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Responses of dual purpose oats (*Avena sativa* L.) to sowing date, method and level of zinc with or without thiourea in irrigated arid ecosystem

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Abstract

A field experiment was conducted for four consecutive winter seasons of 2011-12 to 2014-15 on dual purpose oats to record the responses of sowing date, method and level of zinc with or without thiourea on growth, yield, quality and economics in irrigated arid ecosystem. The treatment consisted in main plot three dates of sowing *viz*., 1st November, 15th November and 30th November; and in sub plot five methods and levels of zinc with or without thiourea namely control (without zinc and thiourea), basal application of $ZnSO_4$ @25 kg/ha, basal application of $ZnSO_4$@12.5 kg/ha + foliar spray (0.5% $ZnSO_4$), basal application of $ZnSO_4$ @12.5 kg/ha + foliar spray (0.5% $ZnSO_4$ + 0.05% thiourea) and basal application of $ZnSO_4$ @12.5 kg/ha + foliar spray (0.05% thiourea). Two foliar spays were done on re-growth foliage at 10 and 25 days after cutting for green fodder as per the treatment. The experiment was conducted in split plot design with four replications. The results showed that maximum green fodder production (114.73 q/ha), grain yield (16.33 q/ha) and straw yield (46.15 q/ha); crude protein per cent (15.52%) and protein yield (12.89 q/ha); zinc content (55.47 ppm) and uptake (460.68 g/ha); zinc use efficiency (0.52 kg grain/g Zn) and dry fodder (2.65 kg dry fodder/g Zn) and water use efficiency for grain (6.4 kg/ha-mm) and dry fodder (32.7 kg/ha-mm); and net returns (Rs. 43294 /ha) and B: C ratio (2.37) were recorded with 15th November sown oat crop. Different methods and levels of zinc application with or without thiourea indicated that maximum yields of green fodder (99.18 q/ha) and grain (15.75 q/ha); zinc content (53.62 ppm) and zinc uptake (392.23 g/ha); net return (Rs.37394 /ha) and B:C ratio (2.10) were recorded with basal application of $ZnSO_4$ (12.5 kg/ha) + foliar spray (0.5% $ZnSO_4$). Whereas higher crude protein per cent (16.39) and protein yield (11.71 q/ha) was recorded with basal application of $ZnSO_4$ @ 12.5 kg/ha + foliar spray (0.5% $ZnSO_4$ + 0.05% thiourea).

Keywords: Dual purpose oats, Green fodder production, Sowing date, Thiourea, Water use efficiency, Zinc level

Introduction

Oats (*Avena sativa* L.) is the most important winter cereal fodder and rich source of energy, protein, vitamin B_1, phosphorus, iron and other minerals. It is mainly grown under the situation, where water supply is limited and farmer cannot grow legumes like berseem and lucerne. It has excellent growth habit, quick recovery after cutting and provides good quality herbage. Furthermore, the demand for oat for human consumption has increased, particularly because of the demonstrated dietary benefits of oat whole-grain products. Health promoting effects of oat products for human consumption have been approved by the AFDA (1996). In India, it is used as green fodder, hay and silage for animals.

Crop yield is influenced by inherent vigour of seed and environmental condition. Genetic improvement is possible due to variation in germplasm, but improvement in productivity is to be achieved through manipulation of environmental factors also. Careful selection of ideal sowing time to take maximum advantage of environmental conditions during growth of oat may help in increasing green fodder production and grain yield. Now it is a well known fact that zinc is considered as fourth most important yield-limiting nutrient after nitrogen, phosphorus and potassium (Maclean *et al.,* 2002). Zinc is an essential micronutrient required for growth and development of the higher plants (Kochian,1993; Marschner,1995) and is involved in membrane integrity, enzyme activation and gene expression (Kim *et al.,* 2002). Its importance for oat productivity is similar to that of major nutrients like nitrogen, phosphorus and potash. Under dryland conditions reduced soil moisture in surface soil layer reduce zinc adsorption and may cause zinc deficiency. Not much attention so far has been given on improving plant biology, more particularly plant molecular mechanisms which inherently influence not only acquisition of water and nutrient from the soil but they also govern their transport inside the plants. Thus these nutrients act as bioregulators and play an important role in improving productivity of crop through enhanced phloem translocation and yield formation in plant. Thiourea application had a role in enhancing canopy photosynthesis and metabolic transport of photosynthetic assimilates to grains via an effect on phloem loading (Sahu and Singh, 1995). Foliar spray of thiourea at vegetative and flowering stages in wheat was recorded with higher plant height and yield attributes *viz.* ear length, effective tiller per meter length, grain per panicle and test weight than control (Bhunia *et al.*, 2015). Similar results of thiourea application in different crops (wheat, sorghum, mustard and sewan grass) with limited irrigation in arid ecosystem were also reported by several researchers (Sahu *et al.,* 2005; 2006; Wakchaure *et al*., 2016; Kumawat *et al*., 2016). However, the information related to response of fodder oats to sowing date, method and level of zinc and thiourea is very meager. Hence, there was a felt need to generate precise information on sowing date, method and level of zinc and thiourea application on fodder oat production, in general and arid ecosystem in particular.

