

“Energy Evaluation of Maize (*Zea mays* L.) under irrigated and un-irrigated conditions.”

Division of Agronomy-SKUAST Kashmir

All Authors are affiliated with: Shere – Kashmir University Of Agricultural Sciences And Technology Of Kashmir

ABSTRACT

Data with respect to yield was taken from Ph.D student Division of Agronomy Shalimar Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir Experiment was conducted during 2012 and 2013 under irrigated and un-irrigated mulched conditions with the objective to study the growth and yield of maize at different planting dates and planting density and to simulate trends of maize production. Experiment was laid in split-plot design assigning four planting dates 15th April, 30th April 15th May and 30th May to main plots and three planting density 50cm×20cm ,60cm×20cm and 70cm×20cm to sub-plots.. Maximum energy was consumed in irrigated conditions as compared to Unirrigated mulch conditions i.e 14805 MJ and 13034 MJ respectively. Irrigated maize sowing on 15th April gives highest net returns of Rs.126740 with a B: C ratio of 2.18 was recorded with 50x20 cm spacing which was followed by 60x20 cm with net returns of Rs.87170. As far as energy ratio energy productivity and net energy were also higher with 5.79 ,204.6 and 70962 MJ respectively. Un-irrigated mulch maize sow on 15th April gives highest net returns of 87170 with a B: C ratio of 2.18 with 60x20 cm spacing which was followed by 50x20 cm with net returns of Rs 75827. As far as energy ratio energy productivity and net energy were also observed to follow the same trend with 5.82 ,182 and 62793 MJ respectively with sowing on 15th April and planted at 50x20 cm apart. For higher energy use efficiency, energy productivity, and net energy, maize crop should be sown on around 15th April with an spacing of 50x20cm or 60x20 cm under irrigated conditions and should be sown on around 15th April with an spacing of 60X20cm under Un-irrigated mulch conditions.

Key words: Maize,Spacing , Date of sowing , Energy ,MJ, Net energy, Energy ratio, Specific Energy, economics B.C ratio.

INTRODUCTION:

Maize (*Zea mays* L.) is emerging as an important cereal crop in the world after wheat and rice. It is now an important ingredient in food, feed, fodder and large number of industrial products. It has acquired dominant role in the farming sector and macro-economy of the Asian region. It has the highest potential of per day carbohydrate productivity. Thus, it is not without any basis that father of green revolution, the renowned Noble Laureate, Dr. Norman E. Borlaug, believes that “After the last two decades saw the revolution in maize and wheat, the next few decades will be known as maize era” (Patil *et al.*, 2000).

Maize known as the “Queen of Cereals” is the third most important cereal crop in India after rice and wheat and is cultivated on 8.17 million ha with the production of 19.73 million tonnes and productivity of 4.21 tonnes ha⁻¹ (Agricultural Research Data Book, 2013). Among the major crops of Jammu and Kashmir in terms of acreage maize is grown in area of 315.81 thousand hectares with the production of 0.63 million tonnes and productivity of 2.0 tonnes ha⁻¹ (D.E.S, 2011). 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. In India maize production in Jammu & Kashmir is 0.53 million tones on an area of 3.17 million hectares with an average yield of 1776 Kg ha⁻¹ (Directorate of Economics and Statistics Government of India 2014)

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

45 maize plant. Moisture stress at the flowering stage drastically lowers the grain yield. Maize is grown in the state during *kharif* season and about
46 85% of the cropped area is rainfed. Under such considerable rainfed area and there is scope of increasing productivity by using low cost
47 available mulch as under existing agro- climatic condition, the maize crop, is prone to the vagaries of rainfall distribution during crop growth.

48 The productivity potential of hybrid/composite cannot be realized without proper management practices. The optimum date of sowing is
49 important for maize so that the genotype grown can complete its life cycle under optimum environmental conditions. Optimum plant density
50 provides conditions for maximum light interception right from early period of crop growth. Sowing dates have a pronounced effect on the yield
51 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
52 this appropriate time due to delay in harvesting of some rabi crops. Late sowing results in a significant decline in maize production (Khan *et al.*,
53 2011). All the crops requires energy either direct or indirect, for calculating the total energy required to get the approx. All the energy sources
54 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
55 release energy directly but release it by conversion process. Some energy is inverted in producing indirect sources of energy. Seeds, manure (
56 FYM and PM), chemicals, fertilizers and machinery can be classified under indirect source of energy.

