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Research Paper

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Evaluation of different agronomic practices on nodule and yield attributes of lentil (*Lens culinaris* Medic L.)

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ABSTRACT

A pure and healthy seed of lentil genotype LH 90-54 was sown on November 17, 2005 as per planting technique treatments with three replications and total number of treatment combinations 3 x 2 x 3= 18 were tested against the growth parameters of lentil (*Lens culinaris*) at Pulse Research Area of CCS Haryana Agricultural University, Hisar during *Rabi* 2005-06. Raised bed sowing, one hand weeding at 60 DAS and application of irrigation over no irrigation produced significantly higher number of nodules plant^{-1} and their dry weight as compared to flat, zero till sowing, pendimethalin and weedy check treatments. Whereas raised bed planting, application of one irrigation at flowering and various weed control treatment in lentil produced significantly higher number of pods per plant. Weed management shown a significant effect on the number of grains per pod. Irrigation, pendimethalin @1kg a.i. ha^{-1} and one hand weeding at 30 DAS produced significantly higher 1000-grain weight. Grain and stover yield of lentil were significantly higher under raised bed planting system, irrigation and controlling of weeds either manually or chemically. Zero tillage and flat bed planting techniques being at par recorded significantly more harvest index over raised bed planting.

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Lentil (*Lens culinaris*) is one of the oldest and valuable human food crop. Mostly it is consumed as a dry grain (decorticated and split). Dehulled lentil grains contain 24-26 per cent protein, 1.3 per cent fat, 2.2 per cent ash, 3.2 per cent fibre and 57 per cent carbohydrate. It is a rich source of calcium (68 mg/100g grain), phosphorus (300 mg/100g grain) and iron (7 mg/100g grain). India represents 50 per cent of the world's acreage and 41 per cent of the world's production. The production of lentil in India is around 1.00 million tonnes from an area of 1.4 million hectare with the productivity of 660 kg/hectare (Anonymous, 2005). In Haryana, lentil is the important winter season pulse crop next to chickpea.

Inadequate soil moisture and heavy infestation of weeds are the important factors, which results in poor productivity of this crop. Timely sowing of lentil is very essential for getting higher yield. Lentil can be sown 7-10 days earlier by zero tillage machine directly without any field preparation after the harvest of rice crop by using residual soil moisture.

Another technology *i.e.* raised bed planting system that is a form of conventional tillage where in sowing is done on raised beds. The important factor including weed management favours the introduction of bed planting because herbicide resistance is already a serious issue. Thus, this system provides an elbow space for increasing the productivity of dry or limited irrigated areas in the later part of crop growth.

Lentil normally meets most of its water requirement from conserved soil moisture. In the absence of enough stored soil moisture and adequate winter rains, the crop responds very well to supplemental irrigation. Water being the scarce commodity in lentil growing areas of India, it warrants judicious use to achieve higher efficiency.

Weeds in lentil have been reported to offer serious competition and cause yield reduction to the extent of 70 per cent (Singh and Singh, 1985). Weed emergence in lentil begins almost with the crop emergence leading to crop-weed competition from initial stages. Labour requirement to remove weeds manually may not be met due to the peak sowing season and hence, the use of herbicide can be explored to economize the weed control particularly in the initial stage as lentil is a slow growing crop.

RESEARCH PROCEDURE

The field experiment was conducted during the *Rabi* season of 2005-06 at Pulse Research Area of CCS Haryana Agricultural University, Hisar. The experiment was laid out in split plot design with three replications and total number of treatment combinations were 3 x 2 x 3 = 18. The grass plot size was 2.4 x 1.8 m. The experimental field was prepared for sowing as per planting technique treatment. The field was ploughed with pressure harrow particularly the area allotted to raised bed and flat bed planting treatments. No harrowing or other tillage practices were done in the experimental area allocated for zero till planting treatment. The experimental area allotted for zero tillage treatment was sprayed with non-selective herbicide *i.e.* glyphosate @ 1 per cent solution 10 days before sowing to check the weeds and left over plants of the previous crop. One pre-sowing irrigation was applied on 13th November 2005. The field was ploughed and prepared as per treatments. Raised bed of 67.5 cm were prepared with tractor drown raised bed planter.