Materials and Methods

Experimental site and climate: A field experiment was conducted for four consecutive winter seasons of 2011-12 to 2014-15 on dual purpose oats at Agricultural Research Station, S K Rajasthan Agricultural University, Bikaner to record response of sowing date, method and level of zinc with or without thiourea on growth, yield, quality and economics in irrigated arid ecosystem. The experimental field soil sample show sandy loam in texture, having field capacity 6.50%, PWP 1.52%, bulk density 1.51 g/cc, pH (1:2) 8.09 and electrical conductivity (1:2) 0.12 dS/m. Further analyses of soil samples indicated that soil was low in organic carbon (0.35%), available nitrogen (111 kg/ ha), medium in available P_2O_5 (15.6 kg/ha) and available K_2O (245.7 kg/ha). During four crop growing seasons, the maximmum and minimum temperatures were 38.5 and 3.9 ^{0}C, respectively, while relative humidity ranged between 60.5 to 86.5 and 13.7 to 28.1%, respectively. Rainfall received during the crop growing period was 0, 26.4, 13.8 and 128.3 mm during the year 2011-12, 2012-13, 2013-14 and 2014-15, respectively.

Experimental design and crop raising: The experiment was conducted in split plot design with four replications. The treatment consisted of three dates of sowing *viz*., 1st, 15th and 30th November in main plot and sub plots with five methods and levels of zinc with or without thiourea. Thus the treatments were control (no zinc and thiourea), basal application of $ZnSO_4$ @25 kg/ha, basal application of $ZnSO_4$@12.5 kg/ha + foliar spray (0.5% $ZnSO_4$), basal application of $ZnSO_4$ @12.5 kg/ha + foliar spray (0.5% $ZnSO_4$ + 0.05% thiourea) and basal application of $ZnSO_4$ @12.5 kg/ha + foliar spray (0.05% thiourea). Fodder oat variety 'Kent' was sown using seed rate100 kg/ha at a spacing of 25 cm x 2-3cm. Recommended dose of NPK (80:40:40) kg/ha with half dose of nitrogen (40 kg/ha) and full dose of phosphorus and potassium were drilled as basal using fertilizer sources of urea, di-ammonium phosphate and muriate of potash, respectively. Cutting for green fodder was done at 60 DAS and thereafter, two foliar spays was done on re-growth foliage at 10 and 25 DAC (days after cutting) for green fodder (as per treatments) using 500 litre water per hectare. The remaining half dose of nitrogen was broad casted with irrigation in two equal splits *i.e.* at 30 DAS and just after cutting for green fodder, respectively. The crop was raised following recommended packages of practices for agro-climatic zone 1-c (hyper arid partially irrigated western plain) of Rajasthan. Pre-sowing irrigation (60 mm) was given using sprinkler system to get proper germination and subsequently six irrigations (40 mm depth) as per crop water requirement were applied during whole crop growing period. Further at crop maturity, harvesting was done on 30th March, 5th, 3rd and 8th April of respective year 2011-12, 2012-13, 2013-14 and 2014-15.

