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Growth kinetics and yield of coriander under limed acid soils of eastern plateau hill regions

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Abstract

To assess the growth and yield performance of coriander, field experiments were carried out consecutively three years in acid soils of Ranchi, Jharkhand with various liming ie, 25%, 50%, 75% and 100% and these were compared with control (No lime). Results revealed that the plant height and number of leaves of coriander were at par with lime except number of leaves per plant at 50DAS. Root and shoot biomass accumulation per plant, dry matter per cent at various stages, number of umbel per plant and seed weight per plant also did not vary statistically with lime. Number of umbel and seeds per plant were more with higher levels of lime. Plant water content reduced progressively with the age of plant from about 95% to around 55%. Relative growth rate (RGR) of root and shoot was more with lime application and it was highest at the age of 51-75 days followed by 76-120 days and 10-50 days, respectively. Shoot demand on root with per unit time was more than double at the age of 51-75 days as compared to initial and later stages. Seed yield of coriander was not significantly influenced by lime. However, it was 8-9 per cent more at higher levels of lime than control. The stover yield and nitrogen uptake was only significantly higher where 100% recommended dose of lime was applied. However, P uptake did not show any statistical variation with lime application. Potassium uptake was more at 75% and 100% application of lime. Most of the growth and yield data were at par with lime indicates that coriander can be adapted well in acid soils having pH 5.5 resultant not responded to lime application distinctly. In general observations, it has been recorded that yield was about to double (28.9 q ha-1) in these medium to higher fertile acid soils as compared to tradition growing areas which broken the yield barrier in this crop by taking coriander variety 'Ajmer Coriander-1'.

Key words: Coriander, acid soils, liming, Ajmer coriander-1, growth kinetics, yield, nutrient uptake

Introduction

Globally 60 per cent land area on earth occupied by the acid soil. In all the thermal belt of the Earth, these arises under humid climatic conditions. In India, total area under degraded and wastelands is 147.75 M ha and the extent of area under chemical degradation particularly by acidification (pH < 4.5 -5.5) was estimated at 16.03 M ha (ICAR, 7). According to different possible classes with different stake holders, the extent of this chemically degraded area has been estimated as 10.71 M ha. In the Jharkhand state, soils mainly developed on granite gneiss (32.6%) and granite schists (14.2 %). Soil acidity problem (pH < 5.5) is acute in 4 lakh hectare of cultivated area. Soil acidification takes place by depletion of calcium and magnesium by leaching process and uptake by crops. Low pH and lower levels of organic carbon, K, Ca, Mg and in some places micronutrients are also the major constraints for growing general crops in these soils. Such soil chemical reaction turn influences both microbial and biochemical processes in soil as well as chemical composition of plants. Liming in these soils play a crucial role for enhancing their productivity. Liming is an expensive management measure and some time it does not work properly. Selection of crops tolerant to acidity is an effective tool to counter this soil problem and breeding of such varieties is of specific importance for attaining higher productivity particularly in the areas where liming is not economical. Mandal *et al.* (13) suggested some of the crop like maize, sorghum, wheat, barley, millets, rice, oats, field beans, soybeans, pea, lentil, berseem, groundnut, sugarcane, cotton and potato for acid soils. However, none of the information available on seed spices like coriander. To take the initiative for sustainable and eco-friendly management of these soils, non-traditional crops like coriander may be tried to grow for their evaluation in relation to

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tolerance level to soil acidity. Moreover, coriander shows lime induced chlorosis in calcareous soil having pH more than 8.5 and its severity further aggravated with high temperature particularly in summer season (Aishwath and Anwer, 1). In some other reports, it has stated that 70 per cent seed spices production comes from Rajasthan and North Gujarat and called as seed spice bowl (Malhotra, and Vashishtha, 11). This resulted a mind-set that geographical situations of this area is most suited for seed spice cultivation. It has also been reported that coriander comes well with the soil pH 6.5-8.0 in well drained loams or sandy soils (Aishwath *et al.*, 2). However these crops are having the most ecological significance and can be grown under various adversities. Besides coriander as a spice, it also an aromatic and medicinal herb used for garnishing food and various parts of coriander possess Diuretic, Antioxidant, Ant-diabetic Anti-convulsant, Sedative Hypnotic, Anti-microbial, Anti mutagenic and Anthelmintic activities. Though this is a very important seed spice crop occupying largest area (557870) and production (532947 tonnes) in the country among the seed spices under various agro-ecological regions. Yet, there is no specific research findings available for the degree of tolerance of coriander to acidity. Therefore, it is imperative to evaluate the crops under these soils so as to diversify the crop in these chemically degraded soil for their management via economic and sustainable way.

