Effect of Tillage and Weed Control Techniques on Energy Dynamics and Profitability of Chickpea (*Cicer arietinum* L.) - Rice Cropping Sequence in Irrigated Ecosystem of C.G. Plains

ABSTRACT

A field study was conducted during *rabi* seasons of 2010-11 and 2011-12 at the Research cum Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh to evaluate the effect of various tillage and weed management techniques on energy dynamics and profitability of chickpea-rice cropping sequence in irrigated ecosystem of C.G. plains. The results indicate that plots were divided into main and sub plots (tillage and weed management practices). Three tillage practices *viz*., conventional tillage (T_1), minimum tillage (T_2) and zero tillage (T_3) in main plot and nine weed management practices as pendimethalin @ 1000 g ha^{-1} PE (W_1), imazethapyr @ 80 g ha^{-1} PE (W_2), imazethapyr @ 90 g ha^{-1} PE (W_3), imazethapyr @ 100 g ha^{-1} PE (W_4) at 2 DAS, imazethapyr @ 70 g ha^{-1} POE (W_5), imazethapyr @ 80 g ha^{-1} POE (W_6), imazethapyr @ 90 g ha^{-1} POE (W_7) at 20 DAS, one hand weeding at 20 DAS (W_8) and weedy check (W_9), in sub plots. Among the various tillage practices, maximum energy use efficiency 3.74 q $MJ^{-1} \times 10^{-3}$ ha^{-1} and energy productivity 160.34 kg MJ^{-1} ha^{-1} were obtained with conventional tillage (T_1) followed by minimum tillage (T_2) and zero tillage (T_3) and among the different weed control methods, maximum energy use efficiency 5.46 q $MJ^{-1} \times 10^{-3}$ ha^{-1} and energy productivity 233.37 kg MJ^{-1} ha^{-1} were found with one hand weeding at 20 DAS (W_8) followed by post-emergence application of imazethapyr @ 90 g ha^{-1} (W_7) followed by imazethapyr @ 80 g ha^{-1} PoE (W_6). The economic production of experiment in terms of net return was maximum under (T_1) conventional tillage Rs.19824.21 ha^{-1} with B:C ratio 1.19 and (W_8) one hand weeding at 20 DAS Rs.19171.44 ha^{-1} with B:C ratio 0.95 and this was followed by @ 90 g ha^{-1} imazethapyr, where net return Rs.19086.74 ha^{-1} and B:C ratio 1.04. The minimum net return and B:C ratio was observed under zero tillage (T_3) and weedy check (W_9).

Keywords: *Rice – chickpea cropping, Tillage and weed management, Energy use efficiency, Energy productivity.*

1. Introduction

Chickpea (*Cicer arietinum* L.) is a leading pulse crop, grown an area of 8.3 million ha with annual production of 7.7 million tonnes, registering an average productivity of 928 kg ha^{-1} (Ministry of Agriculture, 2013). The poor productivity of chickpea is mainly due to competition from diverse weed population (Sharma, 2009; Kumar,2010). Most weed species can grow faster and taller than the chickpea and inhibits the plant growth by curtailing sunlight, nutrients and moisture; and reduces the grain yield up to 75% (Balyan and Bhan, 1984). Tillage systems affect soil disturbance, weed management, and weed seed production, a change in tillage systems will influence the species composition and vertical distribution of weed seeds in agricultural soils (Bhular, 1995). The primary objective of tillage is to control weeds and about 50% of the energy

Comment [H1]: Not reference

required to tillage is spent for weed control only (Yaduraju, 2004). Hand hoeing and tillage are the traditional methods practiced for a long time in most parts of the world (Solh and Pala, 1990). Tillage and/or herbicides are used for weed control, but the degree of control achieved may vary widely depending on weed species present, soil type, climatic condition, crop grown, tillage method and cropping system (Unger et al., 1999). Therefore, keeping above in view, the current study was undertaken with the objective to quantify the weed flora under various tillage system and to evaluate more effective post-emergence herbicide with broader spectrum of weed control and wide adoptability.

