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Energy Evaluation of Maize (*Zea mays* L.) under Irrigated and Un-irrigated Conditions. Division of Agronomy-SKUAST Kashmir

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Authors' contributions

This work was carried out in collaboration between all authors. Author BAL designed and performed the study, wrote the protocol and wrote the first draft of the manuscript. Authors ZADAF and PS managed the analyses of the study. Authors SQ, GS and SK managed the literature searches. All authors read and approved the final manuscript.

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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 50 cm × 20 cm, 60 cm × 20 cm and 70 cm × 20 cm 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

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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 50x20 cm or 60x20 cm under irrigated conditions and should be sown on around 15th April with an spacing of 60X20 cm under Un-irrigated mulch conditions.

Keywords: Maize; spacing; date of sowing; energy; MJ; net energy; energy ratio; specific energy; economics B.C ratio.

1. 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" [1].

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} [2]. 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} [3]. 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} [4].

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. Under such considerable rainfed area and there is scope of increasing productivity by using low cost available mulch as under existing agro- climatic condition, the maize crop, is prone to the vagaries of rainfall distribution during crop growth.

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 [5]. 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.

2. MATERIALS 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 average annual precipitation over past twenty five years is 786 mm (Division of Agronomy, SKUAST-Kashmir) and more than 80% of precipitation is received from western disturbances during winter/spring months. During crop growth period (15^{th} April - 4^{th} October) the maximum temperature ranged between 18℃ to 32℃, while minimum temperature ranged between 4.30℃ to 17.78℃ 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 15^{th} April (D_1), 30^{th} April (D_2), 15^{th} May (D_3) and 30^{th} May (D_4) to main plots and three planting density 50 cm×20 cm (S_1), 60 cm×20 cm (S_2) and 70 cm×20 cm (S_3) to sub-plots. Certified seed of maize variety "C_6" 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 P_2O_5 ha^{-1}, 30 kg K_2O ha^{-1}, 20 kg $ZnSO_4$ ha^{-1} and fertilizer dose of 10 ton FYM ha^{-1}, 90 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1}, 30 kg K_2O ha^{-1}, 10 kg $ZnSO_4$ 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. 1^{st} split at knee high stage and 2^{nd} 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 [5]. Mulching of the un-irrigated crop was done with the available maize straw. A thin layer of mulch of about 5-10 cm 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.

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

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

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

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

3. 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

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.

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.

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,

Table 1. Energy equivalent of input in agricultural production

Particulars	Units	Energy (MJ) equivalent	Remarks
Inputs			1 Adult Woman=0.8 adult man
Human labour			
(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 the machinery equally over the total life span of the machinery in hrs.
(a) Electric Motor	Kg	64.80	
(b) Self Propelled Machines	Kg	64.80	
(c) Farm machinery	Kg	62.70	
Fertilizers			
(i) N	Kg	60.60	Estimate the quantity used.
(ii) P_2O_5	-	11.1	
(iii) K_2O	-	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 requiring dilution
Inferior chemicals	-	10.0	

[6]

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 water 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 stower is also converted into energy output in terms of MJ [7,8,9].

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 ground water). 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 [10] and in rainfed wheat in Iran [11,12]. 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 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	

[6]