A pure and healthy seed of lentil genotype LH 90-54 was sown on November 17, 2005 as per planting technique treatments. In flat bed, the sowing was done with hand plough, whereas, zero till drill machine was used to sow directly the seeds in zero tillage planting treatment. The seeds on raised beds were sown with the help of raised bed planter having two rows on each raised bed of 67.5 cm. Recommended seed rate (35 kg ha^{-1}) was used for sowing of the crop. In all the planting techniques, the number of rows per plot were kept same.

After two weeks of germination, lentil plants were thinned to keep an intra-row spacing of about 7 cm. Gaps were filled wherever necessary to maintain uniform plant population. No weeding was carried out in weedy check plot, however, one hand weeding at 30 DAS and pendimethalin @ 1.0 kg a.i. ha^{-1} (pre-emergence) application were done in their respective treatments. One pre-sowing irrigation was applied for field preparation on 13th November 2005 and one post sowing irrigation was applied at flowering stage on 17th February 2006 as per treatment. To keep the crop free from insects particularly pod borer, first spray of endosulfon @ 1 litre ha^{-1} was done on 17th March and second spray was repeated on 8th April.

Nodulation studies:

Number and dry weight of nodules:

The healthy nodules on the roots of the sampled plants were separated out, counted and oven dried at 70° C for 72 hours and weighed. The results were reported as dry weight of nodules in mg per plant.

Yield attributes and yield:

Number of pods:

The pods from the three sampled plants were removed, counted and the results were reported as number of pods per plant.

Number of grains per pod:

The number of grains per pod was calculated by dividing the total number of grains of five pods by total number of pods.

Thousand grain weight (g):

Grains were collected randomly from the bulk grain yield from each treatment, counted and weighed separately to report the 1000-grain weight (g).

Grain yield per plant (g):

All the pods of three selected and tagged plant were removed and threshed. Threshed material was cleaned. The total grain yield of three plants was recorded. After this average grain yield per plant (g) was worked out.

Grain and straw yield:

The crop was harvested when the leaves turn yellow and the pods were fully matured. After complete sun drying, the bundles were weighed plot-wise for recording the biomass yield. After threshing and cleaning, grain yield was noted and the difference between biomass yield and the grain yield indicated the straw yield. The grain and stover yield kg ha^{-1} were worked out from the plot yield.

Harvest index:

The harvest index was calculated by dividing economic (grain) yield by total biological (grain and straw) yield of the crop.

$$\text{Harvest index (HI)} = \frac{\text{Grain yield (kg per hectare)}}{\text{Biological yield (kg per hectare)}} \times 100$$

Statistical analysis:

The experimental data relating to each character were analyzed statistically by applying the technique of 'analysis of variance' for split-plot design and significance was tested by variance ratio 'F value differences' (Cochran and Cox, 1977). Standard error and critical difference (C.D.) were worked out for each character studied to evaluate differences between treatment means.

RESEARCH ANALYSIS AND REASONING

The data recorded during the course of investigation were tabulated, statistically analysed and results are intepreted here under appropriate heads:

Nodulation studies:

Nodule number and nodule dry weight:

Data on nodule number and dry weight of nodule per plant at 30 DAS and 60 DAS as influenced by different planting techniques, irrigation and weed control are given in Table 1.

Different planting techniques, irrigation and weed management failed to produce significant variation on number of nodules plant^{-1} at the early stage *i.e.*30 DAS. However, these were influenced significantly at 60 DAS, where raised bed sowing produced significantly higher number of nodules plant^{-1}. The flat bed sowing, however, produced significantly lower number of nodules as compared to raised bed sowing but these were significantly higher than zero till sowing.

Nodule numbers were slightly increased with the application of irrigation over no irrigation (Table 1).

Higher number of nodules were recorded in one hand weeding at 60 DAS than pendimethalin and weedy check treatments. Application of pendimethalin @1kg a.i. ha^{-1} also resulted in significantly higher number of nodules as compared to weedy check.