2. MATERIAL AND METHODS:

A field experiment to study the combined effect of tillage and weed control methods on weed dynamics, growth and yield attributes of chickpea cultivar JG-226 after harvest of soybean. The soil of experimental field was *clayey* in texture with neutral pH. The experiment was laid out in Split Plot Design with three replications. The treatment comprised of three tillage practices *viz*., conventional tillage (T_1), minimum tillage (T_2) and zero tillage (T_3) in main plot and nine weed management practices as pendimethalin @ 1000 g ha^{-1} PE (W_1), imazethapyr @ 80 g ha^{-1} PE (W_2), imazethapyr @ 90 g ha^{-1} PE (W_3), imazethapyr @ 100 g ha^{-1} PE (W_4) at 2 DAS, imazethapyr @ 70 g ha^{-1} POE (W_5), imazethapyr @ 80 g ha^{-1} POE (W_6), imazethapyr @ 90 g ha^{-1} POE (W_7) at 20 DAS, one hand weeding at 20 DAS (W_8) and weedy check (W_9), in sub plots. The chickpea seeded @ 80 kg ha^{-1} was sown with the space of 30 × 10 cm. The N, P, K through diamonium phosphate and muriate of potash were applied as basal at sowing of the crop. One protective irrigation gave at the time of sowing for establishment of optimum plant stand.

2.1. Grain yield (kg ha^{-1}):- The sun dried produce of each net plot was tied and bundles were weighed to determine the dry matter of produce (grain+stover). The grain obtained after threshing and winnowing from each net plot was weighed and noted as grain yield of the respective plot.

2.2. Weed index (%):- The weed index(%) of different treatments was calculated at harvest stage with the help of following formula –

$$\text{Weed Index (WI) \%} = \frac{(X-Y)}{X} \times 100$$

Where , X = Yield from best treatment

Y = Yield from particular treatment

Weed index was calculated by the formula mentioned below. It is expressed in percentage.

$$WI (\%) = \frac{\text{Grain yield in hand weeding - grain yield in a treatment}}{\text{Grain yield in hand weeding}} \times 100$$

Where, WI = weed index

2.3. Energetics:- Energy inputs were calculated and estimated in Mega Joule (MJ) ha^{-1} with reference to the standard values prescribed by Mittal *et al.* (1985). These inputs were taken to each treatment of chickpea crop. The standard energy coefficient for seed and straw of chickpea was multiplied with their respective yields and summed up to obtain total energy output. Energy use efficiency and Energy productivity were calculated as per the following formulae -

$$\text{Energy use efficiency } (q\ MJ^{-1} \times 10^{-3}) = \frac{\text{Total produce (q)}}{\text{Energy input } (MJ \times 10^{-3})}$$

$$\text{Energy productivity } (Kg\ MJ\ ha^{-1}) = \frac{\text{Mean Grain Yield } (Kg\ ha^{-1})}{\text{Total energy input, MJ}}$$

2.4. Net return:- Net return was computed from the total output of all main products and by-products after deducting the total cost of cultivation.

2.5. Benefit :Cost ratio:- Benefit :Cost ratio was computed by dividing the net return with total cost of cultivation.

3. RESULT AND DISCUSSION: -

Three tillage and nine weed management practices were evaluated and two years energetics and economics data are presented below: -

3.1. Energetics- Energy inputs were calculated and estimated in Mega Joule (MJ) ha^{-1} with reference to the standard values prescribed by Singh *et al.* (1985). These inputs were taken to each treatment of chickpea crop. The standard energy coefficient for seed and stover of chickpea was multiplied with their respective yields and summed up to obtain energy use efficiency, energy productivity.

Highest energy use efficiency (5.18 q MJ^{-1} x 10^{-3}) and energy productivity (194.76 kg MJ ha^{-1}) were recorded under zero tillage followed by minimum and conventional tillage. The primary objective of tillage is to control weeds and about 50% of the energy required to tillage is spent for weed control only. Yaduraju (2004) also reported similar type of findings.

Among the weed management practices, maximum energy use efficiency (5.88 q MJ^{-1} x 10^{-3}) and energy productivity (247.28 kg MJ ha^{-1}) were found with application of imazethapyr @ 90 g ha^{-1} POE (W_7) and minimum energy use efficiency (4.28 q MJ^{-1} x 10^{-3}) and energy productivity (138.05 Kg MJ ha^{-1}) was used in weedy check (W_9). This might be due to the higher biomass production (grain and straw yield) and lower input use. Singh *et al.* (1985) reported that application of herbicides was the best in terms of energy output (25076 MJ ha^{-1}) than unweeded check. Singh *et al.* (1997) concluded that energy requirement of chickpea production in Madhya Pradesh was 2336 and 5237 MJ ha^{-1} operation-wise and source-wise, respectively. Energy ratio was found to be 8.60 and specific energy was 4.76 MJ kg^{-1}. Jain *et al.* (1998) reported that maximum energy utilization was obtained by hand weeding at 20 DAS (41262 MJ ha^{-1}) which was followed by fluchloralin (PPI) @ 1.0 kg ha^{-1} (30160 MJ ha^{-1}). The lowest energy utilization was recorded in un-weeded check (22416 MJ ha^{-1}).

