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Increasing the Productivity of Lentil through Agronomic Interventions in Nepal

Anil Pokhrel[1*], Tika Bahadur Karki[2] and Sangharsh Raj Dangi[3]

[1]Ginger Research Program, Kapurkot, Salyan, Nepal
[2]National Agronomy Research Centre, Khumaltar, Lalitpur, Nepal
[3]Grain Legumes Research Program, Khajura, Banke, Nepal
*Corresponding author's email: anilp.narc@gmail.com

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ABSTRACT

The low productivity of lentil due to adaptation of poor crop management practices is the main problem of the lentil production in western terai region of Nepal. With an objective of selecting appropriate variety, sowing time, sowing method, seeding rate, priming techniques and weed management practice for lentil cultivation four different experiments were conducted at Grain Legumes Research Program, Khajura, Banke in two winter seasons of 2017/18 and 2018/19. The experiment on sowing time was conducted in split-plot design including four lentil varieties and four sowing dates, while the seeding rate experiment was laid out in split-split-plot design with the treatments of two varieties, two sowing methods and four seed rates. Similarly, seed priming and weed management trails were conducted in RCBD with ten treatments. All the experiments were replicated three times. The highest seed yield of lentil was recorded from the early maturing lentil varieties, i.e. PL 4 (934 kg ha^{-1}) and ILL 7979 (864 kg ha^{-1}). Similarly, lentil sowing on October (940 kg ha^{-1}) produced the higher seed yield than sowing on November (682 kg ha^{-1}). Likewise, the highest seed yield of lentil was recorded from the use of seeding rate 60 kg ha^{-1} (890 kg ha^{-1}), but it was statistically at par with the seeding rates of 40 kg ha^{-1} (865 kg ha^{-1}) and 50 kg ha^{-1} (855 kg ha^{-1}). Differently, the seed yield of lentil didn't differ significantly under line (856 kg ha^{-1}) and broadcasting (847 kg ha^{-1}) methods of sowing. The seed priming with a 250 ppm solution of sodium molybdate (Na_2MoO_4) produced significantly the highest seed yield (961 kg ha^{-1}) in lentil. Similarly, the highest and statistically similar seed yield of lentil was recorded with the weed management practice of two hand weeding (924 kg ha^{-1}) and the use of Pendimethalin (898 kg ha^{-1}) and Pendimethalin-Quizolofop-ethyl (857 kg ha^{-1}) as a pre-emergence. Thus, the adaptation of appropriate variety, planting time, seeding rate, seed priming technique, sowing method and weed management practices are the major factors of production for getting higher yield of lentil.

Keywords: Lentil, seed rate, sowing date, variety, weed management

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INTRODUCTION

Grain legume cultivation is the fundamental part of the Nepalese agriculture production systems, as these crops can be grown in a wide range of land from fertile to degraded or marginal soils, and also because of the *Dal-Bhat-Tarkari* fooding habits of its populace. Indeed, these are the crops which provide opportunities for enhancing income and livelihoods of the poor and marginal farmers. Among the legume crops, lentil (*Lens culinaris* Medikus) is the first important legume crop that is growing highly (26-77%) in all the provinces of Nepal, except Bagmati and Gandaki provinces (Pokhrel et al., 2018). The area coverage and production of lentil is higher in Madesh (37%) and Lumbini (34%) provinces than other provinces of Nepal (Pokhrel et al., 2018). According to MoALD (2021), lentil is grown in an area of 212876 ha that produced 262835 t, more popularly grown under rice based cropping system in winter season. Though, there is increasing trend in growth rate of area (1.0%), production (4.3%) and productivity (3.1%) of lentil over the 15-years (2000/01–2007/08 and 2008/09–2015/16) period in the country, but still its productivity is very low and found stagnant (Pokhrel et al 2018). Nepal has imported 91556 Mt of lentil with an import value of 52 million US$ in the year 2020, which was 147% higher in quantity than in 2015 (FAOSTAT 2021). Therefore, there is a need of increasing production and productivity of lentil for improving farm income and substituting the importation of lentil in the country.

