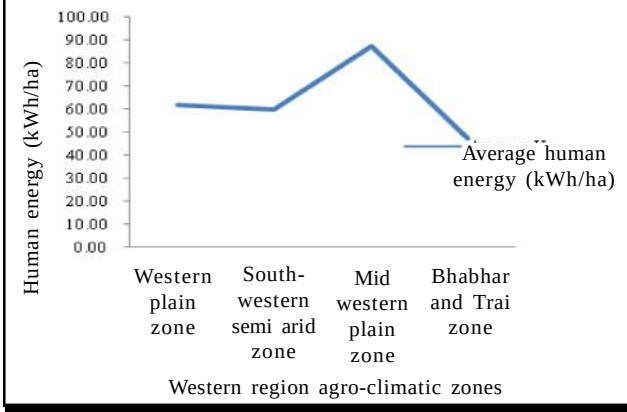

Fig. 7 : Variation of human energy with Western argo-climatic zones

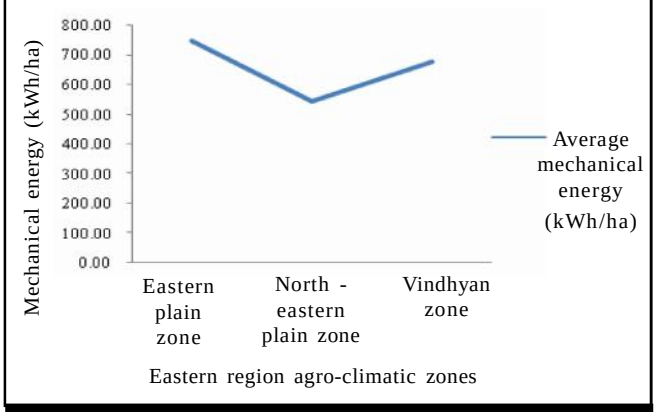

Fig. 10 : Variation of mechanical energy with Eastern argo-climatic zones

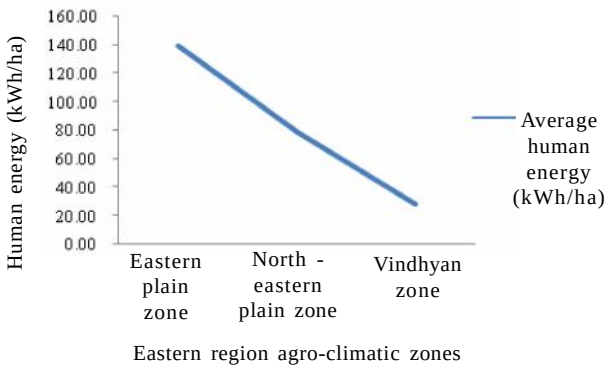

Fig. 8 : Variation of human energy with Eastern argo-climatic zones

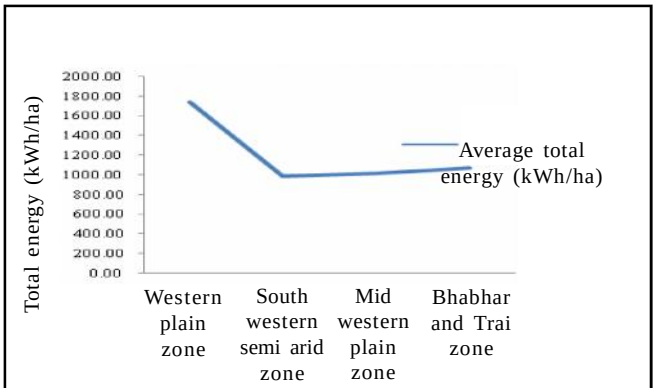

Fig. 11 : Variation of total energy with Western argo-climatic zones

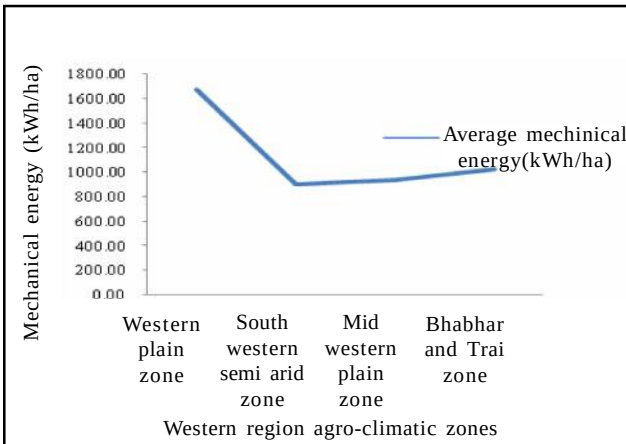

Fig. 9 : Variation of mechanical energy with Western argo- climatic zones

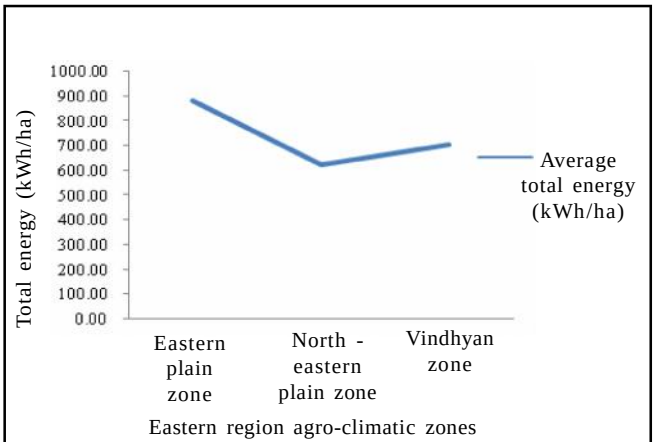

Fig. 12 : Variation of total energy with Eastern argo-climatic zones

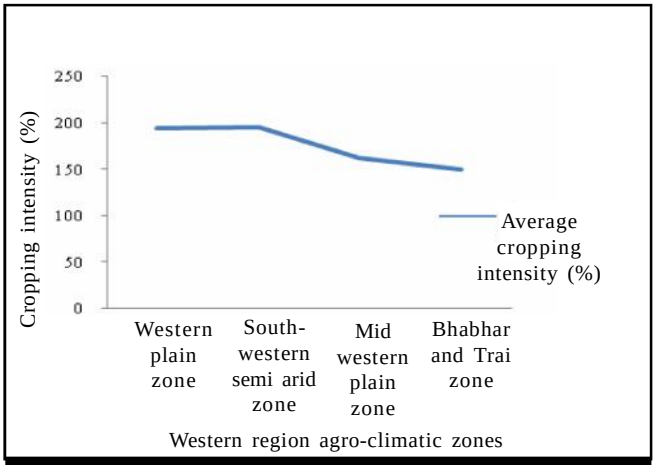

Fig. 13 : Variation of cropping intensity with Western argo-climatic zones

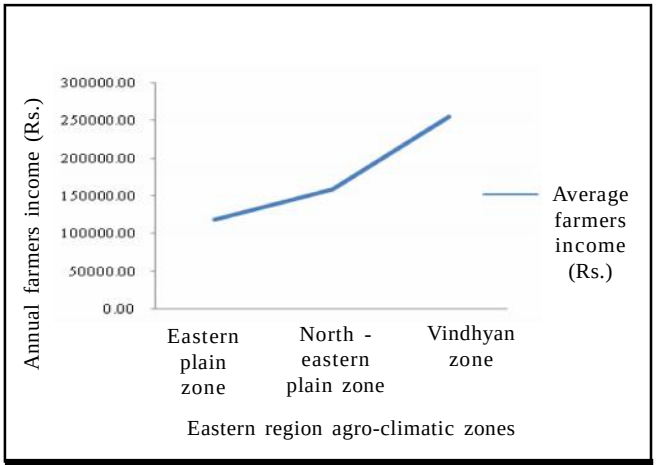

Fig. 16 : Variation of farmers income with Eastern argo-climatic zones

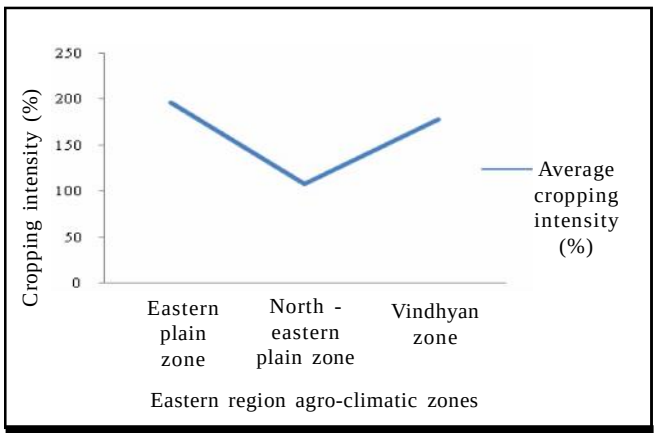

Fig. 14 : Variation of cropping intensity with Eastern argo-climatic zones

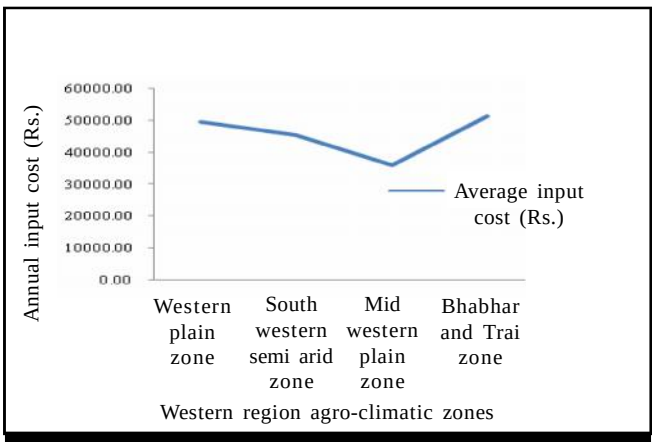

Fig. 17 : Variation of input cost with Western argo-climatic zones

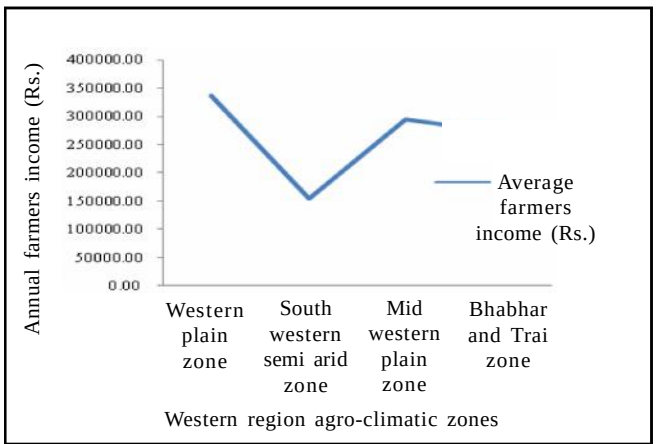

Fig. 15 : Variation of farmers income with Western argo-climatic zones