Significant difference on dry matter of nodules was observed in all the three planting techniques at both the stages. Raised bed planting of lentil produced significantly more dry weight of nodules per plant. The flat bed sowing however, produced significantly lower dry weight as compared to raised bed sowing but these were significantly higher than zero tillage. The lower dry weight in flat and zero till sowing might be due to the affect on the availability of O_2 due to the less friable soil.

Dry weight of nodules was significantly increased with one irrigation at flowering over no irrigation only at 60 DAS (Table 1). The similar finding was reported by Rupela and Kumar Rao (1987) and Sharma *et al*. (1995). Weed management at 30 and 60 DAS significantly influenced dry weight of nodules. Dry weight of nodules was highest in hand weeding treatment. Pendimethalin @ 1 kg a.i. ha^{-1} resulted in significantly lower dry weight of nodules as compared to hand weeding but it produced significantly more dry weight of nodules as compared to weedy check.

Root nodules and there dry weight was found higher in one hand weeding at 30 DAS as compared to pendimethalin @1.0 kg a.i. ha^{-1}, which might be due to the loosening of soil during hand weeding treatment and ultimately better availability of O_2 to the roots. Islam (1980) reported the less dry weight and number of nodules in herbicide treatments. Hand weeding at the time of maximum crop weed competition (30 DAS) resulted in significantly more number of nodules and dry weight was recorded at 60 DAS.

Table 1 : Effect of different treatments on number of nodules and their dry weight (mg)

Treatments	Number		Dry weight (mg)	
	30DAS	60DAS	30DAS	60DAS
Planting technique				
Zero tillage	1.33	6.05	40.51	262.22
Raised bed	1.55	10.00	56.23	288.55
Flat bed	1.44	7.05	44.49	278.77
S E.±	0.11	0.14	0.84	0.58
C.D. (P=0.05)	NS	0.37	2.66	1.82
Irrigation				
No irrigation	1.40	7.14	46.19	272.22
One irrigation at flowering	1.48	8.25	48.03	281.11
S E.±	0.09	0.11	0.63	0.47
C.D. (P=0.05)	NS	0.36	NS	1.48
Weed managements				
Weedy check	1.38	7.00	43.09	273.11
One hand weeding at 30 DAS	1.44	8.55	51.65	280.44
Pendimethalin @1.00 kg a.i./ ha (pre-emerg)	1.72	7.55	46.60	276.44
S E.±	0.11	0.15	1.15	0.46
C.D. (P=0.05)	NS	0.46	3.37	1.34

NS=Non-significant

Yield attributes and yield:

Number of pods per plant:

Number of pods per plant was influenced significantly by different treatments (Table 2). Raised bed planting in lentil produced significantly higher number of pods per plant by a margin of 13.5 and 29.5 per cent higher than flat bed and zero till sowing, respectively. Flat bed sowing also produced significantly higher number of pods per plant as compared to zero till sowing, however, the values were significantly lower than raised bed planting.

Application of one irrigation at flowering in lentil had significantly positive effect on number of pods per plant and it resulted in 7.02 per cent increase in number of pods per plant as compared to no irrigation.

Various weed control treatment had significant effect on the number of pods per plant. Significantly, less number of pods per plant were obtained with the weedy check treatment.One hand weeding at 30 DAS and pendimethalin @ 1kg a.i.ha^{-1} application being at par with each other produced significantly higher number of pods per plant as compared to weedy check.

Significant effect of planting techniques on number of pods per plant was observed, this might be due to better utilization of solar radiation as is evident from the higher CGR and RGR in raised bed planting. This may also be ascribed by higher dry matter production and translocation of photosynthates for productive parts. Similar beneficial effect of bed planting on yield attributes of wheat was reported by Mascangni *et al.* (1995) and Tripathi (1999).

Number of grains per pod:

It can be seen from the data in Table 2 that neither the planting techniques nor irrigation had resulted in significant variation in respect of number of grains per pod.