Many biotic and abiotic factors are responsible for lowering down the production and productivity of lentil, among them selection of suitable variety (Mandi et al 2015; Sen et al 2016; Ouji and Mouelhi 2017), inappropriate time of sowing (Sen et al 2016; Ouji and Mouelhi, 2017), seeding rate (Saleem et al 2012; Iliger and Alagundagi, 2017; Woldeselassie et al 2022), weed management (Erman et al, 2004; Bhattarai et al 2018; Singh et al 2018) and poor seed germination and crop stand establishment (Amir et al 2021; Khan et al 2017) are the major ones that influence the lentil production. Sowing time is an important agronomic variable that affects the growth, development and yield of legume crops to a great extent. However, optimum sowing time varies among locations and maturity period of the specific crop cultivar (Getachew 2001). The poor vegetative growth and reproductive development due to inappropriate sowing time has caused yield loss in legumes (Hall 2004).

The use of optimum seed rate for maintaining the optimum plant population is another important factor of increasing lentil yield, as it directly affects growth and development of lentil plant. The higher plant population may lead to increase the competition between plants for resources, and increases risk of disease, lodging, shedding of flowers and pods, resulting in reduced seed yield, while low plant densities are unable to use the available resources efficiently, resulting low yield. Poor weed management is the another important reason for low productivity of lentil, as it is poor competitor with weeds because of slow growth rate and limited leaf area development in early stages of crop growth and establishment. Considerable yield losses in lentil noted to the extent of 30–100 percent if weeds are not managed within critical growth period of crop (Bekir and Barboras 2005).

Seed priming is the low cost technology that can enhance early crop growth leading to earlier flowering and maturity of the crops. It is the easy, low risk and highly effective technique in crop production system. Patil et al (2018) reported that seed priming led to better crop establishment and growth, earlier flowering, increase seed strength index against environmental stresses. The rapid field emergence and seedling growth considerably contribute to higher yield of lentil (Khan et al 2016) under drought conditions. Seed priming can be done with different

priming solution, soaking in pure water (Hydro-priming), soaking in inorganic salt solutions (Halo-priming) and soaking in different growth hormones (Hormonal-priming).

Therefore, it is imperative to study the effects of sowing date, seed rate and weed management practices on yield attributes and yield of lentil varieties. The main objective of this study is to identify the appropriate seeding date, seeding rate, seeding method and weed management practice for lentil production in western terai region of Nepal.

MATERIALS AND METHODS

Four different experiments were conducted at agricultural farm of NARC, Grain Legumes Research Program, Khajura, Banke, Nepal situated at 28° 06" 45' N latitude, 81° 35" 58' E longitude and 182 masl during the winter season of two consecutive years, 2017/18 and 2018/19. In all the experiments, the plot size was 5 m^2, where fertilizers were applied at the rate of 20:40:20 kg $N:P_2O_5:K_2O$ ha^{-1}, while irrigation and weeding practices were adopted as per needed and based on the treatments.

Sowing time and variety

This experiment consisted of four levels of sowing dates, i.e. (a) 11th October, (b) 26th October, (c) 10th November and (d) 25th November as a main-factor and four levels of varieties, i.e. (a) Black Masuro, (b) Khajura Masuro 4, (c) ILL 7979 and (d) PL4 as a sub-factor, thus making sixteen treatment combinations, which were replicated thrice and was laid out in split-plot design.

Seeding rate, variety and sowing method

This experiment was conducted in a split-split-plot design having three replications with varieties, i.e (a) Black Masuro and (b) ILL 7979 as a main-treatments, sowing methods, i.e. (a) Line sowing and (b) Broadcasting as a sub-treatments and seeding rates, i.e. (a) 30 kg ha^{-1}, (b) 40 kg ha^{-1}, (c) 50 kg ha^{-1} and (d) 60 kg ha^{-1} as a sub-sub-treatments.