57 **Materials and methods**

58 The investigation was conducted at the experimental farm of Division of Agronomy at main Campus of Sher-e-Kashmir University of
59 Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar which is situated 16 Km away from city center that lies between 34.08 ° N
60 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
61 summers and severe winters. The average annual precipitation over past twenty five years is 786 mm (Division of Agronomy, SKUAST-
62 Kashmir) and more than 80 % of precipitation is received from western disturbances during winter/spring months. During crop growth period
63 (15th April - 4th October) the maximum temperature ranged between 18⁰C to 32⁰C, while minimum temperature ranged between 4.30 ⁰C to 17.78
64 ⁰C with relative humidity 49-89% (maximum) and minimum being between 23% to 86%. The mean monthly meteorological data collected for

the cropping season of 2012 and 2013 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 four dates of sowing with three levels of spacing was laid out in a Split Plot Design with three replications assigning four planting dates 15th April (D₁), 30th April (D₂), 15th May (D₃) and 30th May (D₄) to main plots and three planting density 50cm×20cm (S₁), 60cm×20cm (S₂) and 70cm×20cm (S₃) to sub-plots. Certified seed of maize variety “C₆” was used in the experiment. It has vigorous medium tall plants with a tendency to bear 2 cobs plant⁻¹. Cobs are long, tapering towards the end with bright orange flint grains. A fertilizer dose of 10 ton FYM ha⁻¹, 120 kg N ha⁻¹, 60 kg P₂O₅ ha⁻¹, 30 kg K₂O ha⁻¹, 20 kg ZnSO₄ ha⁻¹ and fertilizer dose of 10 ton FYM ha⁻¹, 90 kg N ha⁻¹, 60 kg P₂O₅ ha⁻¹, 30 kg K₂O ha⁻¹, 10 kg ZnSO₄ ha⁻¹ was applied under irrigated and rainfed experiment respectively. Half of recommended nitrogen was applied as basal dose and rest of nitrogen in two splits. 1st split at knee high stage and 2nd at tasseling stage. Phosphorus, potassium and zinc sulphate was applied, as per the recommendation as basal dose at the time of sowing. Furrow method of irrigations was followed. Irrigation was applied at IW/CPE ratio 0.75 in experiment-I. In IW:CPE approach, cumulative pan evaporation values from standard USWB class ‘A’ pan evaporimeter were used for scheduling of irrigation . A common depth of irrigation was maintained at 6 cm uniformly. (Pruitt, 1960; Jenson *et al.*, 1961). Mulching of the un-irrigated crop was done with the available maize straw. A thin layer of mulch of about 5-10cm was done. The grain yield of each net plot was thoroughly cleaned and sun dried. The yield from each plot was recorded separately as kg plot⁻¹ and then converted in q ha⁻¹. After removal of the cobs from stalks, the maize stover was sun dried and weighed to determine the stover yield in q ha⁻¹. After harvesting yield was measured and economics and B:C ratio were worked out for all the treatments in both the experiments. All the operations carried out from sowing to harvest were converted into Mega Joules using conversion table . Yield of grain as well as stover was also converted to Mega Joules to draw the final conclusions with respect to different treatments tried in both the experiments. The aim of this study was to determine the total amount of input output energy used in maize production under temperate condition.

The energy use efficiency, the energy productivity, the specific energy and net energy were calculated using the following formula.

86

87

Energy ratio = $\frac{\text{Energy output (MJ/ha)}}{\text{Energy input (MJ/ha)}}$

88

89

Energy productivity = $\frac{\text{Grain output (MJ/ha)}}{\text{Grain input (MJ/ha)}}$

90

91

Specific Energy = $\frac{\text{Energy input (MJ/ha)}}{\text{Grain output (Kg/ha)}}$

92

93

Net energy (MJ/ha) = Energy output - Energy input

94

95

96 **Discussion**

97

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.

