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Yield, Economics, Nutrient Uptake and Quality of Lentil (*Lens culinaris* L.) as Influence by Salicylic Acid and Potassium Nitrate under Rainfed Condition

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ABSTRACT

A field experiment was conducted at Agricultural Research Farm, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur District, Manipur, India during the year 2018-2019 to study the effect of salicylic acid and potassium nitrate on yield, economics and quality of lentil under rainfed conditions. The findings indicated that seed priming of salicylic acid (SA) @ 200 ppm and scaling up of potassium nitrate (KNO_3) up to 1.5% as foliar application significantly enhanced the yield (grain yield, stover yield and biomass yield) and economics, nutrient uptake and quality of lentil. The treatment combination salicylic acid @ 200 ppm + KNO_3 1.5% gave the maximum grain yield (1104.88 kg/ha), stover yield (1799.06 kg/ha) and biomass yield (2903.95 kg/ha). The gross returns (₹73617), net returns (₹38729) and benefit:cost ratio (2.11) were highest through application of SA @ 200 ppm and KNO_3 @ 1.5%. The N, P and K uptake (kg/ha) and protein content of lentil were highest through application of SA @ 200 ppm and KNO_3 @ 1.5%.

Keywords Foliar application, Lentil, Potassium nitrate, Salicylic acid, Seed priming.

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INTRODUCTION

Pulses are the wonder crops which is an integral part of the vegetarian diet and the cheapest source of protein for the resource poor farmers of the Indian sub-continent. It has a rich source of vitamins, proteins, minerals, crude fiber. Pulses being a lucrative crop can be grown within a short time period and can be beneficial to the soil. It reduces the pressure of external inorganic nitrogen inputs due to biological nitrogen fixation and increased the productivity and fertility of the soil. The eminence of growing pulse crop influenced the Indian economy in terms of their rising domestic demands on account of increase in population and per capita income; their increasing export potential and increased pulses consumption. Lentil is one of the major *rabi* pulses in India which are known to render significant impact on soil health and sustainable agriculture. Lentil is an important legume crop which is grown in an area of 1.80 million hectares and total production of 1.10 million tonnes, with productivity of 611 kg per hectare (FAO State, 2014). It is hardy in nature and consumed mostly as 'dal'.

Lentil cultivation has been increasing from the past 5-7 years in Manipur. The variety HUL-57 is a popular variety of lentil that has been grown successfully under rainfed conditions in Manipur, it is adapted to cool growing conditions and the young plants are tolerant to frost (Laishram *et al.* 2020).

Salicylic acid (SA) is an endogenous plant hormone of phenolic nature that posses an aromatic ring with a hydroxyl group and plays a vital role in plant growth, ion uptake and transport (Hayat *et al*. 2010). SA a natural inductor of thermogenesis, are known to induce flowering in a range of plants, control ion uptake by roots, photoperiodic responses, senescence mediation and stomatal conductivity (Raskin 1992). It has been reported to mitigate the deleterious effects of several environmental stresses on plants including low temperature and chilling, high temperature and drought (Senaratna *et al.* 2000), and salinity (Yildirim *et al.* 2008), increase tolerance and defence to pathogen attack (Raskin *et al.* 1990).

Potassium nitrate is a chemical that is assessed on plant development, amount of nitrate accumulation, reduction and assimilation in leaves exposed to various salinity levels; where lack of potassium affects photosynthetic CO_2 fixation, transport and assimilates (Laishram *et al*. 2020). In plants lacking potassium, membrane and chlorophyll breakdown are favored. Foliar application is regarded as one of the best solutions to lessen and resolve such issues. In general, soil nutrient application effectiveness is poor. The use of nutrients by foliar application may lead to an economical use of fertilizer by avoiding loss due to various processes and giving nutrients at a later stage when the crop need more. In low moisture conditions, foliar application of chemicals during moisture sensitive stages may also result in an instantaneous delivery of nutrients (Wangkheirakpam *et al.* 2020). Potassium nitrate (KNO_3) influences the water economy and crop growth, through its effect on water uptake, root growth, maintenance of turgor, transpiration and stomatal behavior (Hsiao and Lauchli 1986). Lack of adequate and proper nutrition management is just one of several reasons that contribute to lentil productivity issues (Shijagurumayum *et al.* 2022). Considering these views, a study was planned to study the effect of salicylic acid (SA) and potassium nitrate (KNO_3) on yield, economics, nutrient uptake and quality of lentil variety HUL-57 under rainfed condition of Manipur.