Seed priming

This experiment was conducted in a randomized complete block design with three replication including ten treatments as seed priming. The seed priming techniques were (a) Control (unprimed), (b) Pure water, (c) Cattle urine - 20%, (d) Sodium molybdate (Na_2MoO_4) - 250 ppm

(e) Boric acid (H_3BO_3) - 250 ppm, (f) Potassium dihydrogen phosphate (KH_2PO_4) -2%, (g) Gibberellic acid (GA_3) - 100 ppm, (h) Potassium nitrate (KNO_3) - 2%, (i) Calcium sulphate ($CaSO_4$) - 2% and (j) Zinc sulphate ($ZnSO_4$) - 2%. Seed priming was conducted just before the seeding, where lentil seeds were primed for 8 hours based on the treatments and kept in shade for surface drying.

Weed management

This experiment was laid out in a randomized complete block design with three replications. The weed management practices were (a) Pendimethalin, (b) Pendimethalin and Quizolofop-ethyl, (c) Metribuzin, (d) Metribuzin and Quizolofop-ethyl, (e) Oxadiargyl, (f) Oxadiargyl and Quizolofop-ethyl, (g) Quizolofop-ethyl, (h) Two hand weeding, (i) One hand weeding and (j) Unweeded. In this experiment, Pendimethalin, Metribuzin and Oxadiargyl were applied through Penda 30% @ 6 mL, Anchor @ 1 g and Top Star @ 0.2 g L^{-1}per liter of water at a day after

sowing (DAS), respectively, while Quizolofop-ethyl was used through Terga Super @ 2 mL L^{-1} water at 25 DAS. The treatments of hand weeding performed at 25 DAS for one hand weeding and at 25 and 45 DAS in case of two hand weeding treatment.

Soil characteristics

The soils of the experimental plots were found sandy loam with 6.6 to 7.1 pH value that had low amount of organic matter (1.76 to 1.82%) and nitrogen (0.07 to 0.09%) but a high level of phosphorous (98.4 to 123.7 kg ha^{-1}) and potassium (291.1 to 283.3 kg ha^{-1}).

The climatic condition of the study area

The experimental site received 85.6 and 151.7 mm rainfall in the year 2017/18 and 2018/19, respectively during the study period from October to April. December and January are noted as the coolest months. The mean minimum temperature, maximum temperature and rainfall of the study area are presented in Table 1.

Table 1. Average temperatures and rainfall during study periods of the year 2017/18 and 2018/19

Month	2017/18			2018/19		
	Min Tem (ºC)	Max Tem (ºC)	Rainfall (mm)	Min Tem (ºC)	Max Tem (ºC)	Rainfall (mm)
October	21.3	33.0	47.9	13.9	30.4	0.0
November	13.2	28.3	0.0	10.5	25.7	0.0
December	10.7	23.5	0.0	5.9	22.8	6.7
January	9.7	19.0	9.7	8.8	21.8	60.8
February	10.7	25.9	12.8	12.1	25.4	38.1
March	14.5	33.2	5.3	17.2	32.8	2.5
April	24.1	36.9	9.9	20.9	38.1	43.6

Statistical analysis

All the data on yield attributes and yields were analyzed statistically at probability level ≤ 0.05 by using statistical software SPSS version 16.0.

RESULTS AND DISCUSSION

Sowing time and variety

A combined result of 2017/18 and 2018/19 on the growth, development, yield and yield attributing parameters of lentil affected by seeding dates and varieties are presented in Table 2. The entire yield attributes and yield of lentil differed significantly due to the seeding dates and varieties at $p \leq 0.01$, but an interaction of seeding dates and varieties had only influenced the days to flowering (DTF), days to maturity (DTM), plant height and seed yield, significantly. The DTF ranged from 76 days (11^{th} October) to 84 days (10^{th} November), while it was found longer in variety Black Masuro. Similarly, DTM ranged from 110 days (10^{th} November) to 140 days (11^{th} October), while the variety Khajura Masuro 4 (132 days) and Black Masuro (129 days) took longer days for maturing. The increasing temperature in growing period may lead the earlier maturity under later sown conditions. The tallest plant was recorded with the variety Khajura Masuro 4 (29.3 cm), even as earlier sown (11^{th} October) lentil had the highest plant height (30.9 cm) as compared to later sown conditions. The shorter plant height of lentil in later

sown condition might be due to shorter duration of optimum growing environment or earlier maturity of the crop.

