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PRODUCTIVITY, ECONOMICS AND ENERGETICS OF LENTIL AS AFFECTED BY SEEDING METHODS AND SEED RATES AFTER RICE IN LOW LANDS OF EASTERN U.P.

SHER SINGH, GAJENDRA SINGH[2], B.P. SINGH[3] AND M.V. SINGH

Crop Research Station, Narendra Deva University of Agriculture and Technology, Ghaghraghat, Bahraich (Uttar Pradesh) – 271 901

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ABSTRACT

A field experiment was conducted during Rabi season of 2006-07 and 2007-08 to study the effect of seeding methods and seed rates on productivity, economics and energetics of lentil grown after rice. The growth and yield attributes were significantly improved with zero tillage as compared to surface seeding and conventional tillage, however, it was on par with reduced tillage. Zero tillage increase the grain yield by 3.72%, 8.94% and 15.30% over reduced tillage, conventional tillage and surface seeding, respectively. Protein production (301.1 kg ha^{-1}), net return (45.85 x 10^3 ` ha^{-1}) and benefit: Cost ratios (3.91) were highest with zero tillage followed by reduced tillage. Lentil sown in surface seeding required minimum energy input (3.25 x 103 MJ ha^{-1}) and highest energy use efficiency (14.34) followed by zero tillage, reduced tillage and surface seeding. However, maximum output energy (53.4 x 103 M J ha^{-1}) was recorded with zero tillage. The grain (1254 and 1429 kg ha^{-1}) and straw yield (2409 and 2833 kg ha^{-1}) of lentil was significantly higher at 60 kg ha^{-1} over 40 kg ha^{-1} seed rate. Protein production was highest at 60 kg ha^{-1}. The input energy and output energy were increased with increasing seed rate from 40 to 60 kg ha^{-1}; however, energy use efficiency was highest (12.78) with 50 kg ha^{-1} seed rate followed by 60 kgha^{-1} seed rate. Crop sown with 60 kg ha^{-1} or 50 kg ha^{-1} seed rate was on par but gave significantly higher net income (43.97 x 10^3 ` ha^{-1}) over 40 kg ha^{-1} seed rate.

Keywords: Productivity, economics, energetic, seed rate, seeding methods, lentil

INTRODUCTION

Lentil (*Lens culinaris*) being a legume improves soil fertility by adding atmospheric nitrogen into soil and grown on residual moisture after harvest of rice. There are diverse uses of this crop, representing 12% area and production to total rabi pulses in India. The production of lentil in India is 0.98 million tonns from an area of 1.5 million hectare with average productivity of 633 kg ha^{-1}. Uttar Pradesh accounts 40% of area and 46% of the total production of the lentil (Kokate *et al.*, 2013). The productivity of lentil in U.P. is 7.15q ha^{-1} which is considered to be low. Among the various factors responsible for low productivity of lentil, improper method of sowing and use of sub optimum seed rate are considered to be an important. On the other hands, excess moisture and late harvesting of long duration rice varieties resulted in delayed the sowing were mainly responsible for low productivity of lentil in eastern U.P. Hence, use of optimum seed rate and proper method of sowing are considered to be an important factor for obtaining higher yield. Sowing in zero tillage reduces the cost of cultivation and advances the sowing by 8-10 days as compared to conventional tillage consequently higher yield (Bhale and Wanjari, 2009). Maintaining optimum plant population is an important factor for efficient utilization of plant growth resources to harness the optimum productivity of lentil. Although there is yield reduction of lentil due to late sowing but yield loss is often compensated by using higher seed rates which maintain optimum plants per unit land area and increase lentil yield as reported by Singh and Singh (2002). Keeping this in view, the present investigation was undertaken to find out the effect of method of sowing and seed rates on productivity, economics and energetics of lentil grown after rice in low land situation.

MATERIALS AND METHODS

A field experiment was conducted at the Crop Research Station, Ghaghraghat, Bahraich (U.P.) during kharif seasons of 2006-07 and 2007-08 after harvest of rice in lowland situation located at an altitude of 112 metres above mean sea level and is intersected by 27^0 5' N altitude and 81^0 2' E longitude. The soil of experimental site was sandy loam in texture with a p^H of 8.1, electrical conductivity 0.41 dSm^{-1}, organic carbon 3.8 kg^{-1}, and available nitrogen 196.5 kg N ha^{-1}, available phosphorus 18.5 kg P ha^{-1} and available potassium 189.5 kg K ha^{-1}. The experiment was laid out in split-plot design with 4 methods of seeding viz., surface seeding, zero tillage, conventional tillage, and reduced tillage in main plot and 3 seed rates, viz., recommended (40 kg ha^{-1}), 25% more than recommended (50 kg ha^{-1}) and 50% more than recommended (60 kg ha^{-1}) in sub-plot replicated 4 times. The lentil variety "PL 406" was sown after rice in experimental site. In surface seeding and zero

