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Effect of different phosphorus sources and soil amendments on the yield and quality of aswagandh (*Withania somnifera* Dunal) under acid soils

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Abstract

Trials were conducted in acid soil at Yercaud (Tamil Nadu, India) with the objective of identifying the ideal source of phosphorus and soil amendment in aswagandh (*Withania somnifera* Dunal) in acid soils. Application of 60 kg ha^{-1} P_2O_5 as rock phosphate along with dolamite (5.688 t ha^{-1}) for increasing the yield resulted in the highest dry root yield of 814.5 kg ha^{-1} in the present study. There was also an improvement in the total withanolides content due to the application of dolomite and rock phosphate.

Key words: crop yield, diammonium phosphate, dolomite, rock phosphate, super phosphate, *Withania somnifera.*

Aswagandh (*Withania somnifera* Dunal) is one of the indigenous plants, used in several Ayurvedic and Unani preparations. The leaf extract of the plant contains withanolides, which have marked activity against various diseases and bacterial infections. Recently a cancer curing active principle has been identified from this wonder plant. The objective of the study was to increase the yield in acid soil, by identifying suitable soil amendment and source of phosphorus.

The study was carried out at Horticultural Research Station, Yercaud (elevation ranging from 1200 to 1500 m above MSL with the annual rainfall ranging from 1300 to 1600 mm) during 1998 to 2001. The soil was sandy clay loam in texture, with a pH 5.31 and electrical conductivity 0.109 d Sm^{-1}. The available N, P_2O_5 and K_2O contents of the soil were 206, 7.33 and 160 kg ha^{-1}, respectively. The experimental site was thoroughly ploughed and beds of 7.2 m^2 size were prepared. The lime requirement for the experimental area was assessed and 6.2 t ha^{-1} was applied to bring the soil pH to neutral condition. The requirement of dolomite was calculated based on the neutralizing value of $CaCO_3$ equivalent i.e. 5.688 t ha^{-1}. One month old seedlings were planted in the field with a spacing of 60 x 60 cm. The treatments consist of three different phosphorus sources viz. super phosphate, rock phosphate and diammonium phosphate and two soil amendments viz. lime and dolomite and their combinations along with control. The treatments were replicated thrice in a randomised block design. Fifteen days before planting, the required quantity of soil amendments were added and thoroughly incorporated. A fertilizer schedule of 40:60:20 kg N, P_2O_5 and K_2O ha^{-1} was followed. At the time of planting, 50% of N and K_2O and entire dose of P_2O_5 were applied. The remaining 50% of N and K_2O were applied as top dressing, one month after basal application. The soil and

Table 1. Influence of phosphatic fertilizers and liming materials on soil available nutrients and plant total nutrients of aswagandh

Treatment	Soil pH	Available nutrients (kg ha^{-1}) in soil			Available nutrients in plant (%)					
					Shoot			Root		
		Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
T1. Super phosphate	5.74	221.0	21.4	218.3	2.80	1.61	2.82	1.99	1.47	2.13
T2. Rock phosphate	5.79	221.1	22.0	225.0	3.09	1.73	2.76	2.08	1.51	2.21
T3. Diammonium phosphate	5.69	217.8	23.2	211.6	2.84	1.63	2.71	2.05	1.44	2.14
T4. Lime	5.61	211.8	21.4	213.3	2.82	1.52	2.66	1.97	1.45	2.08
T5. Dolomite	5.66	215.2	21.4	220.0	2.89	1.55	2.61	2.01	1.41	2.13
T6. Super phosphate + lime	6.02	226.3	24.8	225.0	3.47	1.77	2.74	2.17	1.64	2.65
T7. Rock phosphate + lime	6.28	233.4	27.6	230.0	3.32	1.94	2.87	2.54	1.75	2.79
T8. Diammonium phosphate+ lime	5.89	227.4	25.5	220.0	3.19	1.73	2.93	2.20	1.53	2.22
T9. Super phosphate + dolomite	6.12	224.7	24.7	225.0	3.51	1.85	2.94	2.42	1.65	2.75
T10. Rock phosphate + dolomite	6.58	250.4	31.1	236.6	3.75	1.95	3.13	2.56	1.99	2.90
T11. Diammonium phosphate + dolomite	5.98	227.7	24.7	223.3	3.39	1.69	2.87	2.20	1.55	2.56
T12. Control	4.48	133.0	3.2	86.6	1.44	1.09	1.03	1.43	0.75	1.25
CD (P= 0.05)	0.08	5.55	0.97	8.07	0.12	0.06	0.05	0.07	0.06	0.08

plant (shoot and root) samples were collected before top dressing, three months after basal application of fertilizers and at the time of harvesting. The soil samples were analysed for soil pH, available nutrients and plant samples for total N, P and K contents (Tandon 1993). The root samples were analysed for total withanolides content (Mishra 1989). The bio-metric observations were recorded at the time of harvest.