MATERIALS AND METHODS

A field experiment was conducted during the year 2018-2019 at Agricultural Research Farm, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur District, Manipur, India (Latitude: 24.72°N and Longitude: 93.86°E) with an elevation of 790 m above sea level. The texture of the experimental soil was clay with pH 5.5, EC 0.4 dS/m and O.C 1.0%. Available N, P and K in the soil were 314.0 kg/ha, 47.0 kg/ha and 269.0 kg/ha respectively. The study was laid out in a Factorial Randomized Block Design (FRBD) taking two factors and three levels each (Factor 1- Salicylic acid (SA) through seed priming - 3 levels: a) S_0: No application, b) S_1: 150 ppm, c) S_2: 200 ppm and Factor 2- Potassium Nitrate (KNO_3) through foliar application - 3 levels: a) K_0: No application, b) K_1: KNO_3 1.5%, c) K_2: KNO_3 2.0%) with four replications and nine treatments. The lentil variety HUL-57 was sown in line at spacing of 30 cm × 20 cm with seed rate of 45 kg/ha. Foliar application of KNO_3 was scheduled in splits by targeting the active growth stages i.e. 30, 60 and 90 days after sowing (DAS) of lentil.

Yield and cost effective of lentil

Yield were recorded plot wise and then expressed as kg/ha. The cost effectiveness of lentil was determined by computing on the basis of the different operations, inputs used for raising the crop and the existing market price of produce.

Nutrient uptake and quality of lentil

Total N concentration of grain and stover samples was estimated by Kjeldhal method by digesting the plant samples with concentrated H_2SO_4 and the rate is accelerated with a digestion mixture ($CuSO_4$ as catalyst and K_2SO_4 for elevating the boiling point) for 4-5 hrs at 420°C. The digest was then distilled with alkali (40% NaOH) and ammonia evolved is quantitatively adsorbed in boric acid. The distillate was back-titrated with 0.1N H_2SO_4 until the pink color starts appearing (Jackson 1973). The total P and K concentration of grain and stover samples were estimated by dry ashing method. The samples were dry ash inside the Muffle furnance for 3 hrs at 550ºC and the powdered sample was diluted with 2N Hcl (10 ml) and kept it for 1 hr after a good stirring. The mixture was filtered through Whatman No. 42 filter paper and the volume of the filtrate was made up to 50 ml with distilled water. The aliquot was used for determination of total P by Vanadomolybdate yellow color method with the help of UV-visible spectrophotometer (Koenig and Johnson 1942). The total K was estimated by flame photometer following the standard method given by (Jackson 1973). The protein content was determined by multiplying percentage of nitrogen content in seed of lentil with a factor of 6.25 (Piper 1966).

Statistical analysis

To compare the effect of SA and KNO_3 on growth and yield of lentil, data were statistically analyzed following Gomez and Gomez (1984). The statistical differences of the data generated for each character were tested with least significant difference (LSD) at 5% probability level using analysis of variance technique (ANOVA). The standard error of means (SEm ±) and critical difference (CD) at 5% level of significance were calculated to compare the treatment means. To observe the significance of differences between the treatments, the mean values were compared by the Duncan's Multiple Range Test (DMRT) at probability <0.05 using SPSS software (Version 16.0).

RESULTS AND DISCUSSION

Yield of lentil (kg/ha)

Perusal of data revealed that application of SA and KNO_3 significantly increased the grain, stover and biomass yield of lentil (Table 1). Scaling up of SA up to 200 ppm (S_2) caused significant enhancement in grain yield (1022.91 kg/ha), stover yield (1714.87 kg/ha) and biomass yield (2737.77 kg/ha) of lentil followed by S_1 (SA @ 150 ppm). Hossain *et al.* (2015) reported significant increased in yield due application SA (200 ppm and 400 ppm). This might be due to the growth promoting effect of SA which increased the level of cell division within the apical meristem of seedling root and caused higher plant growth and increased the dry matter production. Similar findings were also corroborated by Devi *et al.* (2011) and Farjam *et al*. (2014). Similarly, increasing the concentration of KNO_3 upto 1.5% (K_1) led to marked improvement in grain yield (957.71 kg/ha), stover yield (1684.68 kg/ha) and biomass yield (2642.39 kg/ha) of lentil followed by K_2 (KNO_3 @ 2%). Khan *et al.* (2012) also reported similar improvement in yield by application of KNO_3. These findings are in consistency to those achieved by Singh *et al.* (2017). The combine application of SA and KNO_3 significantly influenced the grain yield and biomass yield of lentil. The treatment combination SA @ 200 ppm + KNO_3 @ 1.5% (S_2K_1) gave the maximum grain yield (1104.88 kg/ha) which is 52.65% more than that of the control followed by S_2K_2 and S_1K_1, which is statistically at par with each other. This might be due to the cumulative effect of yield attributing characters and enhanced photosynthetic efficiency and greater diversion of assimilates towards reproductive organs. The treatment combination SA @ 200 ppm + KNO_3 @ 1.5% (S_2K_1) registered the maximum stover yield (1799.06 kg/ha) and biomass yield (2903.95 kg/ha) which is 29.17% and 37.20% more over the control. Abd-El-Rhman and Attia (2016) reported that interaction of SA and KNO_3 is effective in improving the yield parameters under moisture stress conditions by delaying maturity due to enhancement of biochemical and physiological processes. Although, the combine application of SA and KNO_3 significantly influence the grain yield and biomass yield, but couldn't bring a significant change on stover yield.