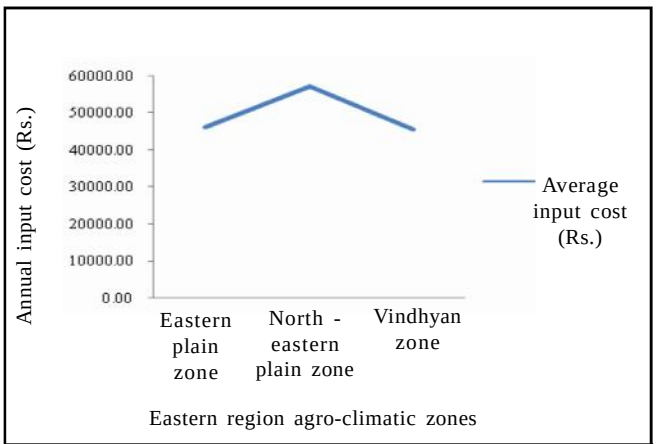

Fig. 18 : Variation of input cost with Eastern argo- climatic zones

Table 1 : Mechanization status parameters of western and eastern region in Uttar Pradesh

Sr. No.	Mechanization status parameters	Western region (Average values)	Eastern region (Average values)
1.	Mechanization index	0.958	0.951
2.	Farm power (kW/ha)	3.98	2.61
3.	Cropping intensity (%)	176	160.42
4.	Irrigation intensity (%)	176	160.42
5.	Annual farmers income (Rs.)	263538	177125
6.	Annual input cost (Rs.)	45609	49586
7.	Human energy (kWh/ha)	63.73	81.98
8.	Mechanical energy (kWh/ha)	1132	655.49
9.	Total energy (kWh/ha)	1203	735.94

Table 2: Degree of mechanization of different farm implements of western and eastern region of Uttar Pradesh

Degree of mechanization	Western region (Average values)	Eastern region (Average values)
Cultivator	0.709	0.558
Power tiller	0.002	0.000
Disc plow	0.002	0.139
M B plow	0.000	0.005
Desi hal	0.007	0.000
Disc harrow	0.267	0.168
Leveller	0.050	0.049
Puddler	0.058	0.287
Bundmaker	0.056	0.006
Rotavator	0.005	0.000
Seed cum ferti drill	0.144	0.013
Diesel engine	0.448	0.238
Electric Pump	0.171	0.250
Sprinkler	0.000	0.002
Dripper	0.000	0.000
Spray manual	0.450	0.379
Spray tractor	0.006	0.001
Harvesting worker	0.986	0.996
Harvesting harvester	0.014	0.004
Thresher	0.427	0.289

eastern region but diesel pumps are more mechanized in eastern region than western region.

Conclusion:

The mechanization index, power availability, cropping intensity, irrigation intensity, annual farmers income, annual input cost, mechanical energy, total energy were higher in western region in comparison to eastern region but human energy was more in eastern region than western region. The average value of mechanization index, power availability, cropping intensity, irrigation intensity, annual farmers income, annual input cost, human energy mechanical energy, total energy in western region and eastern region of Uttar Pradesh were 0.958, 3.98 kW/ha, 176 per cent, 176 per cent, Rs. 263538, Rs.45609, 63.73 kWh/ha, 1132 kWh/ha and 1203 kWh/ha, 0.951, 2.61 kW/ha, 160.42 per cent, 160.42 per cent, Rs.177125, Rs.49586, 81.98 kWh/ha, 655.49 kWh/ha and 735.94 kWh/ha, respectively. Similarly, degree of mechanization was highest in western and eastern region

in harvesting unit operation with harvesting worker followed by land preparation unit operation with cultivator.

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