3.2. Economics- Data indicated that among the tillage management practices, highest gross return was found under conventional tillage (Rs.36623.61 ha^{-1}) followed by minimum tillage (Rs.32752.82 ha^{1}) and zero tillage (Rs.29288.26 ha^{-1}) during both the years. Highest gross return (Rs.39588.94 ha^{-1}) was found with the application of hand weeding at 20 DAS (W_8) followed by (Rs.37453.74ha^{-1}) imazethapyr @ 90 g ha^{-1} POE (W_7), imazethapyr @ 80 g ha^{-1} POE (W_6), imazethapyr @ 70 g ha^{-1} POE (W_5), respectively, during both the years. Among the tillage management practices, conventional tillage was required highest cost of production (Rs.16799.40 ha^{-1}) as compared to minimum (Rs.16790.70 ha^{-1}) and zero tillage (Rs.16277.50 ha^{-1}). Among the different weed management practices, highest cost of production was (Rs.20417.50 ha^{-1})

under hand weeding at 20 DAS (W_8) followed by (Rs.18367.00 ha^{-1}) imazethapyr @ 90 g ha^{-1} POE (W_7). Highest net return was found under (Rs.19824.21 ha^{-1}) conventional tillage with B:C ratio 1.19 followed by (Rs.15962.12 ha^{-1}) minimum tillage with B:C ratio 0.96 and (Rs.13010.76 ha^{-1}) zero tillage with B:C ratio 0.80, during both the years. Highest net return was (Rs.19171.44 ha^{-1}) noted under hand weeding at 20 DAS (W_8) with B:C ratio of 0.95 followed by (Rs.19086.74 ha^{-1}) imazethapyr @ 90 g ha^{-1} POE (W_7) with B:C ratio 1.04, imazethapyr @ 80 g ha^{-1} POE (W_6) with B:C ratio 1.01, imazethapyr @ 70 g ha^{-1} POE (W_5) with B:C ratio 0.94, respectively during both the years. The higher net return was due to the fact that lower cost of weed management and higher grain and straw yields under these treatments. Pinjari (2007) also reported similar results.

3.3. SEED YIELD-

Among various tillage practices, significantly higher seed yield was obtained with conventional tillage, which, was statistically at par with minimum tillage during both the years. Stover yield also followed the similar trend as that of seed yield. Amanullah *et al.* (2010) found that CT was more effective in controlling weeds, enhancing grain and straw yields as compared with NT, in chickpea, where, yields were significantly higher with conventional tillage over zero tillage. Among sub plot treatments, hand weeding resulted in significantly higher yield over recommended herbicide-alachlor. Conventional tillage recorded higher grain yield than zero-tillage. The period of grain formation and grain filling is very sensitive to moisture, nutrients and environmental stresses. The less developed root system under zero tillage conditions might have affected the flow of water and nutrients during grain formation. As a result the grains remained small, which is reflected in the smaller thousand grain weight under zero tillage, which consequently affected grain yield. These results for the tillage effect on root development under zero tillage are in line with the results of Kumar (2010) who reported poor root development under zero tillage system compared to the prolific root growth under conventional tillage system. He further stated that soil conditions under zero tillage were unfavorable for growth as compared to conventional tillage.

Among various weed management practices, treatment of one hand weeding at 20 DAS (W_8) followed by application of imazethapyr @ 90 g ha^{-1} POE (W_7) and imazethapyr @ 80 g ha^{-1} POE (W_6) produced significant higher seed and stover yield as compared to weedy check, during both the years. It was also noted that seed yield under all the weed management practices was significantly higher than weedy check. Also, that post-emergent herbicides out yielded pre-emergent application of herbicides. Almost similar trend for stover yield was obtained as that of seed yield.

