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EFFECT OF CUTTING MANAGEMENT AND PHOSPHORUS LEVELS ON GROWTH, FORAGE AND SEED YIELD OF MULTICUT OAT (*AVENA SATIVA* L.)

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SUMMARY

The field experiment was conducted during the *rabi* season of 2016-17 at the Forage Research Farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar with the objective to study the effect of cutting management and phosphorus fertilization on forage and seed productionof multicut oat. Treatment combinations comprised of eight cutting management treatments *i.e.* C1 (Seed to Seed), C2 (Fodder at 50% flowering), C3 (Fodder 60 DAS- Seed), C4 (Fodder 70 DAS- Seed), C5 (Fodder at 80 DAS- Seed), C6 (Fodder 60 DAS- Fodder at 50% flowering), C7 (Fodder at 70 DAS- Fodder at 50% flowering), C8 (Fodder 80 DAS- Fodder at 50% flowering) and four levels of phosphorus *i.e.* 0, 20, 40 and 60 kg P_2O_5/ha. The experiment was laid out in split plot design and replicated thrice. The soil of the experimental field low in available nitrogen (161 kg N/ha), medium in available phosphorus (12 kg/ha) and available potassium(252 kg/ha, slightly alkaline in reaction (pH 7.8). The results indicated that the highest green fodder and dry matter yield was obtained when only one cut of fodder was taken at 50% flowering stage and it was statistically at par for green fodder yield with treatment where first cut for fodder was taken at 80 DAS and second cut at 50% flowering stage. Harvesting of fodder at 80 DAS gave significantly higher forage yield and seed yield than the harvesting at 60 or 70 DAS. Contrary to this, the straw yield and biological yield were significantly higher in the treatment when the crop was raised purely for seed purpose. Under dual system, delay in first cut *i.e.* from 60 to 80 DAS resulted in a significant increase in fodder and seed yield over the earlier cuttings. Every incremental dose of applied phosphorus upto 40 kg P_2O_5/ha resulted in a significant improvement in forage, seed and straw yield over the lower doses.

Key words : Oat, cutting management, Phosphorus fertilization, fodder yield, seed yield

Oat (*Avena sativa* L.) is the most important cereal fodder crop grown during winter. It is used as green fodder, straw, hay or silage. It is a quick growing crop having good regeneration capacity. Its fodder is palatable, succulent and nutritious in two to three cuttings extending from December to February. Oat grain makes a good balanced concentrate in the ration for poultry, cattle, sheep and other animals (Arora 2014). Looking to the chemical composition on dry matter basis, oat at milk stage contains 6.44 % crude protein, 28.72 % fiber and 53.20 % nitrogen free extract. Beside this, it contains 2.31 % ether extract, 9.33 % total ash, 0.47 % calcium, 0.22 % phosphorus, 0.22 % magnesium, 0.52 % sodium and 2.84 % potassium. It forms an excellent combination when fed along with winter legume fodders like berseem, lucerne, senji or pea. Due to multicut nature, it helps in making up the fodder deficiency during lean period of forage production and the grains produced can be used as concentrate, which is nutritive and economical as compared to other commonly used concentrates

The grain yield of improved varieties of multicut oat is poor due to lodging and as such grain yield potential of this crop is low in comparison to other cereal crops. Lesser seed production of this crop results in less availability of quality seeds to the farmers which is a crucial factor in popularization of improved varieties of this crop. Since the varieties of fodder crops were developed primarily for higher forage yield, their harvesting at vegetative stage eliminated the chances of seed production. Therefore, it is necessary to develop strategies for obtaining considerable yield of green fodder as well as grain from the same crop by adopting appropriate cutting management (Singh et al., 2014).

Nutrients are very essential for better quality

and quantity of fodder. The main constraint in achieving the proven crop potential is imbalanced use of fertilizers, particularly low use of phosphorus as compared to nitrogen. Phosphorus is an essential element that plays a vital role in various metabolic processes of the plant. It is considered essential to seed production and found in large quantity in seeds, but it is generally deficient in most of the Indian soils. Oat green fodder quality as well as seed yield differs significantly at different fertility levels. Keeping this in view, the present study was conducted to study the effect of cutting schedule and varying phosphorus levels on growth, forage yield and seed production of multicut oat.