98

99 **Classification of energy**

100

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

101

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

102

103

104

105 human beings, animals, solar and wind energy, fuel wood, agricultural wastes etc. Non renewable direct sources of energy: In this category,
106 direct energy sources which are not renewable at least in near future say next 100 years are classified.

107 Indirect Source of energy: the indirect sources of energy are those which do not release energy directly but release it by conversion process.
108 Some energy is invested in producing indirect sources of energy. Seed manures, FYM, chemicals, fertilizers and machinery can be classified as
109 indirect sources of energy.

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

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

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

120 In this paper all the farm operations for cultivation of maize starting from field preparation to harvesting are converted in terms of
121 energy utilized by each operation in MJ. The output yield of maize and stower is also converted into energy output in terms of MJ (Mittal and
122 Dhawan 1988. Mittal et al 1974,1985).

123 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
124 income and consumes about 10 per cent of the commercial forms of the energy. Crop cultivation requires application of both animate (bullock,
125 human power) and inanimate (tractors, tillers etc.) forms of energy at different stages. Nutrients are provided through farmyard manure,

126 chemical fertilizers or both. Pesticides are required to check or prevent pest attack. Irrigation is done either manually (manually and animal
127 operated) or through diesel/electric pump set (to fill ground water). To meet the basic food needs of our expanding human population, a
128 productive sustainable agricultural system must become a major priority. The delectable resources are fossil fuels, which are non-renewable
129 since the rate of their utilization exceeds the rate at which they are formed. Energy used in agricultural production has become more intensive
130 due to fossil fuel, chemical fertilizer, pesticide, machinery and electricity to provide substantial increase in food production. Efficient use of
131 energy is one of the principle requirements of sustainable agriculture. Many researchers have studied energy and economic analysis to determine
132 the energy efficiency of plant production such as Isabgual seed in Spain (Modi *et al.*, 2011) and in rainfed wheat in Iran (Yousefi *et al.*, 2009).
133 To get higher productivity, farmers in general use their resources in excess and in-efficiently, particularly when these are priced low or are
134 available in plenty. In modern agricultural systems, the practice involve a shift to a package of improved inputs to achieve greater levels of
135 output, other energy inputs are used to enhance the energy transformations. Energy assessment in agriculture can be made by taking into account
136 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
137 balance of total input and output is evaluated.