Higher seed yield under above treatments was due to the weed managed at critical period and early crop growth, higher dry matter production, high growth in terms of LAI, which resulted in higher production of photosynthesis, which acts as a source and greater translocation of food materials to the reproductive parts resulted in superiority of yield attributing characters and ultimately high yield. Lower weed population and higher weed control efficiency also resulted in higher seed yield. Contrarily, the poor growth of plants as well as development of yield attributing characters in untreated control might be due to less moisture, nutrient, space and light availability at the time of flowering and pod development adversely influenced the seed yield. The lower seed yield under untreated control may be due to the high weed interference. Upadhyay and Bhalla (2002) also reported higher seed yield under manual weeding treatment. The lowest seed yield (1481 kg ha^{-1}) was produced in the plots where weeding was not done throughout the growing season. Singh *et al.* (1986), Yadav *et al.* (1983) and Ahmad *et al.* (1990) reported that hand weeding provided the highest weed control and grain yield. Among the weedicides pre-emergence application of pendimethalin gave the higher seed yield as compared to weedy plot. Higher seed yield under hand weeding and herbicidal treatments is also attributed to better utilization of applied nutrients by crop as compared to weedy-crop. The results are similar to that of the experiment of Amarjeet *et al.* (2006). Sukhadia *et al.* (1999) conducted research on *vertisol* soils in chickpea, showed that the maximum grain and fodder yield (1432 and 1660 kg ha^{-1}, respectively) and highest net return (Rs. 15450 ha^{-1}) were obtained followed one hand weeding + intercropping 30-35 days after sowing. Upadhyay and Bhalla (2002) also reported higher seed yield under manual weeding treatment. Weedy situation prevailing through out the crop period caused 77.79 % reduction in seed yield of chickpea over twice inter-culturing and hand weeding treatment. Varshney and Arya (2004) illustrated that both hand hoeing and pre-emergence herbicides (pendimethalin) significantly increased chickpea yield, weight of 100 seeds. Chaudhary *et al.*, (2005) noted significant effect of hand hoeing and pendimethalin herbicide on number of pods per plant, number of seeds per pod and grain yield of chickpea. Hand hoeing gave more vigorous chickpea plants. Hand hoeing was the only operation that

Comment [H2]: Bhall ? Bhalla

significantly increased seed yield, and most effective weed control measure increased crop growth and yield. Hand hoeing is recommended for controlling weeds when possible in small areas. Maximum seed yield per plant (4.0 g) was observed with weed-free treatment. Significantly higher seed yield per plant was recorded with hand weeding twice which was at par with early post-emergence application of imazethapyr. These results are in collaboration with the findings of Govindra Singh *et al.* (1982). Highest grain yield (1332 kg ha^{-1}) was recorded due to weed-free conditions followed by two hand weeding and imazethapyr. But none of the treatments produced seed yields at par with weed-free treatment.

3.4. WEED INDEX-

Weed index, which is a measure of yield reduction due to weed competition. Weed index was estimated at harvest stages in both the years. Among the tillage management practices, mean data indicated that highest weed index (%) was found with zero tillage with a yield reduction to the tune of 23.03% followed by minimum tillage 17.79% and conventional tillage 16.76 %.

Among various herbicidal treatments, mean data clearly indicated that highest weed index was found with weedy check (W_9) with a yield reduction of 48.41% followed by 25.48% imazethapyr @ 80 g ha^{-1} PE (W_2) and 21.41% imazethapyr @ 90 g ha^{-1} PE (W_3) respectively. This was due to competition offered by unchecked weed growth for nutrients, moisture and light as indicated by poor growth and yield components. However, the lowest yield reduction was obtained under one hand weeding at 20 DAS, mainly due to improved growth of chickpea as a consequence of effective control of weeds and reduction in the crop weed competition. This might have enabled the crop to take up more nutrients. A similar finding was reported by Sanl, A., Kaya, M. and Kara, B. (2009).