Observations and methods of analysis: Green fodder yield of fresh cut forage at 60 DAS and on complete sun drying, dry fodder and biological yield of indidual plot was weighed and thereafter grains were threshed, cleaned and weighed for yields per plot. These data were further computed in terms of yields (green fodder/dry fodder/ biological/grain/straw) per hectare basis. Physiological efficiency (harvest index) was also calculated using economical yield (grain) divided by biological yield and multiplied by 100 for presenting data in percentage. For the determination of crude protein per centage, dry fodder samples were ground and approx. 10 g sample of each plot was sent to Forage Section, Anand Agricultural University, Anand for quality analysis and analyzed data were received every year. Crude protein per centage was multiplied with dry fodder yield for computing protein yield in q/ha. Zinc content in dry fodder and grain was estimated by atomic absorption spectrophotometer (Lindsay and Norwell, 1978). For calculating zinc uptake, zinc content (%) was multiplied by total dry fodder yield and then converted it into g/ha. The pooled data were subjected to analysis of variance (ANOVA) for split plot design following Snedecor and Cochran (1994).

Results and Discussion

Sowing date: Sowing dates had significant effect on yields *viz.*, green fodder, grain, straw and total dry fodder yield; quality namely crude protein content; zinc content and uptake; input use efficiency *viz.,* zinc and water use efficiency and economics as net returns and B:C ratio of fodder oat (Tables1-2). Dates of sowing could not influence leaf: stem ratio significantly. However, highest leaf: stem ratio (0.36) of dual purpose oats was recorded at 15th November sown crop. Maximum green fodder (114.73 q/ha), grain (16.33 q/ha), straw (46.15 q/ha) and total dry fodder (83.05 q/ha) yield of oats were recorded with 15th November sown crop, which was significantly higher by 64.96, 18.76, 47.68 and 57.44 per cent, respectively over 30th November sown crop. However, 15th and 1st November sown crops recorded at par green fodder, grain and straw yields of dual purpose oats. The higher green fodder and grain yields in early sown crops could be ascribed to more time available for vegetative growth and grain development; and favourable environment for its growth during cool winter months. The 1st and 15th November sown oat crop got additional 30 and 15 days, respectively for its vegetative growth and grain development than 30th November sown crop. Dar *et al.* (2014) also reported that early sown fodder oat had higher green fodder yield as compared to late sown. Taneja *et al*. (1990) also reported similar results in Egyptian clover. Sood *et al.* (1992) reported higher fodder yield in early sown oat compared to late sown, which they attributed to availability of congenial temperature for better growth and development of crop in the former. Maximum crude protein per cent (15.52%) and yield (12.89 q/ha); zinc content (55.47 ppm) and uptake (460.68 g/ha); zinc use efficiency of grain (0.52 kg grain/g Zn) and dry fodder (2.65 kg dry fodder/g Zn); and water use efficiency of grain (5.07 kg/ha-mm) and dry fodder (25.79 kg/ha-mm) were recorded with 15th November sown crop. Congenial environmental conditions prevailed during 15th November sown crop might have encouraged more root and shoot growth which in turn ensured higher zinc uptake and water use. Higher utilization of available resources thus resulted in higher fodder and grain yields as well as input use efficiency. Further maximum net returns (Rs. 43294 /ha) and B: C ratio (2.37) was also recorded with 15th November sown crop. The higher net returns and B: C ratio might be due to higher green fodder and grain yields with 15th November sown crop. This was in conformity with the findings of Shekhara and Lohithaswa (2012). Jehangir *et al.* (2013) also reported that sowing dates significantly influenced the net return and B: C ratio in oat.