138 Energy as a critical aspect of national development process. It is expended in agricultural operation in food processing and transportation,
139 in the production of fertilizer, pesticides and farm equipments. The energy sources both animate and inanimate are involved in maize crop
140 production in our valley. The direct sources of energy are those that release the energy directly-like man power, bullocks, stationary and mobile
141 mechanical or electric power units viz., diesel engines, electric motors, power tiller and tractor's. Energy use in agricultural production has
142 become more intensive due to the use of fossil fuel, chemical fertilizer, pesticides, machinery and electricity to provide substantial increases in
143 food production. Efficient use of energy is one of the principal requirements of sustainable agriculture. Many researchers have studied energy
144 and economic analysis to determine the energy efficiency of plant production, such as sugarcane in Morocco , apple in Iran , cucumber in Iran. To
145 get higher productivity the farmers in general , use their resources in excess and inefficiently, particularly when these are **priced** low or free or
146 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 Ph.D student Division of Agronomy Shalimar Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. It was revealed from calculations that more energy was consumed in irrigated conditions as compared to Unirrigated mulch conditions i.e 14805 MJ and 13034 MJ respectively Menon et,al 2015. As various operations from sowing to harvest is concerned the maximum input energy was due to Fertilizers in both irrigated and Unirrigated conditions , however more input of energy was used in irrigated conditions to that of Un irrigated mulch conditions table(3). Decrease in energy input under Unirrigated mulch conditions was due to low fertilizer input. 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). Under irrigated conditions sowing of maize on 15th April gives highest net returns of Rs.126740 with a B: C ratio of 2.18 was recorded with 50x20 cm spacing which was followed by 60x20 cm with net returns of Rs.87170 Gurdeep singh 2015. As far as energy ratio energy productivity and net energy were also observed to follow the same trend with 5.79 ,204.6 and 70962 MJ respectively with sowing on 15th April and planted at 50x20 cm apart this may be due to fact of having higher grain yield in this treatment and followed by treatment 60x20 cm with 5.78 energy ratio, 203.32 energy productivity and net energy of 70696 MJ table (3 and 4). Any further delay in sowing decreases the net returns , energy ratio, energy productivity and net energy as the grain yield also gets decreased with delay in sowing, also wider spacing followed the same trend . Under Un-irrigated mulch conditions sowing of maize on 15th April gives highest net returns of 87170 with a B: C ratio of 2.18 was recorded with 60x20 cm spacing which was followed by 50x20 cm with net returns of Rs 75827. As far as energy ratio energy productivity and net energy were also observed to follow the same trend with 5.82 ,182 and 62793 MJ respectively with sowing on 15th April and planted at 50x20 cm apart this may be due to fact of having higher grain yield in this treatment and followed by treatment 60x20 cm sowing on same date table (6 and 7). Least values of 2.68 of energy ratio, 75.6 energy productivity, and 21848 MJ net energy , were recorded when sowing was carried out on 30th May that too in wider spacing 70X20 cm apart. The reason behind this may be lower yield , as of delayed in sowing of about one month result the early shifting of crop from one stage to another, also wider spacing accommodates much plants in row length thus

169 competition among the plants for light , nutrients etc becomes more. The energy use efficiency, the energy productivity, and net energy, maize
170 crop should be sown on around 15th april with an spacing of 50x20cm or 60x20 cm under irrigated conditions and should be sown on around 15th
171 April with an spacing of 60X20cm under temperate conditions of Kashmir
172

173 **CONCLUSION**

174 Under temperate conditions of Kashmir for attaining better results in terms of energy, maize crop should be sown on around 15th april with an
175 spacing of 50x20cm or 60x20 cm if irrigated conditions and should be sown on around 15th April with an spacing of 60X20cm if Un irrigated
176 mulch condition to gain maximum energy output in terms of energy ratio, Specific energy and Net energy .
177

178 **Literature Cited**

- 179 Agriculture Research Data Book. 2013. IASRI Library Avenue Pusa New Delhi. pp 15-158.
- 180 DES. 2011. Economic survey. Directorate of Economics and Statistics. Planning and Development Department, Jammu and Kashmir, 214.
- 181 Directorate of Economics and Statistics . 2014. Ministry of Agriculture Government of India.
- 182 Khan, H.Z., Iqbal, S., Iqbal, A., Akbar, N. and Jone, D.L. 2011. Response of maize varieties to different levels of nitrogen. *Crop and*
183 *Environment*. **2** (2) : 15-19.
- 184 Pruitt, W.D. 1960. Relation to consumptive use of water to climate. *Transaction of ASAE*, **3** : 9-13.
185
- 186 B. A. Lone, Sameera Qayoom, Lal Singh, Purshotam Singh, Latief Ahmad, Saba Shafai, Asma Fayaz and K. N. Singh- 2014. Energy evaluation
187 of brown sarson at variable sowing time and thinning management under temperate Kashmir conditions. *Research Journal of*
188 *Agricultural Sciences*.5(3):385-389.

189 Gurdeep Singh 2015. Optimization of Agro-techniques to maximize productivity of Maize (*Zea mays* L.) under irrigated and un-irrigated
190 conditions using CERES-Maize Model. *Ph.D thesis Division of Agronomy SKUAST Kashmir*.

191 IRRISTAT, 2012. Maize statistics. International Maize Research Institute (IRRI), Philippines. <http://www.irri.org/science/maizestat>.

192 Mittal, J.P. and Dhawan, K.C. 1988. Energy requirement in Agricultural sector. Punjab Agricultural University, Ludhiana.