Materials and methods

Location and climate

The field experiments were carried out under the Typic Haplustalfs during Rabi season of 2009-2010, 2010-2011 and 2011-2012 at Horticulture and Agro-forestry Research Programme, Plandu, Ranchi, Jharkhand, a regional station of ICAR Research Complex for Eastern Region, Patna. The experiments were laid between around 23.280274ºN and 85.412344ºE Latitude and Longitude, respectively. Climate of the Ajmer area characterized as Humid Subtropical type. The average annual rainfall of the area is about 1430 mm, the most of it 85-90% receives from June to September and that is about 1,100 mm. Summer temperature ranges from 20 to 42 °C and winter from 0 °C to 25 °C. December and January are the coolest months with temperatures dipping to the freezing point in some of the areas.

Treatments and cultural practices

The treatments consisted of four liming levels of 25%, 50%, 75% and 100% of recommended dose of lime and was compared with control where no lime was applied. The treatments were replicated four times under Randomized Block Design. Coriander variety used as a test crop was Ajmer coriander-1 and sown in 30 cm line apart. Recommended cultural practices were adopted for weed free and maintained moisture by irrigations during all the three seasons. The crop was harvested each year when seed matured and colour turned as brownish. After harvest, seeds were separated from the straw by beating bundles thereafter winnowing was done in natural wind.

Soil analysis

Soil samples were collected from the surface (0-15 cm depth) before sowing seed of all the three years crops. Samples were air dried and powdered with wooden mortar and pestle and passed through a 2 mm stainless steel sieve. Experimental soil was analysed for physicochemical properties ie EC and pH (Richards, 20), organic carbon content by rapid chromic titration (Walkley and Black, 26), available N by alkaline permanganate (Subbiah and Asija, 23), available P by 0.5 M $NaHCO_3$ extractable P (Olsen, *et al.*, 15), available K by 1N NH_4OAc extracts method (Jackson, 8) and available micro-nutrients by DTPA (Lindsay, and Norvell, 10).

Texture of experimental soil was sandy loam. Soil EC, pH and organic carbon were 0.14 dSm^{-1}, 5.5 and 0.45%, respectively. However, soil available N, P and K were 215, 17.3 and 344 kg ha^{-1}, respectively. Micronutrient status like iron, zinc, manganese and copper of the soil was 98.9, 5.9, 82.04 and 10.11 kg ha^{-1}, respectively.

Plant analysis (Chemical and growth)

The plant samples were collected after the harvest of crop. Plant samples were successively washed with tape water, 0.1 M HCl and distilled water and dried at 70°C. After proper drying samples were powdered in wily mill and passed through the 20 mesh steal sieve. Nitrogen was estimated by Kjeldahl method (Piper, 17). The samples were digested in nitric and perchloric acid (10:4) for the estimation of P by Venado-molybdo yellow colour method (Chapman, and Pratt, 4) and K by flame photometer.

Relative Growth Rate (RGR) was calculated by the slope of the line from Absolute Growth Rate (AGR) with change over time, as describes by Wareing and Philips (27). Plant moisture content was estimated by gravimetric method and nutrient uptake was calculated by multiplying nutrient content in seed and straw separately and thereafter added both. Shoot demand on root (Sdr - mg plant^{-1} day^{-1}) was analysed as $(W_2/W_1)/L_2$-

L_1 x $\ln(L_2/L_1)/t_2-t_1$, where W and L is the change in root weight and length with time (t).

Statistical Analysis

The data of both the years were analyzed by ANOVA and treatment differences were expressed for Least Significant Differences (LSD) at 5% probability to determine the significance among the treatment means (Cochran and Cox, 5).

Results and discussion

Growth kinetics and yield contributing parameters

Plant height of coriander varied from 130-134.4 cm (Table 1). However, there was no significant variation obtained with the lime treatments at all the three stages. Similarly number of leaves at 50 days were not influenced by application of lime. However, at 75 days number of leaves were more where 100% lime was applied. Though the root and shoot biomass did not vary significantly with lime, yet it was altogether more than the control (Table 2). This because of soil acidity had no adverse effect on coriander.

