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Energy Evaluation of Maize (*Zea mays* L.) at Variable Planting Time and Nitrogen Levels

Asma Fayaz*, K. N. Singh, B. Ahmad Lone and Sandeep Kumar

Division of Agronomy-SKUAST Kashmir

Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir, India

*Corresponding Author E-mail: asmafayaz3@gmail.com

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ABSTRACT

Field experiment was conducted at Sher-e-Kashmir University of Agricultural Science and Technology, Kashmir, during kharif season, 2015 and 2016 with the objective to study the growth and yield of maize under variable planting time and nitrogen levels and to simulate trends of maize production. Experiment was laid in Split-Plot design assigning three planting dates 22nd May, 30th May, 8th June to main plots and four Nitrogen Levels 80kg, 120kg, 160kg, 200kg to Sub-plots. Maximum energy was consumed in Sowing maize on 30th May with 160kg nitrogen level was 16711.72 MJ. Sowing maize on 30th May gives highest net returns of Rs. 106591.0 and 108952.5 with a B.C ratio of 2.62 and 2.67 was recorded with 160kg nitrogen level which was followed by 200kg with net returns of Rs. 103901.0 and 106244.5.As far as enery is concerned highest input was observed with nitrogen level of 200Nkha^{-1}(16711.72) As far as energy output were also observed to follow the same trend with planting on 8th June and 160 kg Nha^{-1} (115530.96 and 114334).

Key words: *Maize, Spacing, Date of sowing, Energy, MJ, Energy input, Energy output, Economics B.C ratio.*

INTRODUCTION

Maize is widely cultivated throughout the world, and produced each year greater than any other grain. The United States produces 40% of the world's harvest; other top producing countries include China, Brazil, Mexico, Indonesia, India, France and Argentina.Maize is cultivated on an area of 161.82 million hectares in the world with production of 844.36 million tonnes (FAO b) and productivity of 5.22 tonnes ha^{-1}. The renowned Noble Laureate Norman E. Borlaug, believes that "As the last two decades saw the revolution of rice and wheat, the next few decades will be known as maize era."[10].

Maize known as the "Queen of Cereals" is the third most important cereal crop in India after rice and wheat and is cultivated on 8.11 million (m) ha with production of 19.73 million tonnes with productivity of 2.41 tonnes ha^{-1} [2].

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Among the major crops of Jammu and Kashmir in terms of acreage maize is grown in area of 0.32 mha with the production of 0.63 m ton. The average yield of 2.0 t/ha of this crop has also nearly doubled since last decade. This increase in yield has been mainly achieved by increase in the area under high yielding varieties. However, the genetic potential of the improved varieties is at least three times of the present average yield of the state.

Being an important cereal, over 85% of its production in the country is consumed directly as food in various forms, the chapatis is the common ‘preparation, whereas, roasted ears, pop corns and porridge are other important forms in which maize is consumed. Besides, it is also used for animal feeding, particularly for poultry and in starch industry. Green maize plants furnish a very succulent fodder during spring and monsoon particularly in North India.

Maize is grown under wide range of climatic conditions, mostly in warmer parts of the temperate region and areas of humid sub-tropical climate. It is grown practically at all altitudes except where it is too cold or the growing season is too short. The crop requires considerable moisture and warmth from the time of planting to the termination of flowering period. The amount and distribution of rainfall are important in maize production. Maize cannot tolerate water stagnation. Rainfall of 50-75 cm during the vegetative period is helpful for proper development of maize plant. Moisture stress at the flowering stage drastically lowers the grain yield. Maize is grown in the state during kharif season and about 85% of the cropped area is rainfed. The maize crop, as such, is prone to the vagaries of rainfall distribution.

The productivity potential of hybrid/composite cannot be realized without proper management practices. The optimum date of sowing is important for maize so that the genotype grown can complete its life cycle under optimum environmental conditions. Optimum plant density provides conditions for maximum light interception right from early period of crop growth. Sowing dates have a pronounced effect on the yield of maize. Maize is generally sown from mid week of April to last week of May in lower belts of valley. However, the field may not be vacant at this appropriate time due to delay in harvesting of some rabi crops. Late sowing results in a significant decline in maize production . All the crops requires energy either direct or indirect, for calculating the total energy required to get the approx. All the energy sources either direct or indirect are converted to calculate the total energy consumed in maize crop. The indirect sources of energy are those which do not release energy directly but release it by conversion process. Some energy is inverted in producing indirect sources of energy. Seeds, manure (FYM and PM), chemicals, fertilizers and machinery can be classified under indirect source of energy.