The yield attribute like number of pods per plant was recorded highest in earlier, i.e 11th October (28) sown condition, in contrast it was noted lowest in 25th November (22) sown lentil, where the lentil variety Black Masuro had the highest pods per plant (29), among the varieties. Likewise, the hundred seeds weight (HSW) was noted in 11th and 26th October (2.1 g) sown conditions, but it was noted lowest in 25th November (1.8) sowing time. The lentil variety PL 4 had the highest weight of hundred seeds (2.7 g) than other tested lentil varieties. The higher weight of hundred seeds in earlier sowing condition because of expose of the crop under optimum growing environment, while in genotypes it might be due to difference in their genetic makeup and differential response to different sowing times.

Sowing on 11th and 25th October recorded significantly the highest seed yield (954 and 926 kg ha^{-1}, respectively) over the 10th November (762 kg ha^{-1}) and 25th November (603 kg ha^{-1}). The higher seed yield of lentil under earlier sown condition in the study was due to higher number of pods per plant and hundred seeds weight. The results of the study in line with the Mandi et al (2015) and Ouji and Mouelhi (2017), where they also experienced the replayed the sowing from earlier to later reduced the plant height, number of pods per plant and seed yield of lentil. In contrast of this study, Sen et al. (2016) reported lentil sown on 15th November produced the highest seed yield, which was about 3 and 16% higher over the earlier (1st November) and later (30th November) sown conditions, respectively. Similarly, the results indicated that early maturing lentil variety PL 4 (934 kg ha^{-1}) produced a significantly the highest seed yield, followed by ILL 7979 (864 kg ha^{-1}) than the varieties, i.e. Black Masuro (778 kg ha^{-1}) and Khajura Masuro (669 kg ha^{-1}), which had higher days for maturity. Moreover, yar didn't influence significantly the seed yield of lentil, but the lower seed yield (801 kg ha^{-1}) of lentil in the second year as compared to the first year (822 kg ha^{-1}) was due to the higher rainfall in the second year, as lentil crop cannot resist higher rainfall under poorly drain condition.

The interaction effect of sowing time and variety on seed yield indicated that the earlier maturing lentil varieties like PL 4 and ILL 7979 are more suitable for mid-season sowing condition as these yielded highest in the second planting date (Figure 1). As the results of this study, Sen et al (2016) also reported the replacement of late maturing lentil varieties along with adjustment of sowing time may help to improve the yield as well as to expand the areas of lentil.

Table 2. Effects of sowing time and variety on yield attributes and yield of lentil

Treatment	Days to flowering	Days to maturity	Plant height, cm	No. of pods $plant^{-1}$	100 seed weight, g	Seed yield, kg ha^{-1}
Sowing time						
11th October	76	140	30.9	28	2.1	954
26th October	80	134	27.8	26	2.1	926
10th November	84	120	24.4	27	1.9	762
25th November	77	110	23.2	22	1.8	603
SEm (±)	1.41	1.44	0.67	0.98	0.55	22.33
LSD (<0.05)	3.99	4.06	1.88	2.76	0.15	63.12
Variety						
Black Masuro	92	129	26.5	29	1.5	778
Khajura Masuro 4	87	132	29.3	26	1.9	669
ILL 7979	69	121	23.2	24	1.8	864

Treatment	Days to flowering	Days to maturity	Plant height, cm	No. of pods plant^{-1}	100 seed weight, g	Seed yield, kg ha^{-1}
PL4	70	123	27.3	25	2.7	934
SEm (±)	1.41	1.44	0.67	0.98	0.05	22.33
LSD (<0.05)	3.99	4.06	1.88	2.76	0.15	63.12
Year						
2017/18	79	127	27.2	22	1.95	822
2018/19	77	125	25.9	29	1.98	801
SEm (±)	0.99	1.02	0.47	0.69	0.38	15.79
LSD (<0.05)	2.82	2.87	1.33	1.95	0.11	44.63
F-test						
Year	ns	ns	ns	**	ns	ns
Sowing time	**	**	**	**	**	**
Variety	**	**	**	*	**	**
Sowing time × Variety	**	**	ns	ns	*	**
CV (%)	8.7	5.6	12.3	18.4	13.6	13.5