MATERIALS AND METHODS

The present investigation was carried out at Forage Research Farm of Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar during *rabi* season of 2016-17. The experiment consisting of 32 treatment combinations with 3 replications was laid out in Split Plot Design. The main plot were assigned the cutting management treatments whereas phosporus levels were kept as sub-plot treatments. The cutting management treatments were: **C1:** No cut for fodder (Seed to Seed), **C2:** Cut at 50% flowering stage for fodder, **C3:** Cut at 60 DAS for fodder and then seed, **C4:** Cut at 70 DAS for fodder and then seed, **C5:** Cut at 80 DAS for fodder and then seed, **C6:** Cut at 60 DAS for fodder and 50% flowering for fodder, **C7:** Cut at 70 DAS for fodder and 50% flowering for fodder and **C8:** Cut at 80 DAS for fodder and 50% flowering. These treatments were tested against four levels of phosphorus *viz.* 0, 20, 40 and 60 kg P_2O_5/ha. The seeds of oat variety HJ 8 were sown in lines 25 cm apart using *pora* method on 25 October, 2016 in each experimental unit. The recommended package of practices was followed to raise a healthy crop. The crop was harvested at different times as per the treatments. Nitrogen was applied in the form of urea in three equal splits. A uniform dose @ 40 kg N/ha was applied by broadcasting method to all the treatments at the time of sowing. The second dose of nitrogen was given after first irrigation and the remaining 1/3rd dose was applied after first cut of fodder in multicut system whereas, at 70 DAS in single cut system. As per the treatments requirement, the phosphorus through Single Super Phosphate was drilled with hand plough before sowing in respective plots. The soil of the experimental site was sandy loam in texture, low in available nitrogen, medium in avalable phosphorus and potassium with slightly alkaline in reaction (Table 1).

Weekly weather parameters recorded at observatory of the Department of Agricultural Meteorology, which is adjacent to Forage Research Farm of CCS Haryana Agricultural University, Hisar during *rabi* season (2016-17) are depicted in Fig. 1.

The observations on growth parameters were recorded at 50% flowering stage as well as at final harvest. Green fodder yield was recorded at each cut and a random sample of 500 g green fodder was taken from each plot and dried in sun and then transferred into an oven for final drying at a temperature of 65°C to a constant dry weight. Dry matter yield was calculated by multiplying dry matter content with total green fodder yield. The observations on seed yield attributing characters were recorded at the maturity of the crop. In present study, observations on fodder, grain and straw yield were recorded so as to evaluate the treatments effect. To bring these entities, *i.e.*, fodder, grain and straw on comparable scale, grain yield equivalent (q/ ha) was worked out considering the price of individual product. The price of green fodder, grain and straw was Rs. 125, 3200 and 220 per quintal, respectively.

RESULTS AND DISCUSSION

Growth parameters

Data pertaining to the growth parameters is

TABLE 1
Chemical analysis of the soil of experimental field

Particulars	Values	Method used
pH	7.8	pH meter with glass electrode in 1:2 Soil Water Suspension (Jackson, 1973)
EC (dS/m)	0.4	Conductivity Bridge Method (Richards, 1954)
Organic carbon (%)	0.41	Digestion Method (Walkley and Black, 1934)
Available nitrogen (kg/ha)	161	Alkaline Permanganate Method (Subbiah and Asija, 1956)
Available phosphorus (kg/ha)	12	Olsen,s Method (Olsen *et al.*, 1954)
Available potassium (kg/ha)	252	Flame Photometric Method (Jackson, 1973)

