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Anjum Ahmad
Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Harishankar Painkra
Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

T Chowdhury
Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Anjum Ahmad
Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Energetics and economics of chickpea (*Cicer arietinum* L.) -soybean cropping sequence as influenced by different tillage and weed management practices in c.g. Plains

Anjum Ahmad, Harishankar Painkra and T Chowdhury

Abstract
A field experiment 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 assess the effect of different tillage and weed management pratices on energetics and economics of chickpea-soybean cropping sequence. The treatments 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 6.22 q MJ^{-1} × 10^{-3} ha^{-1} and energy productivity 265.32 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 9.59 q MJ^{-1} × 10^{-3} ha^{-1} and energy productivity 388.95 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.43800.38 ha^{-1} ha^{-1} with B:C ratio 2.62 and (W_8) one hand weeding at 20 DAS Rs. 45524.27 ha^{-1} with B:C ratio 2.24 and this was followed by @ 90 g ha^{-1} imazethapyr, where net return Rs.44055.83ha^{-1} and B:C ratio 2.41. The minimum net return and B:C ratio was observed under zero tillage (T_3) and weedy check (W_9).

Keywords: Soybean, Chickpea, Handweeding, Tillage, Pendimethalin, imazethapyr

Introduction
Chickpea (*Cicer arietinum* L.) ranks as the third most important annual major food grain legume in the world after dry bean and peas (*Singh and Saxena*, 1999) [16, 17]. In tropical, subtropical, and temperate regions of the country and in recent years, the area, production and productivity is in the increasing trend due to its profitability under rainfed conditions. In Chhattisgarh, chickpea is cultivated in an area of about 3.20 Lakh ha with an average production of 2.12 Lakh tonnes and productivity of 663 kg ha^{-1}. The average productivity of chickpea is still below one ton per hectare, which is considered low by any standards. Under irrigated conditions weeds are a potential threat to the crop reducing the yield by 40 to 87% under severe infestation (*Moorthy et al.*, 2003) [6]. Chickpea is a poor competitor to weeds because of slow growth rate and limited leaf area development at early stages of crop growth and establishment. Weed competition is considered as one of the most important causes of low productivity and inferior quality of chickpea in Chhattisgarh. 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. There is no registered Post-emergence herbicide with broad spectrum weed control is available at the moment. Imazethapyr 10% seems to be promising as it has been proved to be effective against number of leguminous oilseed and pulse crops. Hence, the objective of this experiment to determine the efficacy of pre and post emergence herbicides viz., imazethapyr and different tillage practices used against mixed weed flora of winter chickpea crop.

Methodology

A field experiment to study the 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 was carried out at the Research cum Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur during two consecutive *rabi seasons* of 2010-11 & 2011-12. 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. Seeds were treated with Carbendazim @ 2 g kg^{-1} seeds and thereafter again treated with Rhizobium culture @ 5 g kg^{-1} seed before the sowing. 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. The chickpea crop was sown in 2nd fortnight of November 2010 and 2011 and harvesting was done in 1st fortnight of March 2011 and 2012, respectively. The rainfall received during the cropping seasons of *rabi* 2010-11 and 2011-12 was 32.1 mm and 15.94 mm, respectively.

Results

Three tillage and nine weed management practices were evaluated 2 years are presented below:-

(a) Energetics- Tillage management practice, maximum energy use efficiency (7.57 q MJ^{-1} ha^{-1}) and energy productivity (327.74 kg MJ^{-1} ha^{-1}) were obtained with zero tillage (T_3) followed by minimum tillage (T_2) and conventional tillage (T_1), respectively in both the years. Yaduraju (2004) [20, 22] stated that the primary objective of tillage is to control weeds and about 50% of the energy required to tillage is spent for weed control only.