Soil pH

The soil pH was significantly affected by the treatments (Table 1). Due to the application of soil amendment, the pH gradually increased from the base value of 5.31. Among the treatments, application of rock phosphate along with dolomite (T_{10}) recorded the highest soil pH of 6.58, followed by the application of rock phosphate along with lime (T_7), whereas the control (T_{12}) recorded the lowest pH of 4.48 at the time of completion of study period (2001). Rock phosphate had high neutralising power which raised the soil pH with corresponding increase of exchangeable Ca^{2+}, besides the supply of phosphorus (Mathur & Debnath 1983) and application of soil amendments increased the soil pH and this may be attributed to an increase in the degree of base saturation and neutralization of dominant exchangeable Al^{3+}, H^+ and Fe^{3+} ions in acid soil (Dixit & Sharma 1993).

Available and total nutrients

The data on the available N, P and K in soil and total N, P and K in leaves are presented in Table 1. A significant difference among the treatments was observed in both the soil nutrient status and nutrient content in leaves. Among the treatments, application of rock phosphate along with dolomite recorded the highest soil available N, P and K of 250.4, 31.1 and 236.6 kg ha^{-1}, respectively. The same treatment also recorded the total N, P and K of 3.75, 1.95 and 3.13% in shoots and 2.56, 1.99 and 2.90% in roots, respectively. In general, it was noticed that there was an increase in available N, P and K contents both

in shoot and roots. The increase in the available nutrients with amendments may be attributed to increase in activity of Fe and Al as a result of increase in pH of the soil and minimising the P fixation in acid soils (Marwaha 1994).

Biometrics

Application of soil amendments and phosphorus had significant effect on plant height, shoot weight and root weight (Table 2). Application of rock phosphate along with dolomite recorded maximum plant height (91.17 cm), shoot weight (26.89 g plant^{-1}) and root weight (33.13 g plant^{-1}). The better growth of plants may be attributed to the application of rock phosphate which enhanced the release of available P in soil solution resulting in better availability to plant (Sahoo & Misra 1995) and also the soil amendments which prevent the ill effects due to toxic amount of Fe, Al and Mn, deficiency of phosphorus in acid soils (Ananthanarayana & Prabhu 1992).

Root yield and withanolides content

A significant increase in the root yield and total withanolides content in roots were noticed in the treatments (Table 2). Application of rock phosphate @ 60 kg ha^{-1} along with dolomite @ 5.688 t ha^{-1} recorded the highest root yield 807.6 kg ha^{-1} and total withanolides content of 0.65% in roots.

The increase of available nutrients in soil might have helped the plant to translocate the nutrients to different plant parts. A concomitant increase or decrease of nutrients in plants depends upon the availability of nutrients in soil, which is essential for better yield (Singh & Sarkar 1986). Among the phosphatic fertilizers, application of rock phosphate recorded the highest amount of root yield and available phosphorus in soil. This might be due to the slow release of phosphorus into the solution by rock phosphate and resulted in lower P fixation owing to increased pH (Mongia *et al.* 1998) . The increase in the crop productivity due to application of soil amendments might be due to varied effects such as amelioration of acid soils through reduced acidity, increased supply of Ca and Mg as nutrients, improved availability of native soil nutrients,

Table 2. Influence of phosphatic fertilizers and liming materials on biometrics, root yield and withanolides content in aswagandh

Treatment	Plant height (cm)	Shoot weight (g plant^{-1})	Root weight (g plant^{-1})	Root yield (kg ha^{-1})	Withanolides (%)
T1. Super phosphate	61.50	14.42	18.94	491.3	0.37
T2. Rock phosphate	65.20	15.31	22.09	533.9	0.39
T3. Diammonium phosphate	57.27	14.62	18.60	471.3	0.38
T4. Lime	57.67	14.88	17.58	433.1	0.43
T5. Dolomite	56.30	21.31	17.65	465.6	0.45
T6. Super phosphate + lime	75.10	21.63	24.12	613.3	0.50
T7. Rock phosphate + lime	85.33	22.63	26.34	659.1	0.55
T8. Diammonium phosphate + lime	68.17	18.60	21.73	555.9	0.49
T9. Super phosphate + dolomite	79.80	22.75	23.72	636.2	0.58
T10. Rock phosphate+ dolomite	91.17	26.89	33.13	807.6	0.65
T11. Diammonium phosphate + dolomite	74.77	18.57	24.50	583.3	0.54
T12. Control	33.13	9.51	11.15	340.8	0.29
CD (P= 0.05)	1.04	0.30	0.77	5.35	0.018

improved plant-root development and reduced toxic effects of Mn, Fe and Al (Bishnoi *et al.* 1988). In aswagandh, application of nutrients is known to increase withanolides content in the root (Nigam *et al.* 1991)

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