Economics of lentil (₹/ha)

The data presented in (Table 1) revealed that the economics of lentil was significantly increased by application of salicylic acid (SA) and potassium nitrate (KNO_3). Seed priming of salicylic acid @ 200 ppm (S_2) gave the highest gross return, net return and benefit cost ratio (68204 ₹/ha), (34051 ₹/ha) and

Table 1. Effect of salicylic acid and potassium nitrate on yield (kg/ha) and economics of lentil.

Treatments	Grain yield (kg/ha)	Stover yield (kg/ha)	Biomass yield (kg/ha)	Gross return (₹/ha)	Net return (₹/ha)
Salicylic acid levels					
S_0	784.80	1471.98	2256.78	52484	18335
S_1	898.72	1641.13	2539.85	60059	25906
S_2	1022.91	1714.87	2737.77	68204	34051
SE (m)±	8.715	13.815	15.620	565.34	565.35
CD (p=0.05)	25.589	40.564	45.862	1659.94	1659.98
Potassium nitrate levels					
K_0	818.23	1517.73	2335.96	54703	22655
K_1	957.71	1684.68	2642.39	63936	29049
K_2	930.49	1625.57	2556.06	62108	26587
SE (m)±	8.715	13.815	15.620	565.34	565.35
CD (p=0.05)	25.589	40.564	45.862	1659.94	1659.98
Salicylic acid × Potassium nitrate					
SE (m)±	15.095	23.929	27.054	979.20	979.22
CD (p=0.05)	44.322	NS	79.436	2875.10	2875.17

S_0 = SA 0 ppm, S_1 = SA 150 ppm, S_2 = SA 200 ppm, K_0 = KNO_3 0%, K_1 = KNO_3 1.5%, K_2 =KNO_3 2.0%, NS = Non significant.

(1.99) respectively followed by S_1 (SA @ 150 ppm). Similarly increasing the concentration of KNO_3 upto 1.5% (K_1) gave the highest gross return, net return and benefit cost ratio (63936 ₹/ha), (29049 ₹/ha) and (1.83) respectively followed by K_2 (KNO_3 @ 2%). The treatment combination S_2K_1 gave the highest gross return (₹73617/ha), net return (₹38729/ha) and benefit cost ratio (2.11) where seed priming of salicylic acid (200 ppm) coupled with foliar sprays of potassium nitrate (1.5 %) was done followed by S_2K_2. The production economics of various solutes sprayed during different growth stages indicates variable net returns under different treatment combinations. The increase in net return might be due to increase in grain yield and yield attributing character of lentil and relatively low production cost per unit of yield under the treatment. Similar findings have been reported by Muhal *et al.* (2014) and Vekaria *et al.* (2012). The higher benefit cost ratio in treatments SA @ 200 ppm and KNO_3 @ 1.5 % might be due to the higher gross and net return with comparative lower cost of cultivation in compare with other treatments. Khan *et al.* (2012) also reported higher benefit cost ratio due to application of KNO_3. Improved agronomic technologies like cost effective foliar application techniques has proved to be highly effective and efficient in increasing productivity and profitability and these could possibly help in utilizing untapped potential of lentil through expansion of pulses cultivation in North-Eastern Hill region of India.