[1]*Part of Ph.D these submitted by senior author,*
[2]*Technical Co-ordinator UPDASP, Lucknow,*
[3] *Deptt. of Agronomy R.B.S. College Bichpuri Agra*

tillage treatment no field preparation was done, whereas in conventional tillage (four operation i.e. two ploughing each by harrow and cultivator and planking after each ploughing). In case of reduced tillage (two operation i.e. one ploughing each by harrow and cultivator and planking after each ploughing) was done. In surface seeding, pre- soaked seeds (for 8-10 hr) of Lentil mixed with fresh cowdung in 2:1 ratio to protect the seed from picking by birds was uniformly broadcasted in un-tilled wet soil surface after rice harvest. In zero tillage treatment, lentil was directly sown by zero-till–drill. In conventional tillage, the seeds were broadcasted and mix-up on last ploughing, while in reduced tillage, sowing was done by seed- cum-ferti-drill. The sowing of lentil in surface seeding was done December 15, zero tillage December 21 and conventional and reduced tillage December 31, respectively in both years. The lentil crop was fertilized with recommended dose, i.e. 20:40:20 NPK kg ha^{-1}. The half amount of nitrogen as urea and full dose of phosphorus as single superphosphate and potash as muriate of potash was applied at sowing. Rest amount of nitrogen was applied in two splits i.e. at first and second irrigation. All standard agronomic practices were followed to raise the experimental crop. Data pertaining to yield contributing characters was recorded on 5 plants selected randomly from each plot at harvest. The grain samples were collected at harvest, and analyzed for N content (%) by standard procedure. To work out protein content (%) in grain, n content (%) in grain was multiplied by 6.25. The protein production was worked out by multiplying protein content (%) into grain yield. Energetics of treatments was worked out using the method prescribed by Devasenapathy *et al.* (2009). Economics of treatments was worked out on prevailing market price.

RESULTS AND DISCUSSION

Seeding methods

Growth parameters like plant height, number of branches $plant^{-1}$ and crop dry matter 9 gm^{-2}) were affected significantly due to seeding methods during both the years (Table 1). Lentil sown in zero tillage or reduced tillage was on par but increased significantly growth and yield attributes over rest seeding method. This could be attributed to proper placement of fertilizer and seed which ensured optimum plant population per unit area and lesser intra row competition. However, improper depth of sowing and uneven distribution of seed in surface seeding resulted poor growth parameters. Days to 50% flowering and maturity were higher with zero tillage however, least in conventional tillage due to profuse growth of crop owing to proper placement of seed and fertilizer.

Table 1: Growth parameters of lentil as affected by seeding method and seed rate

Treatment	Plant height (cm)		Branches $plant^{-1}$		Crop dry matter (g m^{-2})		Days to 50% flowering		Days to maturity	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Seeding method										
Surface seeding	35.3	36.2	9.9	11.4	336.0	3757	87.7	89.0	117.3	121.7
Zero tillage	37.5	38.2	10.5	12.0	379.3	429.0	88.3	90.7	119.0	123.3
Conventional tillage	35.7	36.5	10.1	11.6	350.0	399.0	81.7	83.3	110.3	115.0
Reduced tillage	37.5	38.3	10.4	12.01	372.3	423.3	83.3	86.0	113.5	118.3
SEm ±	0.33	0.36	0.13	0.12	3.2	3.4	0.44	0.39	0.46	0.33
CD (P=0.05)	0.74	0.81	0.29	0.27	7.2	7.6	0.99	0.89	1.04	0.76
Seed rate (kg ha^{-1})										
40	35.8	36.6	10.4	11.9	334.3	375.8	85.9	88.0	116.0	120.3
50	36.6	37.5	10.2	11.8	366.5	415.0	85.2	87.2	115.0	119.5
60	37.0	37.8	10.1	11.6	377.5	429.5	84.7	86.5	114.1	119.0
SEm ±	0.29	0.31	0.17	0.17	5.1	5.3	0.30	0.34	0.43	0.34
CD (P=0.05)	0.60	0.64	NS	NS	10.4	10.9	0.62	0.71	0.90	0.71