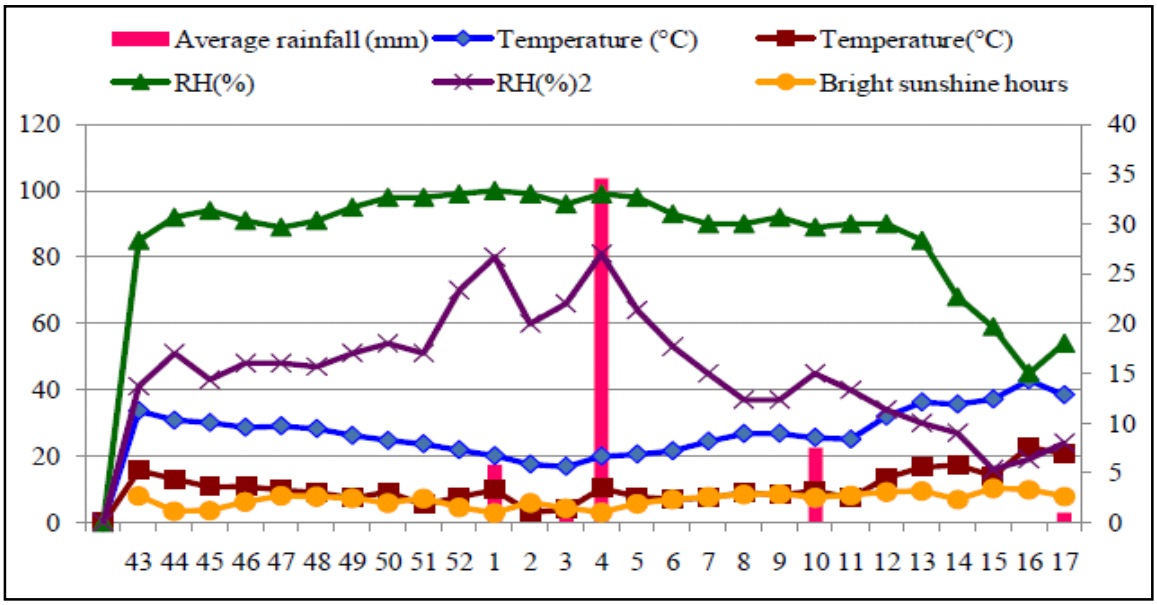

Fig. 1. Weekly meteorological data (November 2016-April 2017).

given in Table 2. Plant height is an index of growth and development. Plant height in I cut increased with delay in I cut i.e. from 60- 80 DAS. At 50% flowering stage, significantly higher plant height was measured with treatment C2 (cut at 50% flowering) than the other treatments. This might be due to the fact that the treatment C2 was harvested first time at 50% flowering where as all remaining treatments were harvested second time. In case of the treatments left for seed production, the plant height at maturity was significantly higher in the treatment C1 where crop was raised only for seed. Reason was same as 50% flowering behind increase in plant height. Similar findings were also revealed by Malik *et al.* (2015) who recorded maximum plant height when oat was cut at 70 DAS followed by cut at 60 DAS and then cut at 50 DAS. Application of graded doses upto 40 kg P_2O_5/ha significantly increased the plant height over their lower levels in first cut, 50% flowering and at maturity. However, the maximum plant height was observed with the application of 60 kg P_2O_5/ ha at all these three stages but non-significant difference was observed between 40-60 kg P_2O_5/ha. The number of tillers were recorded maximum when I cut was taken at 80 DAS, whereas, at 50% flowering stage, significantly higher number of tillers per metre row length were recorded in treatment C2 (cut at 50% flowering) where crop was harvested at 50% flowering. Increasing levels of phosphorus significantly improved the number of tillers upto 40 kg P_2O_5/ha at I cut, whereas, similar response was observed upto 20 kg P_2O_5/ha at 50% flowering stage as well as at maturity. The significantly higher leaf: stem ratio was recorded in treatments C1 (seed to seed) (0.49) and C2 (cut at 50% flowering) (0.49). Maximum leaf: stem ratio was observed with the application of 60 kg $_{P2O5}$/ha. The number of days taken to 50% flowering were shortened in the treatment C1 (seed to seed) and C2 (cut at 50% flowering) when the crop was raised either sole for fodder or seed. The number of days to 50% flowering decreased with increasing phosphorus levels.

Forage yield

The data presented in Table 3 revealed that green fodder yield significantly increased with the delay in I cut from 60-80 DAS . The treatment C8 (cut at 80 DAS and at 50% flowering) recorded the maximum green fodder yield during I cut. First cut at 80 DAS gave maximum fodder yield due to increase in plant height as well as number of tillers were higher at this stage as compared to cut at 60 or 70 DAS. When the crop was harvested for fodder at 50% flowering stage, treatment C2 (cut at 50% flowering) gave significantly higher green fodder yield than the remaining treatments.

Dry matter yield is a measure of green fodder yield on dry weight basis. Under I cut, the dry matter yield was found to be increased significantly with the delay in I cut from 60-80 DAS and the highest was under 80 DAS. The treatment C2 (cut at 50% flowering) was recorded with significantly higher dry matter yield than the other treatments at 50% flowering stage. The delay in I cut for fodder from 60-80 DAS further resulted in significant increase in dry matter

TABLE 2
Growth parameters of oat as influenced by cutting management and phosphorus levels