Zinc level and thiourea application: The study on zinc and thiourea application indicated that leaf: stem ratio (0.38); green fodder (99.18 q/ha), grain (15.75 q/ha) and total dry fodder (73.15 q/ha) yields were higher with basal application of $ZnSO_4$ @12.5 kg/ha + foliar spray (0.5% $ZnSO_4$). Quality parameters like zinc content (53.62 ppm) and uptake (392.23 g/ha) were also higher with same treatment. The superiority of this treatment is further manifested by higher net return (Rs.37394 /ha) and B: C ratio (2.10). However, higher crude protein content (16.39%) and protein yield (11.71q/ha) were recorded with basal application of $ZnSO_4$ @12.5 kg/ha + foliar spray (0.5% $ZnSO_4$ + 0.05% thiourea). All the treatments, except control recorded at par green fodder, grain, straw and total dry fodder yields; crude protein yield; and zinc content and uptake in fodder oat (Tables 1-2). This might have happened due to the fact that zinc application influences auxin synthesis and is involved in membrane integrity, enzyme activation, and gene expression (Kim *et al.,* 2002). Soil application of 25 kg $ZnSO_4$/ha recorded significantly higher green forage yield in pearl millet as compared to control (Patel *et al*., 2007). Mali and Dashora (2003) also recorded significantly higher fodder yield in sorghum by 186 per cent due to application of 25 kg $ZnSO_4$/ha compared to control. Singh *et al.* (2000) reported that application of 25 kg $ZnSO_4$/ha significantly increased grain and stover yields, and net returns of maize over control. Highest zinc use efficiency of grain (0.59 kg grain/g Zn) and dry fodder (2.75 kg dry fodder/g Zn) of fodder oat was recorded with basal application of $ZnSO_4$ @12.5 kg/ha + foliar spray (0.05% thiourea). This might be due to the fact that basal application of $ZnSO_4$ @12.5 kg/ha + foliar spray (0.05% thiourea) recorded higher grain and dry fodder yields at lesser zinc dose coupled with foliar spray of bio-regulator thiourea. Beneficial effects of thiourea in improving crop growth and yield contributing characters *vis-à-vis* physiological efficiency (HI) were also reported earlier in wheat and sorghum (Wakchaure *et al*., 2016), sewan grass (Kumawat *et al.*, 2016), wheat (Bhunia *et al*., 2015), mustard and wheat (Sahu *et al.,* 2005; 2006). Though maximum water use efficiency of grain (4.89 kg/ha-mm) and dry fodder (22.72 kg/ha-mm) was recorded with basal application of $ZnSO_4$ @12.5 kg/ha + foliar spray (0.5% $ZnSO_4$). This might have attributed to higher grain and dry fodder yield of fodder oat with $ZnSO_4$ @12.5 kg/ha basal + foliar spray (0.5% $ZnSO_4$).

Interaction effects of sowing date, zinc level and thiourea application: Sowing date x zinc level and thiourea interaction effects significantly influenced green fodder and grain yields (Table 3) of dual purpose oat. Highest green fodder yield (251.0 q/ha) was recorded with 15th November sown crop with use of $ZnSO_4$ @12.5 kg/ha as basal + foliar sprays (0.5% $ZnSO_4$). Further the highest grain yield (22.2 q/ha) of oats was recorded with same sowing date with use of $ZnSO_4$ @25 kg/ha as basal application. However, 15th November sown crop had at par green fodder and grain yields with non significant effect in all the zinc level treatments with or without thiourea foliar spray. This could have happened because foliar spray treatments were applied on re-growth foliage after cutting for green fodder.

Table 1. Effect of sowing date, Zn level and thiourea on growth, yield and quality of oats (pooled of four years)

Treatment	Leaf: stem ratio	Green fodder yield (q/ha)	Grain yield (q/ha)	Straw yield (q/ha)	Dry fodder yield (q/ha)	Crude protein (%)	Crude protein yield (q/ha)
Sowing date							
1st November	0.32	105.60	16.05	45.23	77.83	13.84	10.77
15th November	0.36	114.73	16.33	46.15	83.05	15.52	12.89
30th November	0.27	69.55	13.75	31.25	52.75	13.95	7.36
CD (P = 0.05)	NS	11.08	1.06	2.49	4.52	0.10	2.09
Zn and thiourea							
T_1	0.24	95.10	14.53	39.10	67.60	11.46	7.75
T_2	0.30	96.50	15.68	41.43	71.73	13.74	9.86
T_3	0.38	99.18	15.75	41.15	73.15	14.49	10.60
T_4	0.36	96.68	15.48	40.93	71.43	16.39	11.71
T_5	0.32	95.73	15.53	41.80	72.10	16.10	11.61
CD (P = 0.05)	0.06	NS	1.02	2.00	3.23	0.02	1.68

