Annals of Arid Zone 39(4): 411-414, 2000

Effect of Phosphorus Application on Fodder and Grain Yield of Oat (*Avena sativa* L.) in Light Soil

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Abstract: A field experiment was conducted during winter seasons of 1993-94 and 1994-95 at Regional Research Station, Bawal, to find out phosphorus requirement of oat for fodder as well as grain. Application of 30 kg P_2O_5 ha^{-1} was found optimum in respect of yield and economic returns of both forage and forage-cum-grain crop of oat. The average net return in forage-cum-grain crop was 2.75 times of forage crop (Rs. 4281 ha^{-1}). On an average, the optimum dose of phosphorus was 32.5 kg ha^{-1} in crop grown for fodder as double-cut. But, when crop was raised for fodder-cum-grain, the optimum dose was 29.07 kg ha^{-1} for fodder and 32.74 kg ha^{-1} for grain crop. The phosphorus-utilization-efficiency was appreciably higher with 30 kg P_2O_5 ha^{-1} in comparison to 60 kg dose, but was at par with optimum dose of phosphorus.

Key words: Oat, phosphorus, economics, response functions, optimum dose, phosphorus-utilization-efficiency.

Oat (*Avena sativa* L.) is an important winter-season cereal fodder widely grown under irrigated condition in India. It is an ideal fodder crop rich in energy, protein, vitamin B_1, phosphorus and iron (Relwani, 1979). Fertilizer is a crucial but expensive input, calling for its judicious use to harness the potential yield and improve quality. Phosphorus is known to improve growth and quality of oat in medium textured soils of acidic to neutral reaction (Ghosh, 1985; Roy and Pradhan, 1992; Patel, 1997-98). The present study was undertaken to evaluate the possible role of P application on forage and grain yield of oat on light textured alkaline soils.

Materials and Methods

The field experiment was conducted at Regional Research Station, Bawal, during winter (rabi) seasons of 1993-94 and 1994-95 to find out the phosphorus requirement of oat grown for forage, as well as forage-cum-grain. The soil was loamy sand, alkaline in reaction (pH 8.4-8.5), low in organic carbon (0.20-0.23%) and available phosphorus (9.2-9.8 kg ha^{-1}). The experiment comprised of two cutting management treatments, i.e., (i) taking two cuttings for fodder, and (ii) having one cut for fodder and allowing the regrown crop to produce grain, along with three phosphorus levels, i.e., 0, 30 and 60 kg P_2O_5 ha^{-1}. The experiment was laid out in randomized block design with four replications. Oat variety Kent was sown in rows 25 cm apart using 75 kg seed ha^{-1} on 30th October and 31st October during 1993-94 and 1994-95, respectively. The crop was given a uniform dose of 120 kg N ha^{-1} in two splits. The half dose of nitrogen and full dose of phosphorus as per treatments was applied as basal and remaining half

Table 1. Effect of phosphorus levels on yield of oat grown for fodder as well as fodder-cum-grain

P_2O_5 levels (kg ha^{-1})	Fodder crop			Fodder-cum-grain crop								
	Green fodder yield (q ha^{-1})			Green fodder yield (q ha^{-1})			Grain yield (q ha^{-1})			Straw yield (q ha^{-1})		
	1993-94	1994-95	Mean	1993-94	1994-95	Mean	1993-94	1994-95	Mean	1993-94	1994-95	Mean
0	477.2	406.3	441.8	165.0	204.2	184.6	18.6	19.0	18.8	44.7	45.9	45.3
30	545.3	453.1	499.2	202.5	249.0	225.8	21.1	21.2	21.2	52.6	53.8	53.2
60	536.5	455.2	495.6	194.6	257.3	226.0	20.8	21.9	21.4	51.9	56.1	54.0
CD (P=0.05)	47.8	38.8	–	28.4	35.3	–	2.0	2.1	–	6.9	7.2	–

N was applied after first fodder cut. In forage-cum-grain, the crop was left for grain after first cut at 75 and 70 days after sowing in first and second year, respectively. While in treatment where two fodder cuts were taken, the second cut for fodder was taken at 50% flowering stage.

To work out the regression equation and response functions of phosphorus, the following equations were fitted on green fodder and grain yield of oat:

$$Y = a + bx + cx^2 \quad .....(i)$$

$$Yr = br + cx^2 \quad .....(ii)$$

where,

Y is yield (kg ha^{-1}); Yr is yield response (kg ha^{-1}); a, b and c are the constants of the regression equation; and x is quantity of phosphorus (kg ha^{-1}).

The optimum dose of phosphorus was computed from the following equation:

$$P(opt) = (q\ p^{-1} - b)\ 1/2c \quad .....(iii)$$

where

q is cost of phosphorus (Rs. 17.25, 19.38 and 18.31 kg in 1993-94, 1994-95 and pool of both year, respectively) and p is

Table 2. Effect of phosphorus levels on economics of oat grown for fodder as well as fodder-cum-grain