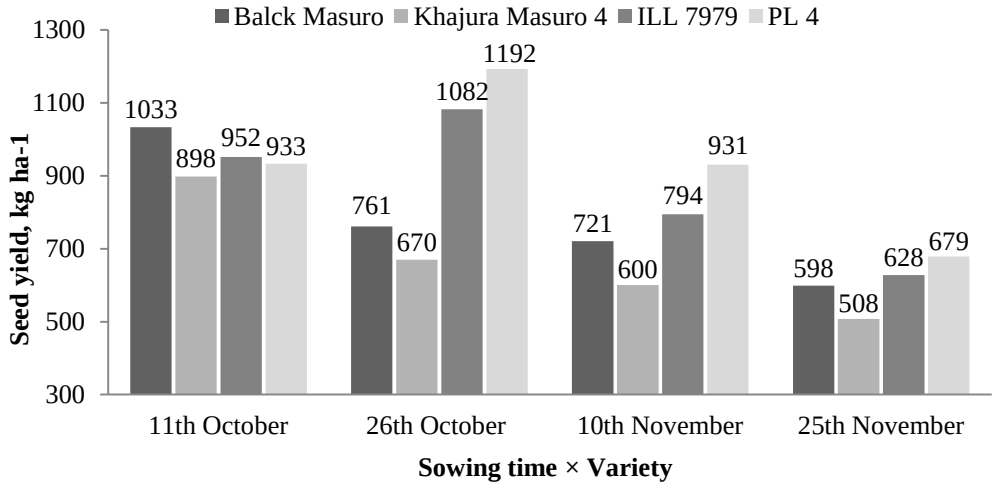

Figure 1. Interaction effect of sowing time and variety on seed yield of lentil

Seeding rate, variety and sowing method

A combined result of 2017/18 and 2018/19 on effects of variety, sowing method and seed rate on yield attributes and yield of lentil are presented in Table 3. The results indicated that variety had only significant influenced on DTF, DTM and HSW, while the significant effect on seed yield imparted due to effect of seeding rates. The interaction effects of variety and seeding rate manipulated the plant height, but the interaction effects of sowing method and seeding rate affects the HSW, significantly.

The lentil variety Black Masuro took longer days for flowering (83 days) and maturity (73 days), and also had longer plant height as compared to ILL 7979, in contrast the variety ILL 7979 was a superior in the number of pods per plant (22), HSW (1.7 g) and seed yield (864 kg ha^{-1}) than Black Masuro. This might be the genetic effects of the crops that prejudiced the

growth, development and resistance of the crop under different growing seasons and conditions. Although, the sowing method of lentil didn't significantly affect the lentil growth, development, yield attributes and yield of lentil, except number of pods per plant, but the line sowing method seemed better than broadcasting method in terms of seed yield. It can be also suggested for equal distribution of seeds in broadcasting method of sowing.

A significantly ($p \leq 0.01$) maximum seed yield of lentil was observed with the seeding rate of 60 kg ha^{-1} (890 kg ha^{-1}) followed by the seeding rates of 40 and 50 kg ha^{-1} (865 and 855 kg ha^{-1}, respectively), which were also noted at par in their seed yield. In contrast, the lowest seed yield of lentil recorded with the seeding rates of 30 kg ha^{-1}. The higher seed yield of lentil under higher seeding rates as compared to lower seeding rates because of maintaining the desired plant population that can use available resources effectively. In the same way of the study, Iliger and Alagundagi (2017) also reported a significantly higher seed yield of lentil from the seeding rate of 40 kg ha^{-1} than the seeding rates of 30 and 35 kg ha^{-1}. Similarly, Saleem et al. (2012) also noted the yield kept on increasing up to seed rate at 43 kg ha^{-1} thereafter yield remained static and non-significant for any further increase in seed rates up to 87 kg ha^{-1}.