Weed management shown a significant effect on the number of grains per pod (Table 2). The number of grains were the highest in pendimethalin @ 1 kg a.i. ha^{-1} treatment and it was statistically at par with hand weeded treatment. Weedy check produced significantly less number of grains per pod as compared to other weed control treatment.

1000-grain weight:

Data presented in Table 2 clearly show that all the planting techniques had non-significant effect in respect of 1000-grain weight. However, it was highest in raised bed sowing.

Irrigation treatment produced significantly higher grain weight than no irrigation treatment. Significantly higher test weight was recorded when irrigation was given at flowering stage as compared to no irrigation treatment.

Among different weed control treatments weedy check resulted in significantly lesser 1000-grain weight than other weed management treatments. Pendimethalin @1kg a.i. ha^{-1} and one hand weeding at 30 DAS being at par with each other produced significantly higher 1000-grain weight as compared to weedy check (Table 2).

Number of pods plant^{-1}, number of grains pod^{-1} and 1000-grain weight were increased significantly with

Table 2 : Effect of different treatments on the yield attributes and yield

Treatments	Pods plant^{-1}	Grain pod^{-1}	1000 grain wt. (g)	Grain yield (kgha^{-1})	Stover yield (kgha^{-1})	Harvest index (%)
Planting technique						
Zero tillage	56.49	1.28	28.2	798	2815	22.16
Raised bed	73.46	1.25	28.8	1014	3740	21.42
Flat bed	64.68	1.35	28.5	900	3187	22.14
S E.±	1.66	0.03	0.2	19	61	0.21
C.D. (P=0.05)	5.22	NS	NS	58	192	0.67
Irrigation						
No irrigation	62.62	1.26	28.0	865	3115	21.86
One irrigation at flowering	67.13	1.33	29.0	943	3379	21.95
S E.±	1.35	0.03	0.2	15	50	0.13
C.D. (P=0.05)	4.26	NS	0.5	48	156	N.S.
Weed management						
Weedy check	60.00	1.18	27.7	809	2925	21.78
One hand weeding at 30 DAS	65.14	1.34	28.9	923	3304	21.96
Pendimethalin @1.00 kg a.i./ ha (pre-emerg)	69.48	1.37	29.0	980	3511	21.95
S E.±	1.51	0.02	0.2	09	42	0.16
C.D. (P=0.05)	4.41	0.07	0.6	27	123	N.S.

NS=Non-significant

irrigation (Table 2) over the unirrigated check because of the better plant growth in irrigated plots. Positive impact of irrigation on number of pods plant^{-1} in pulses was reported by Reddy and Ahlawat (1998).

Weed control influenced the number of pods plant^{-1}, number of grains pod^{-1} and 1000-grain weight, significantly (Table 2). As par weed control is concerned, pendimethalin @ 1.0 kg a.i. ha^{-1} application proved best followed by hand weeding and weedy check treatments. Contribution of weed control measures towards the enhancement of yield attributes could be ascribed to their effect in reducing the crop-weed competition in legumes were reported by several workers (Ahlawat *et al.,* 1981; Das, 1985; Singh, 1985).

Grain and stover yield:

Data pertaining to grain yield (kg ha^{-1}) are presented in Table 2. It can be revealed from the data that grain yield of lentil increased significantly due to raised bed system of planting compared to flat bed and zero tillage planting. Flat bed planting technique also produced significantly higher grain yield (900 kg ha^{-1}) than zero tillage. The per cent increase with respect to grain yield were 12.7 and 27.0 in flat bed and raised bed planting technique over zero tillage, respectively. The highest (1014 kg ha^{-1}) grain yield was produced in raised bed sowing and was the lowest (798 kg ha^{-1}) in zero tillage.

In the irrigation treatment there was a significant increase in grain yield observed as compared to unirrigated control. One irrigation at flowering increase the grain yield of lentil to the tune of 9.0 per cent (Table 2) over unirrigated control.