193 Mittal, J.P. and Dhawan, K.C. 1989. Energy Parameters for Raising Crops Under Various Irrigations Treatments in Indian Agriculture.
194 *Agriculture, Ecosystem and Environment* **25** : 11-25.

195 Mittal, J.P., Sexena, R.P. and Singh, I.J. 1974. The mathematical expression of cost analysis of farm equipment. *Indian Journal Agricultural*
196 *Economics* **19**(1) : 51-59.

197 Modi, V.M. Desai, N.N. and Patel, D. B. 2011. Energy management in Isabgul processing plant. *Electronic Journal of Environmental,*
198 *Agricultural and Food Chemistry* **10**(7) : 2581-2585.

199 Patil, S.J., Wali, M.C., Harlapur, S.I. And Prashanth, M., 2000, Maize Research in north Karnataka. Bulletin, University of
200 Agricultural Sciences, Dharwad, p. 54.

201 Yousefi, M., Damghani, A.M., Khoshbakht, K. and Veisi, H. 2009. Renewable and nonrenewable energy use pattern of rainfed wheat
202 agroecosystems in Iran. *World Applied Sciences Journal* **13**(6) : 1398-1403.

203 Shafique Qadir Memon, Nadeem Amjad, Riaz Ahmed Dayo and Ghulamullah Jarwar. 2015. Energy Requirement and Energy Efficiency for
204 Production of Maize Crop. *European Academic Research* VolIII, Issue 11/ February.

Table 1:- Energy equivalent of input in agricultural production.

Particulars	Units	Energy (MJ) Equivalent	Remarks
INPUTS			
Human labour			1 Adult Woman=0.8 adult man
(a) Adult man	Man hour	1.96	
(b) Woman	Woman hour	1.57	Khild =0.5 adult man.
(c) Child	Child hour	0.98	
ANIMALS			
(a)Bullocks			
(i) large	Pair hour	14.05	Body Weight > 450 kg
(ii) Medium	-	10.10	- 352-450 kg
(iii) Small	-	8.07	- < 350 kg
(b) Buffalo (He)	Pair hour	15.15	He – buffalo = 1.5 Medium bullock
DIESEL	Litre	56.31	51 includes cost
PETROL	Litre	48.23	Of lubricants.
ELECTRICITY	Kwh	11.93	-
MACHINERY			
(a) Electric Motor	Kg	64.80	Distribute the Weight of the machinery equally over the total life span of the machinery in hrs.
(b) Self Propelled Machines	Kg	64.80	
(c) Farm machinery	Kg	62.70	
FERTILIZERS			
(i) N	Kg	60.60	
(ii) P ₂ O ₅	-	11.1	Estimate the quantity used.
(iii) K ₂ O	-	6.1	
FYM	Kg (dry mass)	0.3	Chemical requirey dilution at the time of application.
CHEMICALS			
Superior	Kg	120	
ZNSO ₄	-	20.9	DDT, eypsum & others not
Inferior chemicals	-	10.0	

			requiring dilution
--	--	--	--------------------

Source lone et al. 2014

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 seed except for Ground nut where it is pod.
(3) Sugarcane	Kg harvested mass	5.3	
(4) Vegetables			
(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	

Source: lone et al 2014

Table 3 : Energy equivalents for Maize crop ha⁻¹.

	Common energy involved in irrigated and unirrigated conditions			Energy involved in Unirrigated mulch conditions only	
Particulars	Energy source	Quantity	(MJ) total energy		
Field preparation 1.Tractorization 2 (Tractor ploughing with cultivator 3hrs /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	18hrs@ 1.96/hr	35.28		
6. Formation of ridges , furrows and sowing	15 labours ha ⁻¹	90hrs @ 1.96/hr	176.4		
7.FYM / Fer. FYM N P ₂ O ₅ K ₂ O ZnSo ₄ Labour for Incorporation of FYM & broadcasting of fertilizers	Irrigated 10000 kgha ⁻¹ 120 kgha 60 kgha ⁻¹ 30 kgha ⁻¹ 20 kgha ⁻¹ 10 labours ha ⁻¹	Unirrigated 10000 kgha ⁻¹ 90 kgha ⁻¹ 60 kgha ⁻¹ 30 kgha ⁻¹ 10 kgha ⁻¹ 10 labours ha ⁻¹	Irrigated / Unirrigated @0.3 /kg @ 60.60/kg @ 11.1/kg @ 6.7/kg @20.9/kg 60 hours @ 1.96/hr Unirrigated	Irrigated 3000 7272 666 201 418 117.6	Unirrigated 3000 5454 666 201 209 117.6
8. weeding /hoeing /earthing up	20 labours ha ⁻¹	120 hours	235.2		
9.Irrigation Labour	500mm @2man days/ application	@1.2m ³ 36hrs for 3 application	600 70.56		