Nutrient uptake of lentil (kg/ha)

The analyzed data regarding the nutrient uptake revealed that application of SA and KNO_3 significantly increased the N, P and K uptake (Table 2). Seed priming of SA @ 200 ppm (S2) gave the maximum N uptake (38.16 kg/ha) and (17.65 kg/ha) respectively for grain and stover, P uptake (2.22 kg/ha) and (1.12 kg/ha) respectively for grain and stover and K uptake (11.73 kg/ha) and (18.84 kg/ha) respectively for grain and stover followed by S1 (SA @ 150 ppm). El-Hedek *et al.* (2013) reported increase in phosphorous content due to application of SA. These findings are in consistency to those achieved by Abdel-Lattif *et al.* (2019). Among the different potassium nitrate levels (KNO_3), foliar application of KNO_3 @ 1.5 % (K_1) gave the maximum N uptake (34.15 kg/ha) and (16.47 kg/ha) respectively for grain and stover, P uptake (2.13 kg/ha) and (1.04 kg/ha) respectively for grain and stover and K uptake (10.57 kg/ha) and (17.84 kg/ha) respectively for grain and stover followed by K_2 (KNO_3 @ 2%). Goud *et al.* (2014) reported that application of KNO_3 increased the nutrient uptake, which supplied N and K that are absorbed as anion and cation by plants, and might have delayed the synthesis of abscisic acid

Table 2. Effect of salicylic acid and potassium nitrate on nutrient uptake (kg/ha) and protein content (%) of lentil.

Treatments	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)		Protein content (%)
	Grain	Stover	Grain	Stover	Grain	Stover	
Salicylic acid levels							
S_0	23.35	10.89	1.52	0.68	6.71	11.98	18.57
S_1	31.86	15.35	2.01	1.01	9.77	16.63	22.11
S_2	38.16	17.65	2.22	1.12	11.73	18.84	23.25
SE (m)±	0.786	0.915	0.085	0.047	0.630	0.253	0.480
CD (p=0.05)	2.309	2.686	0.249	0.139	0.743	1.850	1.409
Potassium nitrate levels							
K_0	26.60	12.34	1.65	0.79	7.73	13.32	20.19
K_1	34.15	16.47	2.13	1.04	10.57	17.84	22.03
K_2	32.65	15.08	1.98	0.97	9.92	16.29	21.71
SE (m)±	0.786	0.915	0.085	0.047	0.630	0.253	0.480
CD (p=0.05)	2.309	2.686	0.249	0.139	0.743	1.850	1.409
Salicylic acid × Potassium nitrate							
SE (m)±	1.362	1.584	0.147	0.082	1.091	0.438	0.831
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS

S_0 = SA 0 ppm, S_1 = SA 150 ppm, S_2 = SA 200 ppm, K_0 = KNO_3 0%, K_1 = KNO_3 1.5%, K_2 =KNO_3 2.0%, NS = Non significant.

and promoted higher N uptake. These findings are in consistency to those achieved by Azoz and El-Taher (2018). The interaction effect between salicylic acid (SA) and potassium nitrate (KNO_3) revealed that the maximum N uptake (42.22 kg/ha) and (20.75 kg/ha) respectively for grain and stover, P uptake (2.47 kg/ha) and (1.23 kg/ha) respectively for grain and stover and K uptake (13.22 kg/ha) and (21.21 kg/ha) respectively for grain and stover followed by S_2K_2. Although, the combine effect of SA and KNO_3 couldn't bring a significant change on nutrient uptake of lentil.

Protein content of lentil (%)

The individual effect of SA and KNO_3 significantly influence the protein content of lentil (Table 2). Seed priming of SA @ 200 ppm ($S_{2)}$ significantly increased protein content (23.25 %) and followed by S1 (SA @ 150 ppm). Application of SA increased the protein content which led to increased in biochemical parameters, owing to an increase in synthesis of amino acids which resulted in higher protein content (Jakhar and Sheokand 2015). These findings are in consistency to those achieved by Chen *et al.* (2017). Among the different potassium nitrate levels (KNO_3), foliar application of KNO_3 @ 1.5 % (K1) significantly increased the protein content (22.03 %) followed by K_2 (KNO3 @ 2%). Foliar application of KNO_3 exhibited improvement in protein content might be due to production of quality seeds which met the requirement of N and K during development of seed and translocated the balance nutrients from source to sink (Jabeen and Ahmad 2011). The treatment combination S_2K_1 recorded the highest protein content (23.89 %) followed by S_2K_2 which is statistically at par with each other. The combined effect of salicylic acid and potassium nitrate application on protein content of lentil was found to be non significant.

Based on the results from the experiment it can be concluded that seed priming of salicylic acid (200 ppm) and foliar application of potassium nitrate (1.5%) influence the yield, economics, nutrient uptake and quality content of lentil.

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