T_1: Control; T_2: Basal application of $ZnSO_4$ (25 kg/ha); T_3: Basal application of $ZnSO_4$ (12.5 kg/ha) + foliar spray (0.5% $ZnSO_4$); T_4: Basal application of $ZnSO_4$ (12.5 kg/ha) + foliar spray (0.5% $ZnSO_4$ + 0.05% thiourea); T_5: Basal application of $ZnSO_4$ (12.5 kg/ha) + foliar spray (0.05% thiourea); NS: Non significant

Table 2. Effect of sowing date, Zn level and thiourea on Zn content and uptake, input use efficiency and economics of oat (pooled of four years)

Treatment	Zn content (ppm)	Zn uptake (g/ha)	Zn use efficiency (kg/g Zn)		Water use efficiency (kg/ha-mm)		Net returns (Rs./ha)	B:C ratio
			Grain	Dry fodder	Grain	Dry fodder		
Sowing date								
1st November	49.85	387.98	0.51	2.49	4.98	24.17	39290	2.18
15th November	55.47	460.68	0.52	2.65	5.07	25.79	43294	2.37
30th November	50.27	265.17	0.44	1.69	4.27	16.38	27104	1.59
CD (P = 0.05)	2.66	23.62	-	-	-	-	3102	-
Zn and thiourea								
T_1	45.80	309.61	-	-	4.51	20.99	34536	2.07
T_2	53.46	383.47	0.30	1.37	4.87	22.28	36552	2.02
T_3	53.62	392.23	0.41	1.88	4.89	22.72	37394	2.10
T_4	52.90	377.86	0.40	1.84	4.81	22.18	36328	2.00
T_5	53.53	385.95	0.59	2.75	4.82	22.39	36417	2.07
CD (P = 0.05)	1.51	12.85	-	-	-	-	NS	-

T_1: Control; T_2: Basal application of $ZnSO_4$ (25 kg/ha); T_3: Basal application of $ZnSO_4$ (12.5 kg/ha) + foliar spray (0.5% $ZnSO_4$); T_4: Basal application of $ZnSO_4$ (12.5 kg/ha) + foliar spray (0.5% $ZnSO_4$ + 0.05% thiourea); T_5: Basal application of $ZnSO_4$ (12.5 kg/ha) + foliar spray (0.05% thiourea); NS: Non significant

Table 3. Interaction effect of sowing date, Zn level and thiourea on green fodder and grain yields (q/ha) of dual purpose oats (pooled of four years)

Zinc and thiourea	Sowing date		
	1st November	15th November	30th November
Green fodder yield			
T_1	162.6	248.7	136.8
T_2	160.0	246.1	111.1
T_3	148.3	251.0	121.1
T_4	183.8	238.2	120.6
T_5	173.1	231.9	106.4
CD (P = 0.05)	36.9		
Grain yield			
T_1	17.7	19.2	17.8
T_2	17.4	22.2	19.7
T_3	17.8	20.2	19.5
T_4	15.4	20.5	20.1
T_5	15.9	20.9	18.0
CD (P = 0.05)	2.84		

T_1: Control; T_2: Basal application of $ZnSO_4$ (25 kg/ha); T_3: Basal application of $ZnSO_4$ (12.5 kg/ha) + foliar spray (0.5% $ZnSO_4$); T_4: Basal application of $ZnSO_4$ (12.5 kg/ha) + foliar spray (0.5% $ZnSO_4$ + 0.05% thiourea); T_5: Basal application of $ZnSO_4$ (12.5 kg/ha) + foliar spray (0.05% thiourea)

Conclusion

Studies revealed that 15th November sown oat crop had the maximum green fodder and grain yields; nutrient and water use efficiency for grain as well as dry fodder with higher net returns. Similarly basal application of $ZnSO_4$ (12.5 kg/ha) + foliar spray (0.5% $ZnSO_4$) had maximum yields, yield attributes and net returns. Whereas maximum crude protein content and yield was recorded with basal application of $ZnSO_4$ @ 12.5 kg/ha) + foliar spray (0.5% $ZnSO_4$ + 0.05% thiourea).

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References

AFDA. 1996. Food labeling: health claims, oats and coronary heart disease. American Food and Drug Association. *Federal Register* 62: 358-360.

Bhunia, S.R, I.M. Verma, Mohd. Arif, R. Godara and N.C. Sharma. 2015. Effect of crop geometry, drip irrigation, and bioregulator on growth, yield and water use efficiency of wheat (*Triticum aestivem* L.). *International Journal of Agricultural Sciences* 11: 45-49.