		@ 1.96/ ha		Mulching for (Unirrigated only) Labours to spread mulch
10. Mulch Labours to spread mulch		@ 18/12.5kg straw	750	
	15 labours	60 hrs	117.6	
11. Harvesting & dehusking and tying of stower	15 labours ha ⁻¹	90 hrs	176.4	
Total Energy involved ha⁻¹ irrigated conditions = 14804.92 say 14805 MJ				
Total Energy involved ha⁻¹ Unirrigated Mulched conditions = 13033.76 say 13034 MJ				

Table 4. Relative economics and energy input /output of maize as influenced by different planting dates and planting density under irrigated conditions

Treatments	Grain yield	Straw yield	Cost of cultivation (₹ ha ⁻¹)	Gross returns (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	Benefit : Cost ratio	Energy Input MJ	Energy output MJ
(15 th April)× (50cm×20cm)	51.15	73.45	39920	126308	86738	2.17	14805	85767
(15 th April)× (60cm×20cm)	50.83	74.87	39920	126740	87170	2.18	14805	85501
(15 th April)× (70cm×20cm)	49.84	74.96	39920	125000	85430	2.14	14805	84059
(30 th April)× (50cm×20cm)	46.72	69.18	39920	120458	80888	2.03	14805	78640
(30 th April)× (60cm×20cm)	48.09	69.71	39920	120891	81320	2.04	14805	80730
(30 th April)× (70cm×20cm)	46.74	69.46	39920	119151	79580	1.99	14805	78710
(15 th May)× (50cm×20cm)	41.47	63.63	39920	117543	77973	1.95	14805	70123
(15 th May)× (60cm×20cm)	43.69	63.51	39920	117975	78405	1.96	14805	73369
(15 th May)× (70cm×20cm)	40.48	65.62	39920	116235	76665	1.92	14805	68954
(30 th May)× (50cm×20cm)	21.47	60.97	39920	96033	56813	1.42	14805	40340
(30 th May)× (60cm×20cm)	26.70	85.01	39920	96465	57245	1.43	14805	39249
(30 th May)× (70cm×20cm)	21.30	83.60	39920	94725	55505	1.39	14805	31311

Cost of tractorisation = ₹ 7000 ha⁻¹

Irrigation Mandays @ ₹ 150

Cost of seed = ₹ 28 kg⁻¹,

Cost of stover= ₹ 1.5 kg⁻¹

Urea= 5.5 kg⁻¹, DAP= 22.5 kg⁻¹, MOP= 16.8 kg⁻¹

243 Table 5. Energy ratio, Energy productivity, Specific energy and Net Energy of maize as influenced by different planting dates and planting density under irrigated
244 conditions

Treatments	Energy Ratio	Energy Productivity	Specific Energy (Mj/kg/ha)	Net energy (MJ)
(15 th April)× (50cm×20cm)	5.79	204.6	2.02	70962.3
(15 th April)× (60cm×20cm)	5.78	203.32	1.98	70696.4
(15 th April)× (70cm×20cm)	5.68	199.36	1.98	69254.0
(30 th April)× (50cm×20cm)	5.31	186.88	2.14	63835.3
(30 th April)× (60cm×20cm)	5.45	192.36	2.12	65925.5
(30 th April)× (70cm×20cm)	5.32	186.96	2.13	63905.0
(15 th May)× (50cm×20cm)	4.74	165.88	2.33	55318.6
(15 th May)× (60cm×20cm)	4.96	174.76	2.33	58564.7
(15 th May)× (70cm×20cm)	4.66	161.92	2.26	54149.9
(30 th May)× (50cm×20cm)	2.72	85.88	2.43	25535.6
(30 th May)× (60cm×20cm)	3.22	106.8	2.54	32840.6
(30 th May)× (70cm×20cm)	2.72	85.2	2.38	25477.2