Weed management treatments resulted in realization of significantly higher grain yield of lentil than unweeded control (Table 2). Pre-emergence application of pendimethalin @ 1 kg a.i.ha^{-1} produced the highest (980kg ha^{-1}) grain yield. This data reveal that controlling weeds by pendimethalin resulted in significantly higher grain yield than other weed control measures. Pendimethalin @ 1 kg a.i.ha^{-1} application produced significantly higher yield over manual weeding (one hand weeding at 30 DAS), One hand weeding at 30 DAS also produced significantly higher grain yield (923 kg ha^{-1}) as compared to weedy check treatment. The grain yield recorded an increase of 21.0 and 14.0 per cent due to pendimethalin and one hand weeding at 30 DAS over weedy check, respectively.

The data presented in Table 2 revealed that stover yield was significantly influenced by planting techniques. Sowing of lentil on raised bed resulted in significantly superior stover yield over rest of the two planting techniques. Stover yield was found significantly higher in raised bed than zero till sowing and flatbed planting. The per cent increase in stover yield was 32.8 and 17.3 per cent in raised bed over zero tillage and flat bed, respectively.

Irrigation had positive effect on the stover yield and it was observed that application of one irrigation at flowering resulted in significantly higher stover yield (3379 kg ha^{-1}) as compared to no irrigation (3115 kg ha^{-1}).

Controlling weeds either manually or chemically produced significantly higher stover yield compared to unweeded control. The effect of pendimethalin application was more pronounced as it yielded significantly more stover yield (3511 kg ha^{-1}) than hand weeding and weedy check. The data show that the treatments in the decreasing order of stover yield were pendimethalin, hand weeding and weedy check.

Grain and stover yield (Table 2) varied significantly due to planting methods. Grain and stover yield were significantly higher under raised bed planting system. The grain yield of lentil was recorded to be 1014kg ha^{-1} under raised bed over zero tillage (798kg ha^{-1}) and flat bed (900kg ha^{-1}). Raised bed planting increased grain yield by 27.07 and 12.60 per cent as compared to zero tillage and flat bed, respectively. The increase in grain yield could be attributed to higher number of pods plant^{-1}, increased number of grains pod^{-1} (Table 2) in raised bed planting. Tripathi (1999), Chauhan *et al.* (1997) and Vardi (2003) also reported higher grain yield with bed planting of wheat. The lowest grain yield was recorded from zero till sowing which may be due to poor development of the plant as reflected in the lower plant height, dry matter accumulation and yield attributes. Poor nodulation in this treatment was also responsible for the poor nutrition to the plants that ultimately reflected in poor yield.

Similarly, stover yield was 22.80 and 17.35 per cent higher under raised bed planting than zero tillage and flat bed, respectively. This was mainly because of more number of branches and dry matter accumulation under raised bed planting of lentil. The findings corroborate the results obtained by Chauhan *et al.* (1997).

Grain yield and stover yield of lentil increased significantly with irrigation (Table 2). The increased productivity of grain and stover resulted due to better effect of irrigation on growth and yield attributes, as cited earlier (Table 2). The higher grain yield was recorded when irrigation was given at flowering stage as compared to unirrigated plots. Irrigation at flowering helped in maintaining the soil moisture at the reproductive stage, resulted in maintaining the physiological processes even with the rise in temperature (31^{0}C), ultimately resulted in bolder seeds and more number of pods. Hence, increase in yield parameters and yield with the irrigation. The similar findings were also reported by Singh and Singh (1983)

Oweis *et al*. (2004).

Controlling weeds either manually or chemically improved the grain and stover productivity of lentil (Table 2) by their marked effect in boosting the various growth and yield parameters. Saxena and Wassimi (1980) and Singh (1985) had also reported increase in grain and straw yield in lentil by weed suppression. Weedy check plot depressed the grain productivity significantly as compared to pendimethalin application and hand weeding. This resulted because of suppressed growth of lentil plants in weedy check plot by weeds. In pendimethalin treated plots there were reduced competition by weeds because pendimethalin reduced the weed growth effectively as compared to weedy check plot.

Harvest index:

The data in Table 2 revealed that planting technique had shown significant effect on harvest index. However, irrigation and weed management practices failed to produce significant variation in lentil yield. Zero tillage and flat bed planting techniques being at par recorded significantly more harvest index over raised bed planting.

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