Treatments	Gross returns (Rs. ha^{-1})			Cost of cultivation (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			Benefit-cost ratio		
	1993-94	1994-95	Mean	1993-94	1994-95	Mean	1993-94	1994-95	Mean	1993-94	1994-95	Mean
Fodder crop												
P_0	11930	10158	11044	7433	6854	7143	4497	3304	3901	0.61	0.48	0.54
P_{30}	13633	11328	12481	7950	7435	7693	5683	3893	4788	0.71	0.52	0.62
P_{60}	13413	11380	12397	8467	8016	8242	4946	3364	4155	0.58	0.42	0.50
Mean	12992	10955	11974	7950	7435	7693	5042	3520	4281	0.63	0.47	0.55
Fodder-cum-grain crop												
P_0	17895	19195	18545	8533	7954	8243	9362	11241	10302	1.10	1.41	1.25
P_{30}	20873	22205	21540	9050	8535	8793	11823	13670	12746	1.31	1.60	1.45
P_{60}	20456	22993	21724	9567	9116	9342	11889	13877	12383	1.24	1.52	1.32
Mean	19741	21464	20603	9050	8535	8793	11025	12929	11810	1.22	1.51	1.34

Table 3. Regression equations, optimum dose of P and yield at optimum dose for oat grown for fodder and fodder-cum-grain

Treatment	Regression equation	R^2	Optimum dose ($kg\ ha^{-1}$)	Yield at optimum dose ($kg\ ha^{-1}$)
Fodder crop				
1993-94	$47720+355.16x - 4.272x^2$	1.0	33.37	54815
1994-95	$40630+230.50x - 2.483x^2$	1.0	30.80	45374
Mean	$44180+292.50x - 3.372x^2$	1.0	32.51	50125
Fodder-cum-grain crop				
Fodder yield				
1993-94	$16500+200.66x - 2.522x^2$	1.0	26.10	20019
1994-95	$20420+211.06x - 2.03x^2$	1.0	32.77	25130
Mean	$18460+205.66x - 2.277x^2$	1.0	29.07	22514
Grain yield				
1993-94	$1860+13.00x - 0.155x^2$	1.0	30.69	2112
1994-95	$1900+9.83x - 0.083x^2$	1.0	35.75	2145
Mean	$1880+11.66x - 0.122x^2$	1.0	32.74	2131

the cost of green fodder (Rs. 0.25 kg^{-1}) and grain (Rs. 5 kg^{-1}). The substitution of P (opt) in equation (i) provides optimum yield Y (opt) and in equation (ii) gives optimum response Yr (opt). The phosphorus-utilization-efficiency (PUE) was worked out by dividing yield response by the amount of phosphorus.

Results and Discussion

Oat yield

The green fodder yield in double, as well as in single cut, and grain and straw yield of oat (Table 1) increased significantly with the application of 30 and 60 kg P_2O_5 ha^{-1} as compared to no phosphorus in both the years. However, the 30 and 60 kg P_2O_5 ha^{-1} doses were statistically at par during both the years. On an average, application of 30 kg P_2O_5 ha^{-1} resulted in 13.0% increase in forage yield in double cut system, and 22.3, 12.7 and 17.4% increase in forage, grain and straw yields, respectively, in forage-cum-grain system. Patel (1997-98) has reported similar increase in yield of oat with phosphorus application.

Economic returns

Gross and net returns, as well as benefit-cost ratio of forage-cum-grain crops of oat were higher as compared to crop raised exclusively for fodder (Table 2). The mean gross and net returns in forage-cum-grain crop were 72 and 175% higher than the fodder crop. The mean value of benefit-cost ratio was 1.34 for forage-cum-grain crop as against 0.55 obtained from forage crop. Application of 30 kg P_2O_5 ha^{-1} produced higher gross and net returns as well as benefit-cost ratio than no phosphorus and 60 kg P_2O_5 ha^{-1} levels in both the cutting management treatments.

Table 4 Expected response and PUE of oat grown for fodder as well as fodder-cum-grain.

Treatment	Expected yield (kg ha^{-1})			PUE		
	30	60	Optimum dose	30	60	Optimum dose
Fodder crop						
1993-94	6810	5930	7094	227	99	213
1994-95	4680	4890	4744	156	81	154
Mean	5740	5410	5945	191	90	183
Fodder-cum-grain crop						
Fodder yield						
1993-94	3750	2960	3519	125	49	135
1994-95	4498	5328	4728	150	89	144
Mean	4120	4140	4054	137	69	139
Grain yield						
1993-94	250	220	252	8.3	3.7	8.2
1994-95	220	290	245	7.3	4.8	6.9
Mean	240	260	251	8.0	4.3	7.7

Response functions and PUE

The response functions of phosphorus developed for forage crop as well as forage-cum-grain crop are presented in Table 3. On average basis, the optimum dose of P worked out for forage crop of oat was 32.51 kg ha^{-1}, which produced fodder yield of 501.25 q ha^{-1} in double-cut system. For single-cut forage crop, the optimum dose was 29.07 kg ha^{-1} which would give 225.14 q ha^{-1} green fodder. The optimum dose for seed crop taken after single-cut of fodder, was 32.74 kg ha^{-1} with grain yield of 21.31 q ha^{-1} (Table 3).

The expected response and PUE were worked out at 30 and 60 kg P_2O_5 ha^{-1} and optimum dose of phosphorus under both the cutting management treatments (Table 4). For forage crop, the mean response was higher at optimum, whereas, for forage-cum-grain crop, the response was higher with 60 kg P_2O_5 ha^{-1}. On the other hand, the PUE, both for fodder as well as fodder-cum-grain crop, was appreciably higher with 30 kg P_2O_5 ha^{-1} in comparison to 60 kg P_2O_5 ha^{-1}, but was at par with optimum dose of phosphorus in both the seasons and on mean basis.

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