Table 1. Growth parameters of coriander with lime in acid soils of Ranchi conditions

Treatment	Plant height (cm) at			No of leaves plant^{-1} at	
	50 DAS	75 DAS	Maturity	50 DAS	75 DAS
Control	8.0	55.8	130.2	8.9	30.6
RDL 25%	10.9	55.0	134.4	9.1	32.2
RDL 50%	10.2	48.5	132.4	9.1	34.7
RDL 75%	10.5	44.7	131.2	9.9	35.0
RDL 100%	9.1	55.1	133.0	9.8	**46.9**
CD at 5%	NS	NS	NS	NS	6.7

RDL = Recommended dose of lime, NS=Non significant, DAS = Days after sowing

Table 2. Root and shoot dry biomass accumulation (g plant^{-1}) at various growth stages under limed acid soils

Treatments	Root biomass (g plant^{-1}) at			Shoot biomass (g plant^{1}) at		
	50 DAS	75 DAS	110 DAS	50 DAS	75 DAS	110 DAS
Control	0.18	0.53	1.05	1.18	7.20	10.28
25%RDL	0.20	0.58	1.13	1.33	7.45	11.15
50%RDL	0.18	0.58	1.20	1.38	7.80	11.08
75%RDL	0.20	0.59	1.18	1.38	7.73	11.18
100%RDL	0.20	0.58	1.17	1.35	7.70	11.20
CD(0.05)	NS	NS	NS	NS	NS	NS

RDL = Recommended dose of lime, NS=Non significant, DAS = Days after sowing

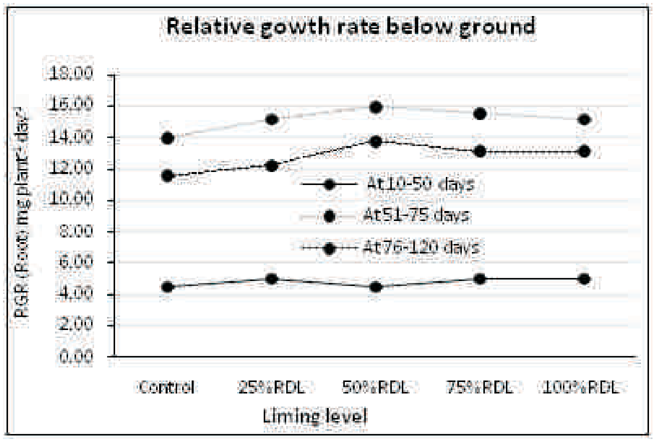
Dry matter accumulation percentage is an important parameters for study the succulence of plant with respect to water requirements and also for the infestation of disease and insect-pests. Results showed that plant retains about 94-95% moisture at its 50 DAS (Days After Sowing) age. This percentage went down from 95 to around 90% at the age of 75 days. However, this percentage of moisture further went down to around 55 at the age of 75 DAS to maturity. This indicates that this stage accumulates highest amount of nutrients and photosynthates and only 40-45% moisture (Table 3). The dry matter accumulation and number of umbellate plant^{-1} were also not influenced by lime at any stage except at 50 DAS. Which indicates that coriander is adoptive in acid soils. Moreover, number of umbel per plant were only more at 100% lime. Interestingly, the influence of lime was more pronounced on number of seed per plant as compared to control. However, seed weight per plants did not influenc significantly, whereas it was marginally more with lime as compared to control.

Table 3. Yield and yield parameters of coriander with lime in acid soils of Ranchi

Treatment	Dry matter (%) at			No. of umbellat e /umbel	Number of (plant1)		Seed weight (g) plant^{-1}
	50 DAS	75 DAS	Maturity		umbel	seed	
Control	5.0	9.6	44.7	5.9	46.6	699.5	10.0
RDL 25%	5.5	9.7	43.9	5.9	52.6	864.0	10.2
RDL 50%	5.4	8.9	45.4	6.3	56.2	860.8	11.5
RDL 75%	5.5	9.5	43.6	6.4	55.3	906.0	11.3
RDL 100%	5.8	9.4	41.5	6.4	58.0	877.0	11.5
CD at 5%	0.6	NS	NS	NS	10.4	63.7	NS