Table 3. Effects of variety, sowing method and seed rate on yield attributes and yield of lentil

Treatment	Days to flowering	Days to maturity	Plant height c(m)	No. of pods $plant^{-1}$	100 seed weight (g)	Seed yield, kg ha^{-1}
Variety						
Black Masuro	83	113	19.2	20	1.5	839
ILL 7979	73	111	18.9	22	1.7	864
SEm (±)	0.34	0.26	0.37	1.36	0.03	15.93
LSD (<0.05)	0.97	0.73	1.04	3.84	0.09	44.84
Sowing method						
Broadcasting	79	112	18.8	23	1.6	847
Line sowing	78	112	19.3	19	1.6	856
SEm (±)	0.34	0.26	0.37	1.36	0.03	15.93
LSD (<0.05)	0.97	0.73	1.04	3.84	0.09	44.84
Seed rate						
30 kg ha^{-1}	79	112	18.8	23	1.5	796
40 kg ha^{-1}	79	112	19.4	20	1.6	865
50 kg ha^{-1}	78	113	18.7	22	1.6	855
60 kg ha^{-1}	78	112	19.2	20	1.6	890
SEm (±)	0.49	0.37	0.52	1.93	0.04	22.52
LSD (<0.05)	1.37	1.04	1.47	5.43	0.12	63.42
F-test						
Year	**	**	**	**	**	**
Variety	**	**	ns	ns	**	ns
Sowing method	ns	ns	ns	*	ns	ns
Seed rate	ns	ns	ns	ns	ns	*
Variety × Sowing method	*	ns	ns	ns	ns	ns
Variety × Seed rate	ns	ns	*	ns	ns	ns
Sowing method × Seed rate	ns	ns	ns	ns	*	ns
CV (%)	3.0	1.6	13.4	44.8	13.7	13.0

Seed priming

A combined result of 2017/18 and 2018/19 on growth, yield attributes and yield of lentil affected by different seed priming treatments are presented in Table 4. A significant difference was observed only in days to maturity and seed yield because of the priming treatments. Data on days to flowering and maturity ranged from 94 to 100 days and 134 to 138 days, respectively. Seed priming with $ZnSO_4$-2% required longer days to flowering followed by control and pure water (97 days) treatments, while early maturity of lentil was observed with treatments GA_3-100 ppm. Seed priming with $CaSO_4$-2% (138 days) and KNO_3-2% (137 days) resulted more number of maturity days as compared to other treatments. Similarly, the variation in plant height of lentil due to the effect of priming treatments ranged from 23.0 to 29.3 cm, where the longer plant height was observed from the treatments Na_2MoO_4-250 ppm and $CaSO_4$-2%.

The data of different priming treatments on number of pods per plant and hundred seed weight ranged from 30 to 54 and 1.2 to 1.4 g, respectively. The maximum number of pods plant^{-1} was recorded by the treatment $ZnSO_4$-2% (54), followed by control (42) and $CaSO_4$-2% (40), while it was noted lower from pure water (30) and GA_3-100 ppm (33). Likewise, the highest hundred seed weight (1.4 g) of lentil was noted from the majority of the treatments except KNO_3-2% (1.2 g), GA_3-100 ppm (1.3 g), H_3BO_3 -250 ppm (1.3 g) and Cattle urine-20% (1.3 g). The seed yield of lentil due to the effect of priming treatments ranged from 325 ($ZnSO_4$-2%) to 961 (Na_2MoO_4-250 ppm). The yield data revealed that the highest grain yield was found from the use of primed seed with Na_2MoO_4-250 ppm, followed by $CaSO_4$-2% (891 kg ha^{-1}), KH_2PO_4-2% (876 kg ha^{-1}), Pure water (845 kg ha^{-1}) and Cattle urine-20% (823 kg ha^{-1}). In contrast, the lowest grain yield of lentil was recorded by treatment $ZnSO_4$-2%, followed by KNO_3-2% (657 kg ha^{-1}) and GA_3-100 ppm (696 kg ha^{-1}).