245 Table 6. Relative economics and Energy input / output of maize as influenced by different planting dates and planting density under
246 Unirrigated conditions .

Treatments	Grain yield	Straw yield	Cost of cultivation (₹ ha ⁻¹)	Gross returns (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	Benefit : Cost ratio	Energy Input MJ	Energy Output MJ
(15 th April)× (50cm×20cm)	41.76	63.14	39920	126308	86738	2.17	13034	70479
(15 th April)× (60cm×20cm)	45.50	62.10	39920	126740	87170	2.18	13034	72817
(15 th April)× (70cm×20cm)	43.53	62.47	39920	125000	85430	2.14	13034	72984
(30 th April)× (50cm×20cm)	38.53	60.27	39920	120458	80888	2.03	13034	65357
(30 th April)× (60cm×20cm)	42.01	58.39	39920	120891	81320	2.04	13034	70162
(30 th April)× (70cm×20cm)	39.59	59.81	39920	119151	79580	1.99	13034	66809
(15 th May)× (50cm×20cm)	35.23	54.87	39920	117543	77973	1.95	13034	59689
(15 th May)× (60cm×20cm)	43.69	94.00	39920	117975	78405	1.96	13034	71408
(15 th May)× (70cm×20cm)	40.48	93.30	39920	116235	76665	1.92	13034	67571
(30 th May)× (50cm×20cm)	21.47	66.80	39920	96033	56813	1.42	13034	32688
(30 th May)× (60cm×20cm)	26.70	69.60	39920	96465	57245	1.43	13034	42526
(30 th May)× (70cm×20cm)	21.30	68.20	39920	94725	55505	1.39	13034	32604

262 Cost of tractorisation = ₹ 7000 ha⁻¹
263 Irrigation Mandays @ ₹ 150
264

Cost of seed = ₹ 28 kg⁻¹,
Cost of stover= ₹ 1.5 kg⁻¹

Urea= 5.5 kg⁻¹, DAP= 22.5 kg⁻¹, MOP= 16.8 kg⁻¹
Mulch = ₹ 2000 ha⁻¹

247

248

249

250

251

252

253

254

255

256

257

258

259

260

261

262

263

264

265
266

Table 7. Relative economics ,Energy ratio, Energy Productivity, Specific energy and Net energy of maize as influenced by different planting dates and planting density under Unirrigated mulch conditions

Treatments	Energy Ratio	Energy Productivity	Specific Energy (MJ/kg/ha)	Net energy (MJ)
(15 th April)× (50cm×20cm)	5.41	167.04	2.06	57445.4
(15 th April)× (60cm×20cm)	5.82	182.00	2.10	62793.4
(15 th April)× (70cm×20cm)	5.60	174.12	2.09	59950.8
(30 th April)× (50cm×20cm)	5.01	154.12	2.16	52284.0
(30 th April)× (60cm×20cm)	5.38	168.04	2.23	57128.9
(30 th April)× (70cm×20cm)	5.13	158.36	2.18	53775.9
(15 th May)× (50cm×20cm)	4.58	140.92	2.38	46655.4
(15 th May)× (60cm×20cm)	4.89	151.56	2.32	50744.1
(15 th May)× (70cm×20cm)	4.80	148.12	2.32	49503.0
(30 th May)× (50cm×20cm)	2.62	74.00	2.70	21116.2
(30 th May)× (60cm×20cm)	2.92	84.48	2.69	24993.5
(30 th May)× (70cm×20cm)	2.68	75.6	2.64	21848.2

267