Treatments	Plant height (cm)			Number of tillers/ mrl			Leaf : Stem ratio at 50% flowering	Days to 50% flowering
	I Cut	50% flowering	Maturity	I Cut	50% flowering	Maturity		
(A) Cutting management								
C_1 (Seed to Seed)	-	-	171.9	-	-	82.5	0.49	121.6
C_2 (Fodder at 50% flowering)	-	168.8	-	-	87.7	-	0.49	121.3
C_3 (Fodder 60 DAS-Seed)	75.5	-	160.2	58.0	-	81.3	0.32	140.3
C_4 (Fodder 70 DAS-Seed)	101.3	-	150.8	69.9	-	71.3	0.36	146.4
C_5 (Fodder 80 DAS-Seed)	121.3	-	138.0	88.8	-	72.7	0.41	145.5
C_6 (Fodder 60 DAS-Fodder at 50% flowering)	72.1	155.0	-	56.3	64.8	-	0.31	138.2
C_7 (Fodder 70 DAS-Fodder at 50% flowering)	105.1	147.5	-	65.0	66.7	-	0.34	146.0
C_8 (Fodder 80 DAS-Fodder at 50% flowering)	123.7	128.2	-	80.0	70.5	-	0.39	145.9
S. Em±	4.2	3.7	6.1	4.4	6.1	1.7	0.01	0.8
C. D. (P=0.05)	13.4	13.1	18.1	14.2	18.6	5.9	0.04	2.4
(B) Phosphorus levels (P_2O_5 kg/ha)								
0	80.1	128.9	140.6	62.7	66.8	68.2	0.36	138.8
20	100.1	150.1	155.6	68.8	71.4	76.8	0.38	138.5
40	108.9	159.5	162.1	73.1	74.8	80.5	0.39	137.9
60	110.3	160.9	162.7	74.1	76.5	80.0	0.42	137.3
S. Em±	1.4	2.7	1.6	1.4	1.5	1.8	0.01	0.3
C. D. (P=0.05)	4.1	7.9	4.7	3.9	4.5	5.2	0.02	1.0

TABLE 3
Effect of cutting management and phosphorus levels on forage yield of oat

Treatments	Green fodder yield (q/ha)			Dry matter yield (q/ha)		
	I Cut	50% flowering		I Cut	50% flowering	Maturity
(A) Cutting management						
C_1 (Seed to Seed)	-	-	-	-	-	-
C_2 (Fodder at 50% flowering)	-	599.0	599.0	-	125.9	125.9
C_3 (Fodder 60 DAS-Seed)	89.9	-	-	4.8	-	-
C_4 (Fodder 70 DAS-Seed)	178.7	-	-	15.3	-	-
C_5 (Fodder 80 DAS-Seed)	294.5	-	-	31.1	-	-
C_6 (Fodder 60 DAS-Fodder at 50% flowering)	74.8	331.2	406.1	4.5	60.7	65.2
C_7 (Fodder 70 DAS-Fodder at 50% flowering)	188.3	315.8	504.1	17.4	67.7	85.1
C_8 (Fodder 80 DAS-Fodder at 50% flowering)	294.6	301.6	596.3	29.4	71.9	101.3
S. Em±	7.7	8.4	9.2	0.3	0.7	2.0
C. D. (P=0.05)	24.7	29.8	32.0	0.9	2.9	6.2
(B) Phosphorus levels (P_2O_5 kg/ha)						
0	159.3	351.4	468.7	14.1	72.5	82.7
20	182.0	386.9	520.8	16.9	79.5	92.2
40	191.7	404.4	553.7	18.5	89.1	102.9
60	210.9	410.5	562.1	18.6	86.1	100.7
S. Em±	5.9	8.9	9.4	0.3	1.3	1.3
C. D. (P=0.05)	16.9	25.9	27.5	0.9	3.7	3.9

yield at 50% flowering stage. As it is a measure of green fodder yield, so, increase in the yield of green fodder will also improve dry matter yield. The data further indicated that with the every incremental dose of phosphorus upto 40 kg P_2O_5/ha brought a significant improvement in dry matter yield over the lower doses at all the three stages *i.e*. I cut, 50% flowering and total dry matter yield. These results regarding crop dry matter yield are in close conformity with the results reported by Luikham *et al.* (2014) *i.e*. the highest green and dry fodder yield was obtained with the application of 40 kg P_2O_5/ha.

Seed yield and its attributes

The data presented in Table 4 reveals that number of panicles per metre row length were observed to the significantly higher in treatment C3 (cut at 60 DAS and then left for seed) than the other treatments. The minimum number of panicles were recorded with treatment C5 (cut at 80 DAS and at 50% flowering). Application of phosphorus increased the number of panicles per metre row length. A significant increase was noticed with the application of 20 kg P_2O_5/ha over the control and no significant increase was noticed thereafter upto 60 kg P_2O_5/ha.

The data given in Table 4 further indicates that significantly more number of grains per panicle were recorded in the treatment C1 (seed to seed) than the other treatments except C4 (cut at 70 DAS and then left for seed) where non-significant differences was observed. The minimum number of grains per panicle were noticed when the crop was harvested for fodder at 60 DAS and then left for seed purpose (C3). The increasing dose of phosphorus from 0-40 kg P_2O_5/ ha resulted in a significant improvement in number of grains per panicles over the lower doses. However, application of 60 kg P_2O_5/ha could not bring any significant variation over 40 kg P_2O_5/ha.