Zero tillage gave higher grain (1269 and 1450 kg ha^{-1}) and straw yield (2508 and 2831 kg ha^{-1}) in respective years which was on par with reduced tillage but both were significantly out yielded to conventional tillage and surface seeding (Table 3). The per cent increase of grain yield by zero tillage was recorded to be 8.94, 15.3 and 3.72 over conventional tillage, surface seeding and reduced tillage, respectively. The higher grain and straw yield in zero tillage or reduced tillage may be ascribed to significant improvement in growth and yield attributes as compared to conventional tillage and surface seeding. These findings coincide with those of Mishra (2007) and Singh *et al.* (2011) who reported the higher yield with zero till sowing as compared to conventional tillage due to more number

of days taken to 50% flowering and longer duration of the crop might have led to the development of better sink by better utilization of resources which was later on translocated to pods and grains. The lowest grain yield (1113 and 1252 kg ha^{-1}) was recorded in surface seeding due to poor growth and yield attributes owing to improper depth of sowing and uneven distribution of seed. Protein yield (301.1kg ha^{-1}) was significantly higher in zero tillage as compared to conventional and surface seeding because of higher grain and straw yield with former treatment.

Table 2: Yield attributes of lentil as affected by seeding method and seed rate

Treatment	Pods $plant^{-1}$		Grains $plant^{-1}$		Grain yield$plant^{-1}$ (g)		1000-grain weight (g)	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Seeding method								
Surface seeding	30.9	33.9	51.5	56.0	0.94	1.04	18.27	18.63
Zero tillage	33.4	36.2	56.8	61.6	1.06	1.18	18.91	19.29
Conventional tillage	31.5	34.2	53.0	57.1	0.98	1.07	18.48	18.75
Reduced tillage	33.0	35.5	55.6	60.6	1.05	1.16	18.80	19.17
SEm ±	0.36	0.35	1.6	1.7	0.02	0.03	0.05	0.06
CD (P=0.05)	0.81	0.79	3.5	3.8	0.05	0.06	0.11	0.13
Seed rate (kg ha^{-1})								
40	32.9	35.3	56.4	61.4	1.06	1.16	18.77	19.15
50	32.0	34.9	54.2	58.1	1.01	1.12	18.59	18.89
60	31.7	34.6	52.0	56.9	0.96	1.06	18.48	18.84
SEm ±	0.22	0.23	1.1	1.9	0.02	0.02	0.05	0.06
CD (P=0.05)	0.46	0.47	2.2	3.9	0.05	0.05	0.11	0.12

The maximum net return (45.85 x 10^3 ` $ha^{-1}$) as well as benefit: cost ratio (3.91) was highest with zero tillage because of lower expenditure incurred and higher yield. The lowest net returns of 39.10 x $10^3$ ` ha^{-1} was recorded in surface seeding owing to poor yield. Singh and Singh (1993) also reported higher net income of lentil sown in zero tillage. Energy input was lowest in surface seeding (3.25 x 10^3 MJ ha^{-1}) followed by zero tillage sowing (3.82 x 10^3 MJ ha ha^{-1}). Crop sown in either zero tillage or reduced tillage was on par but gave significantly higher out put energy (53.4 x 10^3 MJ ha^{-1}) and (52.2 x 10^3 MJ ha^{-1}), espectively as compared to rest seeding methods. Zero tillage recorded higher energy use efficiency (13.98).

Seed rates

Plant height and crop dry matter (g m^{-2}) was increased with increasing **seed** rate from 40 to 60 kg ha^{-1}.Crop sown with 60 kg ha^{-1} seed rate was on par with 50 kg ha^{-1} **seed rate** but recorded significantly taller plants and higher crop dry matter as compared to 40 kg ha^{-1} seed rate. This was mainly due to heavy intra row competition resulted in fast growth of crop at higher seed rate.The branches $plant^{-1}$, days to 50% flowering and maturity, and yield attributes were reduced with increasing seed rates from 40 to 60 kg ha^{-1}, however, recorded higher at 40 kg ha^{-1} seed rate followed by 50 and 60 kg ha^{-1}. This was mainly due to the fact that growth of Individual plant improved at lower seed rate owing to lesser intra row competition as compared to higher seed rates. Singh *et al.*, (2011) recorded higher growth and yield attributes at higher seed rate. Grain and straw yield increased significantly with increasing seed rate from 40 to 60 kg seed ha^{-1}. The per cent increase in the grain yield due to 60 kg ha^{-1} seed rate was recorded to be 9.7 and 12.8% over 50 and 40 kg seed ha^{-1}, respectively on pooled basis. Increasing grain yield at higher seed rate was mainly due to higher plants and crop dry matter. These results are in conformity with the findings of Singh and Singh (2007) and Singh *et al.* (2007). Singh and Singh (2002) also reported higher yield at higher rate i.e. 60 kg ha^{-1}. Lower yield with 40 kg ha^{-1} seed rate failed to maintain the desired plant population in spite of higher values of yield attributes resulted in poor yield. Crop sown with 60 kg ha^{-1} seed rate gave significantly the higher protein yield as compared to 50 kg seed ha^{-1} owing to higher yields. Lentil sown with 60 kg ha^{-1} recorded maximum input energy (4.26 x10^3 MJ $ha.^{-1}$) and output energy (53.1x10^3 MJ ha^{-1}) followed by 50 and 60 kg ha^{-1}. However, energy use efficiency was maximum (12.78) with 50 kg ha^{-1} seed rate followed by 60 kg ha^{-1} seed rate. This was because of lesser input energy and higher output energy due to higher yield. Crop sown with higher seed rate i.e. 60 kg ha^{-1} gave the higher net return of 43.97x 10^3 ` ha^{-1}, however, benefit : cost ratio was highest (3.55) with