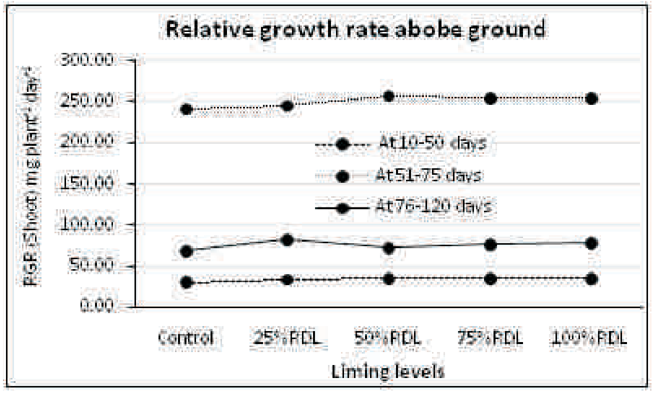
RDL = Recommended dose of lime, NS=Non significant

Relative growth rate (RGR) of root was more with lime application (Figure 1). The highest root weight attained in per unit time by the plants at the age of 51-75 days followed by 76-120 days and 10-50 days, respectively. This might be due to active growth of plant, which was highest at this stage. At later stage of plant, lower RGR was also reported by Wareing and Philips (27). Average dry root biomass was three times more at the age of 76-120 days than the age of 10-50 days. This extent was four time at 51-75 days. Relative growth rate of shoot also followed the similar trend as that of root, however, the extent of variation was much higher than the root (Figure 2). Per unit time plant biomass accumulation was more than double at 76-120 days of crop. However this extent was about 7-8 times than the initial stage. This is because of coriander proved its plasticity with acid soils and accommodated well in new soil conditions. RGR and growth related traits gradually decrease with time also reported by Poorter, (18).



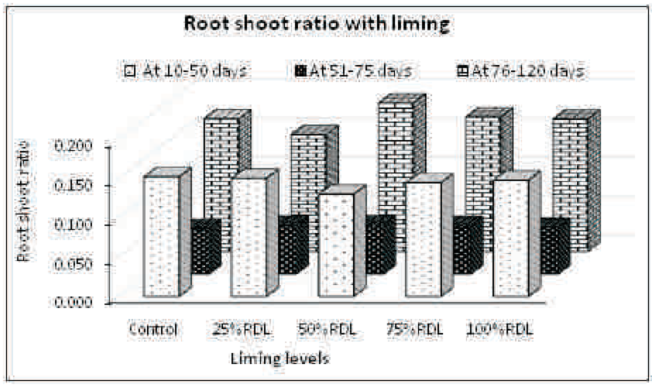
RDL = Recommended dose of lime

Fig 1. Relative growth rate below the ground of coriander under limed acid soil.



RDL = Recommended dose of lime

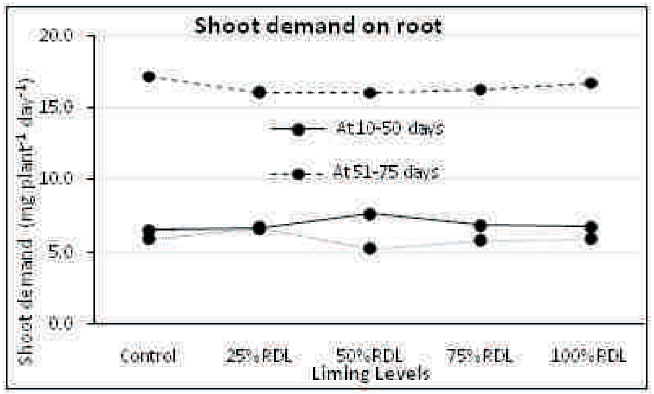
Fig 2. Relative growth rate above the ground of coriander under limed acid soil.



RDL = Recommended dose of lime

Fig 4. Root shoot ratio of coriander under limed acid soil

Shoot demand on root is a pressure generated by shoot on root for nutrient and water uptake. These findings indicate that this per unit time pressure was more than double at the age of 51-75 days (Figure 3). However, it was almost similar at 10-50 days and 76-120 days. Hence the stage of 51-75 days is more crucial for the agronomic management of this crop. Root shoot ratio was wider at last stage of crop than first two stages as the root decaying takes place at latter stage (Figure 4). However, root shoot ratio was more at initial stage than the second stage, which might be due to the fact that photosynthates were not transferred properly at early stage than second one for the root development. Gadgil, and Gadgil, (6) reported that partitioning of dry matter between the root and shoot tissue of a plant is regulated precisely at a constant value for given genotype under specified environmental conditions. But individuals of different species or of the same species under different environmental conditions show characteristic variation in the root shoot ratio. Increasing root shoot ratio implies that plant allocating some of the resources to the production of root which could have been utilized for the production of shoot.