The increased in seed yield of lentil with different priming solutions might be due to completion of pre germination metabolic activities during seed priming, making the seed ready for soon germination after planting. Karjule and Shelar (2019) was also reported that pre-sowing seed priming significantly influenced the root and shoot length. It was revealed from this study that different seed priming techniques had various effects on growth, development and yield of lentil. In lentil, except priming treatment zinc sulphate ($ZnSO_4$)-2%, all other treatments had positive effect on grain yield as compared to Control (unprimed) and priming with pure water. The results were in close conformity with the results reported by Kumar et al. (2019), where they noted the priming treatment sodium molybdate (Na_2MoO_4) as the best seed priming treatment that showed higher benefit cost ratio in lentil production. In contrast of this study, Yucel (2012) reported the seed priming with pure water as the most effective measure than seed priming with potassium nitrate (KNO_3) and potassium dihydrogen phosphate (KH_2PO_4). The lowest grain yield from the priming treatment zinc sulphate ($ZnSO_4$)-2% in lentil was due to toxic effect of it on seed that hindered seed germination.

Table 4. Effects of seed priming on yield attributes and yield of lentil

Treatment	Days to flowering	Days to maturity	Plant height (cm)	No. of pods plant^{-1}	100 seeds weight (g)	Seed yield (kg ha^{-1})
Control (unprimed)	97	136	24.0	42	1.4	754
Pure water	97	136	26.7	30	1.4	845
Cattle urine-20%	94	136	27.7	38	1.3	823
Na_2MoO_4-250 ppm	96	136	29.3	37	1.4	961
H_3BO_3 -250 ppm	94	136	25.3	34	1.3	765

Treatment	Days to flowering	Days to maturity	Plant height (cm)	No. of pods plant^{-1}	100 seeds weight (g)	Seed yield (kg ha^{-1})
KH_2PO_4-2%	94	136	26.7	38	1.4	876
GA_3-100 ppm	99	134	23.0	33	1.3	696
KNO_3-2%	95	137	25.0	36	1.2	657
$CaSO_4$-2%	95	138	29.3	40	1.4	891
$ZnSO_4$-2%	100	136	24.7	54	1.4	325
GM	99	136	26.7	38	1.4	759
F-test	ns	*	ns	ns	ns	**
LSD (<0.05)	6.21	4.18	3.85	16.71	0.18	221.01
CV (%)	3.8	1.8	8.4	25.5	7.6	17.0

Weed management

A combined result of 2017/18 and 2018/19 on yield attributes and yield of lentil affected by different weed management practices are presented in Table 5. Among the growth development, yield and yield attributing parameters, the number of pods per plant, weeds dry weight and seed yield were affected significantly at ($p \leq 0.01$) by the weed management practices, but year had a significant effect on all the recorded parameters of lentil. The DTF, DTM, plant height and HSWwere ranged from 89 to 92 days, 123 to 124 days, 21.6 to 24.5 cm and 1.5 to 1.7 g, respectively. The highest number of pods per plant was noted through the use of Pendimethalin (27) followed by the Pendimethalin and Quizolofop-ethyl (25), one hand weeding (25) and two hand weeding (23), but the lowest of it recorded under Unweeded condition (15) followed by using of Metribuzin (16), Oxadiargyl (16) and Metribuzin and Quizolofop-ethyl (17).