MATERIAL AND METHODS

The investigation was conducted at the experimental farm of Division of Agronomy at main Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar which is situated 16 Km away from city center that lies between 34.08° N latitude and 74.83° E longitude at an altitude of 1587 meters above the mean sea level. The climate is temperate type characterized by hot summers and severe winters. The climate is temperate type characterized by hot summers and severe winters. The average annual precipitation over past twenty five years is 786 mm (Division of Agronomy, SKUAST-Kashmir) and more than 80 per cent of precipitation is received from western disturbances during winter/spring months. During crop growth period (22nd May - 4th October) Wettest months during crop growth period were September (320.6 mm) and july (101.4 mm) during 2015 and 2016, respectively. The mean maximum and minimum temperature for entire crop growth period of maize crop for 2015 was 33.5 and 20.0 ^{o}C, respectively and corresponding values for 2016 were 34.0 and 20.5 ^{o}C. The mean monthly meteorological data collected for the cropping season of 2015 and 2016 during experimental period recorded at the Meteorological observatory at Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, ShalimarThe mean monthly meteorological data collected for the cropping season of 2015 and 2016 during experimental period recorded at the Meteorological observatory at Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar.

The experiment included three dates of sowing with four nitrogen levels was laid out in split plot design with three replications assigning three planting dates 22nd May (D_1), 30th May(D_2), 8th June (D_3) to main plots and four nitrogen levels 80kg (N_1),120kg (N_2),160kg (N_3), 200kg (N_4) to sub-plots. Certified seed of maize variety "C_4" was used in the experiment. It has vigorous medium tall plants with a tendency to bear 2 cobs plant^{-1}. Cobs are long with conical cylindrical ears. Grains are flint type with orange yellow colour. The cost of cultivation and gross returns of different treatments were worked out at the existing market rates of both inputs and outputs. The net returns were calculated by subtracting the cost of cultivation from gross returns. Then benefit: cost ratio was worked out by dividing net returns with the cost of cultivation. Benefit: cost ratio was worked out as follows:

$$\text{B : C ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

The concept of energy analysis and efficiency in any production system relates to the input and output of energy .Energy efficiency is related to the ratio of input and output of energy in food systems. If output of the energy exceeds input, the process is described as 'efficient' and if input exceeds output, the process is described as 'inefficient'. All the input and output factors were converted into mega joules (MJ) by use of refrence and then energy input, energy output and net energy for different treatment combinations were calculated as under.

DISCUSSION

The energy source can be classified in a number of ways based on the nature of their transaction, also the energy sources are classified based on animate and inanimate characteristics.

3.1 Classification of Energy

3.1.2 Indirect source of energy

The indirect sources of energy are those which do not release energy directly but release it by conversion process. Some energy is invested in producing indirect sources of energy. Seed manures, FYM, chemicals, fertilizers and machinery can be classified as indirect sources of energy**.**

On the basis of source, the energy can be classified as direct and indirect energy.

3.1.1 Direct source of energy

The direct source of energy are those release the energy directly like man power, bullocks, stationary and mobile mechanical or electric power units *viz.*, diesel engines, electric motor, power tiller and tractors. The direct energy may be further classified as renewable and non-renewable sources of energy depending upon their replenishment. Renewable direct sources of energy. In this category, the energy sources, which are direct in natural but can be subsequently replenished, are grouped. The energies which may fall in the group are human beings, animals, solar and wind energy, fuel wood, agricultural wastes etc. Non renewable direct sources of energy: In this category, direct energy sources which are not renewable at least in near future say next 100 years are classified.

Each and every energy source has some economic value. Some energy source are available comparatively at low cost where as other are available cheaply are called non commercial source of energy. Human labour and bullocks exemplify the category of non commercial source of energy. Human labour and animals are readily available and can be used as a source of power directly.

The energy input of various direct sources of power is given in Table 1. Continuous demand in increasing food production resulted in intensive use of chemical fertilizer, pesticides, agricultural machinery and other natural recourses.