Among the weed management practices, maximum energy use efficiency (10.04 q MJ^{-1} ha^{-1}) and energy productivity (412.13 kg MJ^{-1} ha^{-1}) were obtained with application of POE imazethapyr @ 90 g ha^{-1}followed by imazethapyr @ 80 g ha^{-1}(W_6) and minimum energy use efficiency (4.62 q MJ^{-1} ha^{-1}) and energy productivity (230.06 kg MJ^{-1} ha^{-1}) found by weedy check (W_9). This might be due to lower intra-specific competition for growth limiting factors, maximum biomass production and comparatively lower energy use. Verma and Srivastava (1989) [19] found that energy output and water use with optimum tillage were higher than with zero tillage. However, energy use efficiency (EUE; energy output: energy input ratio), energy productivity (g MJ^{-1}) and WUE were not affected by tillage methods. Cultural (Two hand hoeings) and chemical (One kg 2,4-D/ha post-emergence) methods of weed control were superior to the unweeded control in terms of EUE, energy productivity and WUE. Rao and Bhan (1985) [11] found that manual weeding accounts for 46 Mcal ha^{-1}. Chauhan *et al.* (2003) [3] found that the energy requirement for wheat cultivation was minimum for no-tillage (30586 MJ ha^{-1}) and maximum for conventional farmers' practice (34759 MJ ha^{-1}) of broadcast sowing.

Sharma *et al.* (1998) [13] concluded that the total production energy requirement for chickpea (*Cicer arietinum* L.) production was estimated 3534 MJ ha^{-1}, of which the operational energy was 1204 MJ ha^{-1}. The input-output energy ratio was 6.65. From a survey in three districts of Haryana, Gupta *et al.* (1984) [4] found that energy use efficiency ranged from 0.17 to 0.28 for given data for six chosen farms and observed that the energy efficiency for grain varied from 0.06 to 0.28 and from 0.29 to 1.16 for total produce. Billore *et al.* (1999) [21] reported that application of alachlor @ 3.0 kg ha^{-1} (PE) and pendimethalin @ 1.0 kg ha^{-1} (PE) were inferior to imazethapyr @ 0.1 kg ha^{-1} (POE) with respect to energy output and energy use efficiency.

(b) Economics- The data on economics of *rabi* chickpea crop emphasized that Conventional tillage (₹ 16799.40 ha^{-1}) was required highest cost of cultivation as compared to minimum (₹16790.70 ha^{-1}) and zero tillage (₹ 16277.50 ha^{-1}) during both the years. Among the different weed management practices,the maximum total cost of cultivation (₹ 20417.50 ha^{-1}) was recorded under one hand weeding at 20 DAS (W_8) and minimum (₹ 16277.50 ha^{-1}) was noted under untreated control (W_9). Among the tillage management practices, maximum gross return and net return was found under conventional tillage (₹ 60599.78 ha^{-1} GR) with B:C ratio of 2.62 and (₹ 43800.38 ha^{-1} NR) respectively,followed by minimum and zero tillage during both the years. Tillage is single most important factor that influences weed infestations and causes variations in crop yields and cost of production. Among different weed management practices, Highest gross return (₹ 65941.77 ha^{-1}) and net return (₹ 45524.27 ha^{-1}) was found with the one hand weeding at 20 DAS (W_8) with B:C ratio of 2.24 followed by POE imazethapyr @ 90 g ha^{-1} (W_7), and lowest gross return (₹ 34596.73 ha^{-1}) and net return (₹ 18319.23 ha^{-1}) was recorded by weedy check (W_9) with B:C ratio 1.09, during both the years. The higher B:C ratio under above treatments might be due to higher seed yield coupled with lower cost of weed management treatments. The above treatment also reduced the weed density and weeds dry weight m^{-2}, which resulted in better utilization of available resources leading to more grain yield and finally increased the gross, net return and benefit: cost ratio. Similar findings were also reported by Singh *et al.* (1991) [18], Porwal (2000) [10] and Patel *et al.* (2006) [7-9]. Two hand weedings (30 and 45 DAS) produced the highest gross income (Rs. 62,500 /ha) and net monetary returns (Rs. 25635/ha) indicating superiority of this treatment over rest of the treatments. The B:C ratio was the highest under two hand weeding (30 and 45 DAS) followed by Pursuit (EPOE) @ 100 g a.i. ha^{-1}. These results are in close conformity with the earlier findings of Singh and Sharma (1990) [15], Chandrakar and Urkurkar (1993) [2], Chandel *et al.* (1995) [1], and Jain *et al.* (2000) [5]. Post emergence application of imazethapyr on 21 DAS was found more remunerative as it fetched maximum gross income of Rs. 18985/ha, net income of Rs. 11845/ha and benefit cost ratio of 2.66 followed by application of 28 DAS. Higher economic benefit was obtained by the application of imazethapyr at 90 g/ha followed by 75 g/ha. Imazethapyr at 90 g/ha recorded higher gross income (Rs. 18775 ha), net income (Rs. 11365 ha) and benefit cost ratio (2.53) which surpassed the benefits than lower doses and control. Excellent control of weeds and higher yield might be attributed to superior economic indices under higher doses of application of 21 DAS.