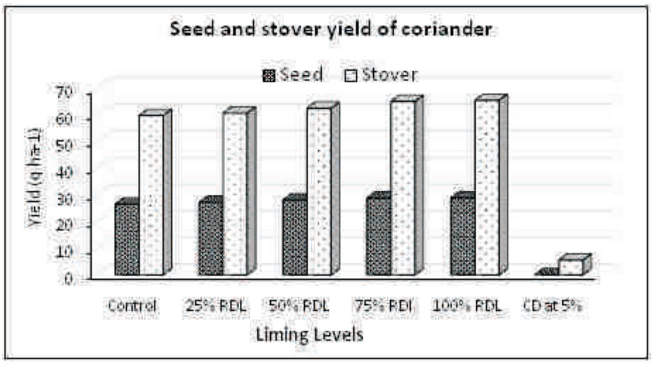


RDL = Recommended dose of lime

Fig 3. Shoot demand on root of coriander under limed acid soil

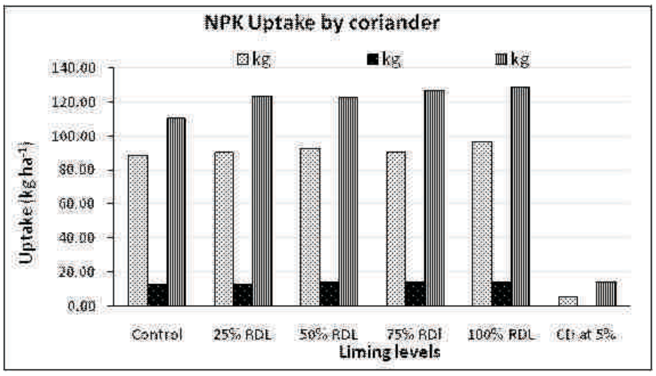
Yield and uptake of nutrients

Seed yield of coriander was not significantly influenced by lime. However, it was 8-9 per cent more at higher levels of lime than control (Figure 5). The stover yield was only significantly higher at 100% recommended dose of lime was applied. Which showed that liming effect was pronounced on biomass than the seed yield. Which is confirmed by seed weight per plant was at par with liming. This indicates that coriander can be adapted well in acid soils having pH 5.5 resultant not responded to lime application distinctly. Moreover, coriander yield was substantially higher in these acid soils than the soil having neutral to higher pH or the potential yield in traditional areas. Mallarino, (12) reported positive response of corn and soybean to lime application in soil having pH <5.0 in Iowa. In contrast to this harmful effect of soil acidity on legumes has been recognized by Barber (3). Thereafter, investigations have differentiated between soil acidity (high H^+ ion activity) and factors related to acidity and between the effects of these factors on the plant, on the bacterium, and on nodule formation and function (Vincent 25, Munns 14). These findings also indicate that coriander is most adaptive to lower pH 5.5 particularly in Eastern Plateau Hill Regions. Nitrogen uptake in coriander was only higher at 75% and 100% per cent recommended dose of lime (Figure 6). However, P uptake did not show any statistical variation with lime application. This might be due to dilution effect of P with higher biomass at higher levels of lime. Potassium uptake was more at 75% and 100% application of lime may be due to more biomass at higher level of lime and also higher K content in plant at that level. Rao et al. (19), reported coriander as a low input crop taking variety Cimpo S-33. However, Ajmer coriander-1 is a high input crop needs medium to higher fertility for its optimum growth.



RDL = Recommended dose of lime

Fig 5. Seed and stover yield (q ha^{-1}) of coriander under limed acid soil.



RDL = Recommended dose of lime

Fig 6. N, P and K uptake by coriander under limed acid soil.

Conclusion

Based on the above findings, it can be concluded that coriander variety Ajmer coriander -1 is adoptive to soil having pH 5.5 as there was no significant variation obtained in growth kinetics, yield and yield parameters with application of various doses of lime to raise the pH. The yield obtained in these medium to higher fertile acid soil was substantially higher than the neutral to alkaline soils of Rajasthan.

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