Among management practices, efficient use of non-monetary inputs such as water management, time and method of fertilizer application, selection of cultivar, plant density seedling age, transplanting and harvesting schedules are some of the important means to enhance the maize productivity. Date of sowing along with optimum plant population and Nitrogen levels plays a major role in maize production, almost 65% of maize in Kashmir is produced as rainfed thus having low productivity. However management of non- monetary inputs can increase the productivity of maize.

In this paper all the farm operations for cultivation of maize starting from field preparation to harvesting are converted in terms of energy utilized by each operation in MJ. The output yield of maize and stover is also converted into energy output in terms of MJ.

In India, agriculture not only provides food for all but also employs 70 per cent of the population, generates 40 per cent of the national income and consumes about 10 per cent of the commercial forms of the energy. Crop cultivation requires application of both animate (bullock, human power) and inanimate (tractors, tillers etc.) forms of energy at different stages. Nutrients are provided through farmyard manure, chemical fertilizers or both. Pesticides are required to check or prevent pest attack. Irrigation is done either manually (manually and animal operated) or through diesel/electric pump set (to fill groundwater). To meet the basic food needs of our expanding human population, a productive sustainable agricultural system must become a major priority. The delectable resources are fossil fuels, which are non-renewable since the rate of their utilization exceeds the rate at which they are formed. Energy used in agricultural production has become more intensive due to fossil fuel, chemical fertilizer, pesticide, machinery and electricity to provide substantial increase in food production. Efficient use of energy is one of the principle requirements of sustainable agriculture. Many researchers have studied energy and economic analysis to determine the energy efficiency of plant production such as Isabgual seed in Spain and in rainfed wheat in Iran. To get higher productivity, farmers in general use their resources in excess and in-efficiently, particularly when these are priced low or are available in plenty. In modern agricultural systems, the practice involve a shift to a package of improved inputs to achieve greater levels of output, other energy inputs are used to enhance the energy transformations. Energy assessment in agriculture can be made by taking into account the whole system of agriculture or for a specific crop production. In case of crop production, the entire system has to be considered and energy balance of total input and output is evaluated.

Table 1. Energy equivalent of input in agricultural production

Particulars	**Units**	**Energy (MJ) equivalent**	**Remarks**
Inputs			1 Adult Woman=0.8
Human labour			adult man
(a) Adult man	Man hour	1.96	Khild =0.5 adult man.
(b) Woman	Woman hour	1.57	
(c) Child	Child hour	0.98	
Animals			
(a) Bullocks			Body Weight > 450 kg
(i) Large	Pair hour	14.05	- 352-450 kg
(ii) Medium	-	10.10	- < 350 kg
(iii) Small	-	8.07	He – buffalo = 1.5
(b) Buffalo (He)	Pair hour	15.15	Medium bullock

Diesel	Litre	56.31	51 includes cost
Petrol	Litre	48.23	Of lubricants.
Electricity	Kwh	11.93	-
Machinery			Distribute the Weight of
(a) Electric Motor	Kg	64.80	the machinery equally
(b) Self Propelled Machines	Kg	64.80	over the total life span of the machinery in hrs.
(c) Farm machinery	Kg	62.70	
Fertilizers			
(i) N	Kg	60.60	Estimate the quantity
(ii) P_2O_5	-	11.1	used.
(iii) K_2O	-	6.1	
FYM	Kg (dry mass)	0.3	Chemical require
Chemicals			dilution at the time of
Superior	Kg	120	application.
$ZNSO_4$	-	20.9	DDT, eypsum & others
Inferior chemicals	-	10.0	not requiring dilution

Table 2. Energy equivalent of output in agricultural production

Particulars	Units	Equivalent energy (MJ)	Remarks
Output			
(1) Crereals & Pulses	Kg (dry mass)	14.7	The main input is grain.
(2) Oilseeds	-	25.0	The main output is
(3) Sugarcane	Kg harvested mass	5.3	seed except for Ground nut where it
(4) Vegetables			is pod.
(i) Higher food value Sweet Potato, Tapioca.	Kg	5.6	
(ii) Medium food value Potato, beet root, Colacasia		3.6	
(iii) Low food value carrot, radish, onion, Beet root.		1.6	
(5) Fruit for Seed Vegetables	Kg	1.9	
(6) Ground family vegetables	Kg	0.8	
(7) Leafy vegetable	Kg	0.8	
(8) Fruits			
(i) Higher food value Tannid, grapes	Kg	11.8	
(ii) low food value	Kg	1.9	
(9) Fibre crops	Kg by man	11.8	
(10) Fuel crops	-	18.0	
(11) Fodder crops	-	18.0	
By products straw	12.5 Kg dry mass	18.0	