Dar, N. A., K. N. Singh, L. Ahmad, J. A. Sofi, M. E. Bhat, and R. Kotry. 2014. Influence of dates of sowing, cultivars and different fertility levels on fodder oat (*Avena sativa* L.) under temperate conditions of Kashmir valley (India). *Range Management and Agroforestry* 35: 51-55.

Jehangir, I. A., H. U. Khan, F. U. Rasool and T. Mubarak. 2013. Yield and economics of oats (*Avena sativa* L.) as influenced by fertility and cutting management at different sowing dates. *Range management and Agroforestry* 34: 179-181.

Kim, T., A.M. Harry and Y.W. Hazel. 2002. Studies on the effect of zinc supply on growth and nutrient uptake in pecan. *Journal of Plant Nutrition* 25: 1987-2000.

Kochian, L.V. 1993. Zinc absorption from hydroponic solution by plant roots. *Zinc in soils and plants*. Kluwer Publishers, The Netherlands. pp. 45-57.

Kumawat, S.M., Mohd. Arif, Dushayant Singh, P.S. Rathore and S.S. Shekhwat. 2016. Effect of growth regulators on growth, yield and quality of sewan grasss (*Lasiurus sindicus* Henr.). *Range Management and Agroforestry* 37: 39-43.

Lindsay, W.L. and W.A. Norvell. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Journal of the Indian Society of Soil Science* 42: 421-428.

Maclean, J.L., D.C. Rawe and G.P. Hettel. 2002. Rice Almanac: Source book for the most important economic activity on Earth. 3rd edn. International Rice Research Institute, Manila, Philippines; CABI, Wallingford, UK. pp. 253.

Mali, A.L. and L.N. Dashora. 2003. Response of sorghum to iron and zinc. *Annals of Agricultural Research* 24: 421-422.

Marschner, H. 1995. *Mineral Nutrition of Higher Plants.* 2nd edn. Academic Press, London. pp. 889.

Patel, A.S., A.C. Sadhu, M.R. Patel and P.C. Patel. 2007. Effect of zinc, FYM and nitrogen uptake by pearl millet (*Pennisetum glaucum*). *Indian Journal of Agricultural Sciences* 80: 213-216.

Sahu, M. P. and D. Singh. 1995. Role of thiourea in improving productivity of wheat (*Triticum aestivum* L.) *Plant Growth Regulation* 14: 169-173.

Sahu, M. P., S. M. Kumawat, S. F. D'souza, N. K. Ramswamy and G. Singh. 2005. Sulphydryl bioregulator technology for increasing mustard production. *Research Bulletin*, RAU-BARC No. 1. pp. 1-52.

Sahu, M. P., S. M. Kumawat, N. K. Ramswamy, G. Singh and S. F. D'souza. 2006. Sulphydryl bioregulator technology for increasing wheat productivity. *Research Bulletin*, RAU-BARC No.1. pp. 1-56.

Shekara, B. G. and H. C. Lohithaswa. 2012. Effect of time of sowing, seed rate and planting geometry on green forage yield and quality of fodder oat. *Forage Research* 38: 122-124.

Singh, A., A.K. Vyas and A.K. Singh. 2000. Effect of nitrogen and zinc application on growth, yield and return of maize. *Annals of Agricultural Research* 21: 296-297.

Snedecor, G. W. and W. G. Cochran. 1994. *Statistical Methods*. 8th edn. East West Press Pvt. Ltd., New Delhi.

Sood, B.R., R. Singh and V.K. Sharma. 1992. Effect of sowing dates and cutting management in forage yield and quality of oat (*Avena sativa*). *Forage Research* 18: 130-134.

Taneja, K. D., Sharma, H.C. and D.P. Singh, 1990. Effect of last cut and fertility levels on green forage, stover and seed yield of Egyptian clover under late sown conditions. *Forage Research* 16: 127-137.

Wakchaure, G. C, P.S. Minhas, P. Ratnakumar and R. L. Choudhry. 2016. Plant bioregulators for raising crop and water productivity. *ICAR News Letter* 22: 1-2.