Table 1: Energetics and economics of chickpea after harvest of soybean as influenced by different tillage and weed management practices

Treatments	Net return (Rs. /ha)	B:C ratio	Energy productivity (Kg MJ^{-1} ha^{-1})	Energy use efficiency (q MJ^{-1} $x10^{-3}$ ha^{-1})
Main Plot: Tillage management				
Conventional	43800.38	2.62	265.32	6.22
Minimum	37518.37	2.24	262.18	6.16
Zero	32994.48	2.04	327.74	7.57
Sub Plot: Weed management				
Pendimethalin @ 1000 g/ha PE	34049.30	1.87	335.61	7.59
Imazethapyr @ 80 g/ha PE	30873.93	1.69	324.34	7.17
Imazethapyr @ 90 g/ha PE	34972.77	1.91	352.16	8.14
Imazethapyr @ 100 g/ha PE	37431.70	2.03	369.27	8.68
Imazethapyr @ 70 g/ha POE	40102.50	2.23	384.03	9.11
Imazethapyr @ 80 g/ha POE	42481.33	2.34	400.73	9.68
Imazethapyr @ 90 g/ha POE	44055.83	2.41	412.13	10.04
One hand weeding at 20 DAS	45524.27	2.24	388.95	9.59
Weedy Check	18319.23	1.09	230.06	4.62

Plate 1: General view of experiment - Rice-Chickpea

Conclusion

This review reveals economics of *rabi* chickpea crop emphasized that Among the tillage management practices, maximum gross return and net return was found under conventional tillage (₹ 60599.78 ha^{-1} GR) with B:C ratio of 2.62 and (₹ 43800.38 ha^{-1} NR) respectively,followed by minimum and zero tillage during both the years. Among different weed management practices, Highest gross return (₹ 65941.77 ha^{-1}) and net return (₹ 45524.27 ha^{-1}) was found with the one hand weeding at 20 DAS (W_8) with B:C ratioof 2.24 followed by POE imazethapyr @ 90 g ha^{-1} (W_7), and lowest gross return (₹ 34596.73 ha^{-1}) and net return (₹ 18319.23 ha^{-1}) was recorded by weedy check (W_9) with B:C ratio 1.09, during both the years. The higher B:C ratio under above treatments might be due to higher seed yield coupled with lower cost of weed management treatments. The above treatment also reduced the weed density and weeds dry weight m^{-2}, which resulted in better utilization of available resources leading to more grain yield and finally increased the gross, net return and benefit: cost ratio. Tillage management practice, maximum energy use efficiency (7.57 q MJ^{-1} ha^{-1}) and energy productivity (327.74 kg MJ^{-1} ha^{-1}) were obtained with zero tillage (T_3) followed by minimum tillage (T_2) and conventional tillage (T_1), respectively in both the years. Among the weed management practices, maximum energy use efficiency (10.04 q MJ^{-1} ha^{-1}) and energy productivity (412.13 kg MJ^{-1} ha^{-1}) were obtained with application of POE imazethapyr @ 90 g ha^{-1}followed by imazethapyr @ 80 g ha^{-1}(W_6) and minimum energy use efficiency (4.62 q MJ^{-1} ha^{-1}) and energy productivity (230.06 kg MJ^{-1} ha^{-1}) found by weedy check (W_9).

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