Table 3. Energy equivalents for Maize crop ha^{-1}

Particulars	**Common Energy involved**		
	Energy source	**Quantity**	**(MJ) total energy**
Field preparation 1.Tractorization 2 (Tractor ploughing with cultivator 3 hrs/ha for 1 ploughings)	Mechanical	6 hrs	80.99
2.Pulverizing the soil with rotovator 3 hrs	Mechanical	3 hrs	40.49
3. Diesel for ploughing	21 lit.	6 hrs	1182.5
4.Diesel for rotavator	10.5 lit.	3 hrs	591.3
5.Man power	3 man days ha^{-1}	18 hrs@ 1.96/hr	35.28
6.Formation of ridges , furrows and cowing	15 labours ha^{-1}	90 hrs @ 1.96/hr	176.4
7. FYM	10000 kgha^{-1}	@ 0.3 /kg	3000
8. N	80 kgha^{-1} 120kgha^{-1} 160kgha^{-1} 200kgha^{-1}		4848 7272 9696 12120
P_2O_5	60 kgha^{-1}	@ 11.1/kg	666
K_2O	30 kgha^{-1}	@ 6.7/kg	201
$ZnSo_4$	20 kgha^{-1}	@ 20.9/kg	418
Labour for incorporation of FYM & broadcasting of fertilizers & broadcasting of fertilizers	10 labours ha^{-1}	60 hours @ 1.96/hr	117.6
8. Weeding /hoeing /earthing up	20 labours ha^{-1}	120 hours	235.2
9. Irrigation labour	500 mm @ 2 man days / Application	@1.2m^3 36 hrs for 3 application @ 1.96/ha @1.96/ ha @18/12.5 kg straw	600 70.56 750
10. Harvesting and dehusking and tying of stower	15 labours ha-1	90 hrs	176.4

Table 4. Relative economics and energy in put /output of maize as influenced by different planting dates and Nitrogen levels

Treatments	Grain yield	Straw yield	Cost of Cultivation (ha^{-1})	Gross returns (ha^{-1})	Net return (ha^{-1})	Bene fit : Cost ratio	Energy Input MJ	Energy output MJ
(D_1N_1)	49.12	187.23	40180	126324.5	86144.5	2.14	7332.76	99167.52
(D_1N_2)	51.43	189.75	40420	125102.5	84682.5	2.09	11863.72	102926.1
(D_1N_3)	54.34	187.34	40660	136781.0	96121.0	2.36	14287.72	106856.76
(D_1N_4)	48.32	190.45	40900	131427.5	90527.5	2.21	16711.72	98455.2
(D_2N_1)	52.73	201.34	40180	135661.0	95481.0	2.37	7332.76	106506.06
(D_2N_2)	55.65	212.54	40420	138301.0	97881.0	2.42	11863.72	112411.26
(D_2N_3)	57.4	216.34	40660	147251.0	106591.0	2.62	14287.72	115530.96
(D_2N_4)	53.21	223.34	40900	144801.0	103901.0	2.54	16711.72	110379.66
(D_3N_1)	43.12	211.12	40180	116528.0	76348.0	1.90	7332.76	93787.68
(D_3N_2)	47.79	210.21	40420	117771.5	77351.0	1.91	11863.72	100521.54
(D_3N_3)	48.21	214.45	40660	128932.0	88272.0	2.17	14287.72	101749.5
(D_3N_4)	42.43	216.75	40900	128587.5	87687.5	2.14	16711.72	93584.1

Cost of tractorisation=7000 ha^{-1} Cost of seed=28 kg^{-1}, Urea= 5.5 kg^{-1}, DAP= 22.5 kg^{-1}, MOP= 1 6.8 kg^{-1}
Cost of stover=1.5 kg^{-1}

Table 4. Relative economics and energy in put /output of maize as influenced by different planting dates and Nitrogen levels