Test weight is a measure of 1000 grains weight. As per the research findings, there was non-significant increase in test weight but it increased with the advancement of age (Table 4). Similar data was also reported by Malik *et al.* (2015) which indicated that the test weight of oat was highest (39.23) with cutting at 60 DAS and it was significantly higher than the test weight at 50 and 70 DAS, however, 50 and 70 DAS were found at par. Application of 40 kg P_2O_5/ha proved to be significantly better than control and 20 kg P_2O_5/ha for test rate.

Seed yield was increased from with delay in I cut i.e. from 60-80 DAS and minimum was recorded under no cut treatment. The reason for minimum yield was that the crop was lodged due to weak stem and rain at the time of vegetative growth. Lodging hinders the movement of growth nutrient to the economic part of plant and so there was reduction in seed yield under treatment which was mainly grown for seed purpose. Similar results were also found by Khandey *et al.* (2009) who concluded that increase in phosphorus upto 40 kg P_2O_5/ ha recorded significantly higher seed and straw yield over the lower doses.

Inverse relation was noticed between seed and straw yield i.e. with lesser seed yield the straw yield became higher. Straw yield was recorded significantly higher in case of seed to seed treatment and lower was under treatment C5 (fodder at 80 DAS and then left for seed). Marcela *et al*. (2012) also reported the similar findings i.e. straw production was higher under free growth, i.e., no cutting as compared to cut at two heights (15 and 30 cm). Increase in straw yield was recorded upto the application of 20 kg P_2O_5/ha. Biological yield is a measure seed yield and straw yield. As per the research findings, biological yield was noticed to be significantly higher in treatment

TABLE 4

Effect of cutting management and P levels on yield attributing characters seed yield of oat

Treatments	No. of panicles/ mrl	No. of grains/ panicle	Test weight (g)	Seed yield (q/ha)	Straw yield (q/ha)	Biological yield	Harvest index (%)	Seed yield equivalents (q/ha)
(A) Cutting management								
C_1 (Seed to Seed)	82.3	78.2	37	3.8	122.7	126.5	2.9	3.8
C_2 (Fodder at 50% flowering)	-	-	-	-	-	-	-	12.9
C_3 (Fodder 60 DAS-Seed)	87.5	72.8	38	5.1	107.1	112.3	4.6	6.9
C_4 (Fodder 70 DAS-Seed)	76.6	77.5	36	5.5	73.0	78.6	7.1	9.3
C_5 (Fodder 80 DAS-Seed)	75.2	74.2	36	5.5	62.3	67.8	8.1	10.1
C_6 (Fodder 60 DAS-Fodder at 50% flowering)	-	-	-	-	-	-	-	8.5
C_7 (Fodder 70 DAS-Fodder at 50% flowering)	-	-	-	-	-	-	-	10.4
C_8 (Fodder 80 DAS-Fodder at 50% flowering)	-	-	-	-	-	-	-	12.1
S. Em±	1.3	0.9	0.1	0.1	2.7	2.5	0.2	0.2
C. D. (P=0.05)	4.6	3.2	NS	0.5	9.5	8.9	0.7	0.6
(B) Phosphorus levels (P_2O_5 kg/ha)								
0	75.3	62.3	35	3.7	85.5	89.2	4.6	7.9
20	79.9	73.3	36	5.1	91.2	96.3	5.8	9.4
40	82.1	82.2	38	5.7	93.2	98.8	6.3	10.0
60	84.3	84.8	38	5.4	95.3	100.7	5.9	9.5
S. Em±	1.6	1.2	0.1	0.1	2.1	2.1	0.3	0.1
C. D. (P=0.05)	3.1	3.6	2.0	0.5	6.2	6.3	0.8	0.4

where the cut was taken at 50% flowering (Table 4). Application of 20 kg P_2O_5/ha significantly improved the yield only over the control.

CONCLUSION

As per the research findings, it may be concluded that harvesting of crop for fodder at 80 days after sowing and then left for seed production gave higher fodder and seed yield than the early harvesting at 60 or 70 DAS in dual system. This may be due to the fact that crop harvested at 80 DAS took more time to harvest and it increases the fresh weight and dry weight of crop. In case where two cuts for fodder were taken, cut at 80 DAS and II at 50% flowering was proved better. However, the harvesting of crop for sole fodder at 50 per cent flowering stage gave comparatively higher returns. Further, it is also concluded that the crop should be fertilized with 40 kg P_2O_5/ha for good quality higher fodder yield, seed production, net returns.

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