Table 3: Grain and straw yield, protein yield, energetics and economics of lentil as affected by seeding method and seed rate

Treatment	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Protein yield (kg ha^{-1})		Input energy (x10^3 MJ ha^{-1})	Output energy (x10^{3}MJ ha^{-1})	Energy use efficiency	Net return (x10^3 ₹ ha^{-1})	B:C ratio
Seeding method	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08					
Surface seeding	1113	1252	2218	2484	252.1	277.1	3.25	46.8	14.34	39.10	3.61
Zero tillage	1278	1450	2508	2831	285.2	317.0	3.82	53.4	13.98	45.85	3.91
Conventional tillage	1169	1335	2341	2660	264.1	294.6	4.75	49.7	10.45	39.80	3.05
Reduced tillage	1228	1402	2458	2793	274.7	306.5	4.62	52.2	11.28	42.64	3.30
SEm ±	18.45	17.76	36.63	35.12	9.5	9.76	-	0.6	0.11	0.48	0.04
CD (P=0.05)	41.73	40.17	82.86	79.44	21.5	22.1	-	1.3	0.25	1.09	0.09
Seed rate											
40	1116	12.63	2215	2495	253.8	280.2	3.96	46.9	12.07	38.64	3.36
50	1221	1388	2429	2748	273.6	304.6	4.11	51.5	12.78	42.94	3.55
60	1254	1429	2499	2833	279.8	311.6	4.26	53.1	12.69	43.97	3.48
SEm ±	16.98	24.05	34.27	47.38	7.0	7.1		0.56	0.15	0.61	0.05
CD (P=0.05)	35.05	49.62	17.73	97.79	14.5	14.6		1.2	0.31	1.27	0.11

50 kg seed ha^{-1} owing to comparatively narrow margin in yield reduction then that of cost incurred with 50 kg ha^{-1}. The lowest net return (38.64 x 10^3 ` ha.) and benefit: cost ratio (3.36) was recorded at 40 kg seed ha^{-1}. These findings are in confirmation of the earlier report of Singh *et al.* (2007). Zero tillage increase the grain yield by 3.72%, 8.94% and 15.30% over reduced tillage, conventional tillage and surface seeding, respectively. Protein production was also significantly higher with zero tillage followed by reduced tillage. The net return (45.85 x 10^3 ` ha^{-1}), benefit cost ratio (3.91) were highest with zero tillage followed by reduced tillage. Surface seeding required minimum energy input (3.25 x 10^3 MJ ha^{-1}) and gave higher energy used efficiency (14.34) followed by zero tillage, reduced tillage and conventional tillage. The maximum output energy (53.4 x 103 MJha^{-1}) was recorded with zero tillage. The grain and straw yield of lentil was significantly higher at 60 kg ha^{-1} seed rate. Crop sown with 40 kg seed ha^{-1} recorded significantly higher yield attributes followed by 50 and 60 kg ha^{-1} seed rate. Protein production was highest at 60 kg ha^{-1} .The input and output energy were increased with increasing seed rate from 40 to 60 kg ha$^{-1,}$ however, energy use efficiency was highest with 50 kg ha^{-1} seed rate followed by 60 kgha^{-1} seed rate. Crop sown with 60 kg ha^{-1} or 50 kg ha^{-1} was on par but gave significantly highest net income over 40 kg ha^{-1} seed rate.

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