Treatments	Grain yield	Straw yield	Cost of Cultivation (ha^{-1})	Gross returns (ha^{-1})	Net return (ha^{-1})	Bene fit : Cost ratio	Energy Input MJ	Energy output MJ
(D_1N_1)	47.41	197.23	40180	124284.5	84104.5	2.09	7332.76	99919
(D_1N_2)	49.30	197.00	40420	126867.5	86267.5	2.13	11863.72	103020
(D_1N_3)	50.01	192.00	40660	128820.0	88160	2.16	14287.72	104159
(D_1N_4)	49.80	192.45	40900	128150.0	87250	2.13	16711.72	103811
(D_2N_1)	52.32	207.00	40180	135690.0	95510	2.37	7332.76	108230
(D_2N_2)	54.78	201.64	40420	140506.0	100086	2.47	11863.72	112293
(D_2N_3)	56.02	212.75	40660	149612.5	108952.5	2.67	14287.72	114334
(D_2N_4)	55.90	216.43	40900	147144.5	106244.5	2.59	16711.72	114067
(D_3N_1)	45.31	213.45	40180	126637.5	86457.5	2.15	7332.76	98488
(D_3N_2)	50.21	208.76	40420	131734.0	91314	2.25	11863.72	106283
(D_3N_3)	51.90	213.67	40660	136710.5	96050.5	2.36	14287.72	108766
(D_3N_4)	50.88	213.65	40900	135907.5	95007.5	2.32	16711.72	107339

Cost of tractorisation =7000 ha^{-1} Cost of seed =28 kg^{-1}, Urea= 5.5 kg^{-1}, DAP= 22.5 kg^{-1}, MOP= 1 6.8 kg^{-1}
Cost of stover=1.5 kg^{-1}

Energy as a critical aspect of national development process. It is expended in agricultural operation in food processing and transportation, in the production of fertilizer, pesticides and farm equipments. The energy sources both animate and inanimate are involved in maize crop production in our valley. The direct sources of energy are those that release the energy directly-like man power, bullocks, stationary and mobile mechanical or electric power units *viz.,* diesel engines, electric motors, power tiller and tractor's. Energy use in agricultural production has become more intensive due to the use of fossil fuel, chemical fertilizer, pesticides, machinery and electricity to provide substantial increases in food production. Efficient use of energy is one of the principal requirements of sustainable agriculture. Many researchers have studied energy and economic analysis to determine the energy efficiency of plant production, such as sugarcane in Moroco, apple in Iran, cucumber in Iran. To get higher productivity the farmers in general, use their resources in excess and inefficiently, particularly when these are priced low or free or are available in plenty under Kashmir conditions for cultivation of maize. So the present study reveals with output input energy use in maize crop. The aim of the study is to determine the total amount of input- output energy used in maize and to take decisions with regards to energy management to crop production under temperate conditions.

For calculating energy input/output for maize cultivation on 1 hectare of land, calculations were carried out using data from experiment conducted during 2015-2016 at Division of Agronomy Shalimar Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. Total energy utilized for maize cultivation on 1 hectare of land = energy utilized in total all the operations carried out on crop duration from sowing to harvest (Table 4). During both the years sowing of maize on 8th June gives highest net returns of Rs. 106591.0 and Rs. 108952.5 with a B: C ratio of 2.62 and 2.67 was recorded with 160kg Nha^{-1} which was followed by N_4(200kg Nha^{-1}) with net returns of 103901.0 and 106244.5. As far as energy output were also observed to follow the same trend with planting on 8th June and 160 kg Nha^{-1} (115530.96 and 114334) this may be the fact of having higher grain yield in this treatment followed by treatment N_4 200kg Nha^{-1}(110379.66 and 114067) . Any further delay in planting decreases the net returns and energy output as the grain yield also gets decreased with delay in planting, also nitrogen levels followed the same trend. Least values of net returns (76348.0 and 86457.5) energy output, were recorded when sowing was carried out on 30th June that too with 80kg Nha^{-1} . The reason behind this may be lower yield , as of delayed in sowing of about 20 days that result the early shifting of crop from one stage to another, also lower level of nitrogen fertilizer had contributed to the lower grain yield of maize crop

CONCLUSION

Under temperate conditions of Kashmir for attaining better results in terms of energy, maize crop should be sown on around 8th June with Nitrogen levels 160kgha^{-1}to gain maximum energy output.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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