A significantly highest weeds dry weight was observed under the treatment of unweeded (282.8 g m^{-2}) followed by Quizolofop-ethyl (235.3 g m^{-2}). In opposition to it was recorded the lowest in two hand weeding (58.7 g m^{-2}) that was seemed statistically at par with the use of Pendimethalin and Quizolofop-ethyl (74.0 g m^{-2}) and Pendimethalin (96.0 g m^{-2}) for weed management. Similarly, the highest and statistically similar seed yield of lentil was recorded with the weed management practice of two hand weeding (924 kg ha^{-1}), Pendimethalin (898 kg ha^{-1}) and Pendimethalin and Quizolofop-ethyl (857 kg ha^{-1}). But, the lowest seed yield was found in treatment of Quizolofop-ethyl (632 kg ha^{-1}), which was statistically same with the treatments of Metribuzin (656 kg ha^{-1}), Oxadiargyl (702 kg ha^{-1}), unweeded (711 kg ha^{-1}), Metribuzin and Quizolofop-ethyl (722 kg ha^{-1}), Oxadiargyl and Quizolofop-ethyl (736) kg ha^{-1} and one hand weeding (754 kg ha^{-1}).

Though, the two hand weeding gave the higher yield of lentil but the use of herbicides also seemed economical in controlling the weeds and increasing the crop yield. The results of the study was with Erman et al (2004) and Singh et al (2018), where they noted use of herbicides might be the potential option for the economical management of weeds in lentil cultivation. In another study on weed management, Bhattarai et al (2018) reported that the use of pre-emergence herbicides followed by one hand weeding reduced the weed dry weight and increased the seed yield.

Table 5. Effects of different weed management practices on yield attributes and yield of lentil

Treatment	Days to flowering	Days to maturity	Plant height, cm	No. of pods plant^{-1}	100 seeds weight (g)	Weeds dry weight (g m^{-2})	Seed yield (kg ha^{-1})
Pendimethalin	92	123	24.5	27	1.6	96.0	898
Pendimethalin - Quizolofop-ethyl	92	124	23.7	25	1.6	74.0	857
Metribuzin	90	123	23.1	16	1.6	159.3	656
Metribuzin - Quizolofop-ethyl	90	123	21.8	17	1.6	115.0	722
Oxadiargyl	90	123	22.6	16	1.7	166.0	702
Oxadiargyl - Quizolofop-ethyl	90	123	22.8	20	1.6	230.3	736
Quizolofop-ethyl	90	124	21.6	20	1.5	235.3	632
Two Hand weeding	90	123	21.9	23	1.5	58.7	924
One Hand weeding	90	123	22.7	25	1.6	113.6	754
Unweeded	89	123	21.9	15	1.6	282.5	711
SEm (±)	0.93	0.37	1.43	1.86	0.59	34.09	39.56
F-test							
Year	**	**	**	**	**	-	**
Management practices	ns	ns	ns	**	ns	**	**
LSD (<0.05)	2.67	1.06	4.11	5.32	0.17	101.28	113.27
CV (%)	2.5	0.7	15.6	22.2	9.3	42.5	12.8

CONCLUSIONS

Based on the results of the experiments, it could be concluded and recommended as:

- Early maturing lentil varieties produced 24% higher seed yield as compared to late maturing varieties.
- Early sowing is the most important for lentil production, as sowing of lentil on 11th October, 26th October and 10th November produced 58, 53 and 26 percent more seed yield than sowing on 25th November.
- The increasing of seed rate increased the seed yield of lentil, but the seeding rate of 40 kg ha^{-1} was the best and economical seed rate for lentil production. The existing seed rate of 20 kg ha^{-1} k in lentil is seemingly not sufficient to obtain optimum yield.
- Sowing of lentil seeds after priming with sodium molybdate (Na_2MoO_4)-250 ppm produced 27% and 13% more grain yield as compared to control (unprimed) and priming with pure water, respectively.
- There was no significant difference in seed yield of lentil under line and broadcasting methods. Though, line sowing method seemed better for higher seed yield, but one can use the broadcasting method of sowing with a uniform distribution of seeds, while broadcasting.
- The weed management practices, i.e. two hand weeding and use of Pendimethalin as pre-emergence herbicides increased the seed yield of lentil by 30 and 26 percent, respectively.

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AUTHORS' CONTRIBUTION

Anil Pokhrel and Sangharsh Raj Dangi carried out experiment and prepared manuscript. Tika Bahadur Karki contributed to prepare ANOVA and the manuscript.

CONFLICTS OF INTEREST

The authors have no any conflict of interest to disclose.

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