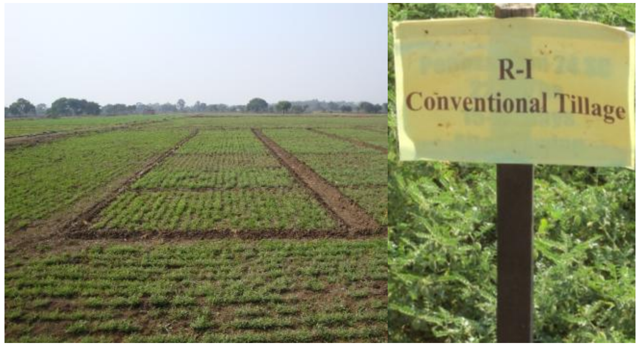

Plate No.-1 : Effect of conventional tillage on plant population

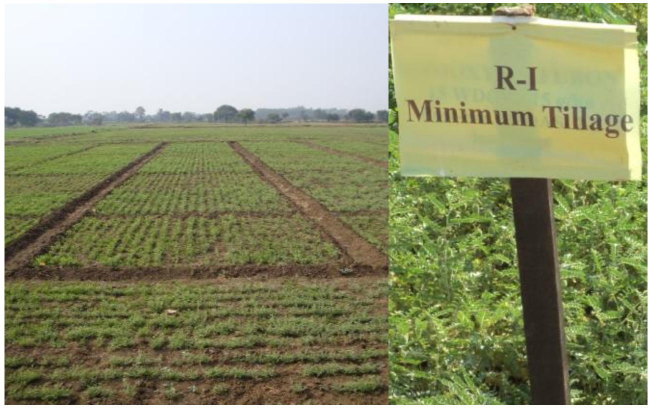

Plate No.-2 : Effect of minimum tillage on plant population

Plate No.-3 : Effect of zero tillage on plant population

4. CONCLUSION

This review reveals that the maximum mean seed yield of chickpea sown after harvest of rice was 878.25 kg ha^{-1} , net return Rs.19824.21 ha^{-1} with B:C ratio 1.19, energy use efficiency 3.74 q $MJ^{-1} \times 10^{-3}$ ha^{-1} and energy productivity 160.34 kg MJ^{-1} ha^{-1} were found under conventional tillage (T_1) followed by minimum tillage (T_2) and zero tillage (T_3). chickpea sown after harvest of rice produced 914.68 kg ha^{-1} mean seed yield under post-emergence application of imazethapyr @ 90 g ha^{-1} at 20 DAS and among the different weed control methods maximum energy use efficiency 5.46 q $MJ^{-1} \times 10^{-3}$ ha^{-1} and energy productivity 233.37 kg MJ^{-1} ha^{-1} , Rs.19171.44 ha^{-1} with B:C ratio 0.95 were found with one hand weeding at 20 DAS (W_8) followed by post-emergence application of imazethapyr @ 90 g ha^{-1} (W_7) , where net return Rs.19086.74 ha^{-1} and B:C ratio 1.04 followed by imazethapyr @ 80 g ha^{-1} PoE (W_6).

REFERENCES

Ahmed MS, Khalid, Siddiqui SU. Efficacy of pre- and post-emergence herbicides and their application methods on the growth, yield and nodulation of chickpea (*Cicer arietinum*). Pak. J. Weed Sci. Res.1990;3:89-97.

Amanullah J, Thsanullah D, Ali K, khan, IA. Tillage and several rates effect on weed biomass, grain and biological yield of dryland chickpea. Pakistan Journal of Botany. 2010;42(6):4011-4016.

Amarjeet SB, Singh M, Kachrood D, Sharm BC, Shrivan DR. Efficacy of herbicides in transplanted medium duration rice (Oryza sativa under subtropical conditions of Jammu. Indian Journal of Agronomy. 2006;51(2):128-130.

Balyan RS, Bhan VM. Promising the herbicides for weed control in chickpea. Indian J. Weed Sci.1984;16(2):69-75.

Buhler DD. Influence of tillage systems on weed population dynamics and management in corn and soybean production in central USA. Crop science.1995;35:1247-1257.

Chaudhary BM, Patel JJ, Delvadia DR. Effect of weed management practices and seed rates on weeds and yield of chickpea. Indian Journal of Weed Science. 2005;37(¾): 271-272.

Singh G, Singh B, Singh D. Studies on weed control in urdbean. In :Abstracts of Papers. Annual Conferences of ISWS held at Hisar, December 27-30. 1982;22.

Jain KK, Tiwari JP, Sahu TR. Energy and nutrient utilization in soybean-weed ecosystem under different methods of sowing and herbicidal treatments. J. Oilseeds Res.1998;15 (1) : 86-92.

Kumar N, Mina BL, Singh KP, Chandra S, Kumar M, Shrivastava AK. Weed control for yield and profit maximization in wheat *(Triticum aestivum)* in Indian Himalayas. Indian Journal of Agronomy. 2010;55(2):5.

Kumar S, Singh R, Kumar N. Performance of different herbicide in Weed growth of chickpea (*Cicer arietinum* L.). International Journal of Agricultural Sciences. 2010;6**:**202-205.

Ministry of Agriculture. Agricultural Statistics at a Glance 2013, Directorate of Economics and Statistics, Government of India, New Delhi. 2013.

Pinjari, S.S. Effect of integrated nutrient management and polythene mulch on the performance of sweet corn under lateritic soils of Konkan. Ph.D. (Agri.) Thesis, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and Dist. Ratnagiri (M.S.).2007.