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

Particulars	Common energy involved in irrigated and unirrigated conditions			Energy involved in Unirrigated mulch conditions only	
	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 sowing	15 labours ha^{-1}	90 hrs @ 1.96/hr	176.4		
7. FYM / Fer.	Irrigated	Unirrigated	Irrigated / Unirrigated	Irrigated	Unirrigated
FYM	10000 $kgha^{-1}$	10000 $kgha^{-1}$		3000	3000
N	120 kgha	90 $kgha^{-1}$	@ 0.3 /kg	7272	5454
P_2O_5	60 $kgha^{-1}$	60 $kgha^{-1}$	@ 60.60/kg	666	666
K_2O	30 $kgha^{-1}$	30 $kgha^{-1}$	@ 11.1/kg	201	201
$ZnSo_4$	20 $kgha^{-1}$	10 $kgha^{-1}$	@ 6.7/kg	418	209
Labour for incorporation of FYM & broadcasting of fertilizers	10 labours ha^{-1}	10 labours ha^{-1}	@ 20.9/kg 60 hours @ 1.96/hr Unirrigated	117.6	117.6
8. Weeding /hoeing /earthing up	20 labours ha^{-1}	120 hours	235.2		
9. Irrigation	500 mm	@$1.2m^3$	600		
Labour	@2 man days/ application	36 hrs for 3 application @1.96/ ha	70.56		
10. Mulch		@18/12.5 kg straw	750	Mulching for (Unirrigated only)	
Labours to spread mulch	15 labours	60 hrs	117.6	Labours to spread mulch	
11. Harvesting & dehusking and tieing 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
(15th April)× (50 cm×20 cm)	51.15	73.45	39920	126308	86738	2.17	14805	85767
(15th April)× (60 cm×20 cm)	50.83	74.87	39920	126740	87170	2.18	14805	85501
(15th April)× (70 cm×20 cm)	49.84	74.96	39920	125000	85430	2.14	14805	84059
(30th April)× (50 cm×20 cm)	46.72	69.18	39920	120458	80888	2.03	14805	78640
(30th April)× (60 cm×20 cm)	48.09	69.71	39920	120891	81320	2.04	14805	80730
(30th April)× (70 cm×20 cm)	46.74	69.46	39920	119151	79580	1.99	14805	78710
(15th May)× (50 cm×20 cm)	41.47	63.63	39920	117543	77973	1.95	14805	70123
(15th May)× (60 cm×20 cm)	43.69	63.51	39920	117975	78405	1.96	14805	73369
(15th May)× (70 cm×20 cm)	40.48	65.62	39920	116235	76665	1.92	14805	68954
(30th May)× (50 cm×20 cm)	21.47	60.97	39920	96033	56813	1.42	14805	40340
(30th May)× (60 cm×20 cm)	26.70	85.01	39920	96465	57245	1.43	14805	39249
(30th May)× (70 cm×20 cm)	21.30	83.60	39920	94725	55505	1.39	14805	31311

Cost of tractorisation = ₹ 7000 ha^{-1} *Cost of seed = ₹ 28 kg^{-1},* *Urea= 5.5 kg^{-1}, DAP= 22.5 kg^{-1}, MOP= 16.8 kg^{-1}*

Irrigation Mandays @ ₹ 150 *Cost of stover= ₹ 1.5 kg^{-1}*

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

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

Table 6. Relative economics and Energy input / output of maize as influenced by different planting dates and planting density under 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
(15th April)× (50 cm×20 cm)	41.76	63.14	39920	126308	86738	2.17	13034	70479
(15th April)× (60 cm×20 cm)	45.50	62.10	39920	126740	87170	2.18	13034	75827
(15th April)× (70 cm×20 cm)	43.53	62.47	39920	125000	85430	2.14	13034	72984
(30th April)× (50 cm×20 cm)	38.53	60.27	39920	120458	80888	2.03	13034	65317
(30th April)× (60 cm×20 cm)	42.01	58.39	39920	120891	81320	2.04	13034	70162
(30th April)× (70 cm×20 cm)	39.59	59.81	39920	119151	79580	1.99	13034	66809
(15th May)× (50 cm×20 cm)	35.23	54.87	39920	117543	77973	1.95	13034	59689
(15th May)× (60 cm×20 cm)	43.69	94.00	39920	117975	78405	1.96	13034	71468
(15th May)× (70 cm×20 cm)	40.48	93.30	39920	116235	76665	1.92	13034	67111
(30th May)× (50 cm×20 cm)	21.47	66.80	39920	96033	56813	1.42	13034	38088
(30th May)× (60 cm×20 cm)	26.70	69.60	39920	96465	57245	1.43	13034	45426
(30th May)× (70 cm×20 cm)	21.30	68.20	39920	94725	55505	1.39	13034	38064

Cost of tractorisation = ₹ 7000 ha^{-1} Cost of seed = ₹ 28 kg^{-1}, Urea= 5.5 kg^{-1}, DAP= 22.5 kg^{-1}, MOP= 16.8 kg^{-1}
Irrigation Mandays @ ₹ 150 Cost of stover= ₹ 1.5 kg^{-1} Mulch = ₹ 2000 ha^{-1}

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

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 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. 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 2.18was recorded with 50x20 cm spacing which was followed by 60x20 cm with net returns of Rs.87170 [13 and 14]. 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 com with 5.78 energy ratio, 203.32 energy productivity and net energy of 70696 MJ (Tables 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 (Tables 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 competition among the plants for light, nutrients etc becomes more. The energy use efficiency, the energy productivity, and net energy, maize crop should be sown on around 15th April with an spacing of 50x20 cm or 60x20 cm under irrigated conditions and should be sown on around 15th April with an spacing of 60X20 cm under temperate conditions of Kashmir.

4. CONCLUSION

Under temperate conditions of Kashmir for attaining better results in terms of energy, maize crop should be sown on around 15th April with an spacing of 50x20 cm or 60x20 cm if irrigated conditions and should be sown on around 15th April with an spacing of 60X20 cm if Un irrigated mulch condition to gain maximum energy output in terms of energy ratio, Specific energy and Net energy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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