Sanl A, Kaya M, Kara B. Effect of herbicide application & hoeing times on weed flora, yield & some yield components of Chickpea (*Cicer arietinum* L.). Anadolu. Tarm Bilimleri Dergisi. 2009;24(1):13-20.

Sharma LK, Saini D.P. Variability and association studies for seed yield and yield components in chickpea (*Cicer arietinum* L.). Research Journal of Agricultural Sciences. 2010;1(3):209-211.

Sharma PB. Economics of rice-based cropping system in deep black soil. Indian J. Agron. 1987;32(4):335-340.

Singh RK, Singh DK, Singh RP. Weed-crop competition in wheat as affected by different weed species. Indian Journal of Weed Science.1997;29:199.

Singh A, Ahlawat IPS, Saraf CS. Studies on weed control in chickpea. Indian Journal of Agronomy.1986;31(3):269-272.

Singh MK, Pal SK, Thakur R, Verma UN. Energy input-output relationship of cropping systems. Indian J. Agric. Sci. 1997;67(6):262-264.

Singh MP, Saxena KA Singh, HK. Energetics of cropping systems. Indian J. Agron. 1985;34(2):1-9.

Singh RC. Comparative studies of herbicides in relation to agronomical practices in Chickpea. In: Abs. of Papers, Annual conf. of Indian Soc. of Weed Sci. 1985;56-57.

Solh MB, Pala M. Weed control in chickpea. Option Mediterranean's series seminaries. 1990;9:93-99.

Solh, M.B. and M. Pala. 1990. Weed control in Chickpea. International center for Agricultural Research in the Dry Area (ICARDA). Options Mediterraneennes-serie Seminaries. 1990;9:93-99.

Sukhadia NM, Ramani BB, Modhwadia MM, Khanpara VD, Asodaria KB. Integrated weed management in chickpea. Gujarat Agric. Univ. Res.1999;24(2):7-12.

Unger PW, Miller SD, Jones OR. Weed seeds in long term dryland tillage and cropping system plots. Weed Research.1999;39:213-223.

Upadhyay VB, Bhalla, CS. Efficacy of cultural, mechanical and chemical weed control in chickpea (*Cicer arietinum* L.). Indian J. Weed Sci. 2002;34 :141-142.

Varshney JG, Arya, R.L. Effect of integrated nutrients use and weed-control methods in sole gram (*Cicer arietinum* L.) and gram+Indian mustard (*Brassica juncea*) intercropping system. Indian J. Agri. Sci. 2004;74(3):121-125.

Yadav, SK, Singh, SP, Bhan, VM. Weed control in chickpea. Tropical Pest Management. 1983; 29(3):297-298.

Yaduraju, NT. Foreword. In:Tillage and weed management. Technical Bulletin No. 1 NRCWS, Jabalpur. 2004.

Table 1: Pooled (2010-11 and 2011-12) grain yield, weed index, energetics and economics of chickpea after harvest of rice as influenced by different tillage and weed management practices

Treatments	Grain yield (Kg/ha)	Weed Index (%)	Net return (Rs. ha^{-1})	B:C ratio	Energy use efficiency (q MJ^{-1} x 10^{-3} ha^{-1})	Energy productivity (Kg MJ ha^{-1})
Main Plot: Tillage management						
Conventional	878.25	16.76	19824.21	1.19	3.74	160.34
Minimum	807.87	17.79	15962.12	0.96	3.97	158.14
Zero	723.26	23.03	13010.76	0.80	5.18	194.76
Sub Plot: Weed management						
Pendimethalin @ 1000 g/ha PE	780.34	18.95	13862.96	0.77	5.09	205.99
Imazethapyr @ 80 g/ha PE	727.43	25.48	11355.84	0.63	5.04	195.42
Imazethapyr @ 90 g/ha PE	781.89	21.41	12771.14	0.70	5.26	205.58
Imazethapyr @ 100 g/ha PE	809.34	14.09	15510.94	0.84	5.50	224.72
Imazethapyr @ 70 g/ha POE	851.77	11.91	16850.74	0.94	5.58	230.42

Imazethapyr @ 80 g/ha POE	889.10	7.94	18209.6	1.01	5.78	240.44
Imazethapyr @ 90 g/ha POE	914.68	5.34	19086.74	1.04	5.88	247.28
One hand weeding at 20 DAS	966.83	-	19171.44	0.95	5.46	233.37
Weedy Check	506.75	48.41	4482.25	0.28	4.28	138.05