Range Management and Agroforestry 45 (1) : 171-174, 2024
ISSN 0971-2070 (Print); 2249-5231 (Online)
https://doi.org/10.59515/rma.2024.v45.i1.24

Short communication

Effect of intercropping and zinc management on weed density and fodder yield in oats

Muskan Porwal[1*], S.R. Kantwa[2], S.S. Singh[1], Prabhu Govindasamy[2,3], Badal Verma[4] and Srinivasan Ramakrishnan[2]

[1]Rani Lakshmi Bai Central Agricultural University, Jhansi-284003, India
[2]ICAR-Indian Grassland and Fodder Research Institute, Jhansi-284003, India
[3]ICAR-Indian Agricultural Research Institute, New Delhi-110012, India
[4]Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur-482004, India
[*]Corresponding author email: muskanporwal363@gmail.com

Received: 16th March, 2023 Accepted: 12th January, 2024

Abstract

A study was conducted to investigate the effect of intercropping and zinc application on weed density and forage yield in the Bundelkhand region during the *Rabi* season of 2020-2021 at the Research Farm of Rani Lakshmi Bai Central Agricultural University, Jhansi. The experiment comprised eight treatments with sole cropping of oat (CS_1) and intercropping of oat with berseem (CS_2)] in the main plot and four nutrient management practices [control (NM_1), recommended dose of fertilizers RDF (NM_2), recommended dose of fertilizers with zinc sulfate (NM_3) and recommended dose of fertilizers with nano zinc (NM_4)] in sub-plots in split plot design. The results showed that the weed density (150 m^{-2}) and weed biomass (26.1 g m^{-2}) in CS_2 was found significantly lower than CS_1 (186 m^{-2} and 34.5 g m^{-2}, respectively). NM_4 treatment had significantly lower weed density (158 m^{-2}) and weed biomass (25.6 g m^{-2}) than NM_3 (215 m^{-2} and 45.13 g m^{-2}) and NM_2 (175 m^{-2} and 25.6 g m^{-2}) among nutrient management practices. Also, intercropping + RDFnZn treatment produced significantly the highest green fodder yield (57.3 t ha^{-1}) when compared to the rest of the treatments.

Keywords: Green Fodder Yield, Intercropping, Nano zinc, Nutrient management

The majority of the Indian population (~20.5 million) is dependent on livestock and it contributes 28.4% to the agricultural Gross Domestic Product (GoI, 2019). Fodder crops are a major source of feed for the livestock population. However, due to tremendous pressure on lands to produce more food crops to fulfill the demand of the ever-increasing population, the total fodder crop cultivated area is being limited to 8.4 m ha (Kumar and Faruqui, 2010). Even after producing 734.2 mt of green fodder and 326.4 mt of dry fodder, the country faces a huge shortfall of 11.24% green fodder and 23.4% dry fodder (Roy *et al*., 2019). This can be managed by increasing forage production through minimizing yield losses from weeds, pests, and diseases (Kumar *et al*., 2023). Oat is the most prominent *Rabi* cereal fodder crop grown in India. But oat suffers severe yield and quality losses due to weeds. The weed causes significant yield losses in crops such as lucerne (11.3%) and oat (8.1%), as reported by Mir *et al*. (2018) and Mukherjee *et al.* (2019). Weed management is an important factor for enhancing the productivity of oats because many crop-associated weeds like sweet clover (*Melilotus albus* Medik), toothed dock (*Rumex dentatus* L.) and lamb's quarters (*Chenopodium album* L.) are predominant in Jhansi district. These compete with the oat crop for light, nutrients, water and space. The current method of weed management in oat is the combination of cultural and chemical methods, such as post-emergence application of metsulfuron-methyl @ 0.008 kg *a.i.* ha^{-1} + 1 hand weeding and metsulfuron-methyl @ 0.012 kg *a.i.* ha^{-1} (Hedayetullah and Zaman, 2022), and pre-emergence application of pendimethalin @ 0.37 kg *a.i.* ha^{-1} at 1-3 days after sowing (Kumar *et al*., 2015). The chemical weed control methods are effective against weeds. However, there is a huge concern about the effect of herbicide residues in feed and fodder and also, the cost of chemical weed management hinders the use of herbicides in forage crops. Therefore, a wise alternative to manage weeds effectively without causing significant harm to the crop is the utilization of intercrops (cultural method). Intercropping with legumes not only helps in weed suppression and enhancing fodder yields but also provides a balanced diet to cattle and improves soil fertility (Iqbal *et al*., 2018).

Further, zinc nutrient has played an immense role in the physiological activities of plants, from being involved as a constituent of various enzymes to being a precursor of auxin synthesis and thus promoting the growth of plants (Umair *et al*., 2020; Choudhary *et al*., 2021). Among the several ways of inorganic and organic application of zinc in soil, the application of zinc in nanoformulation (nano Zn) is more effective owing to its high surface area and effective absorption (Al-Jabri *et al*., 2022). Nano-zinc fertilizers have been shown to increase the growth and yield of crops in addition to being cost-efficient (Qureshi *et al*., 2018). It is also believed that enhanced crop growth would help in weed suppression. However, there is a lack of research on the effect of the combination of zinc management and legume intercropping on weeds in oats. Therefore, this study was designed to evaluate the effect of zinc management and oats + berseem intercropping on weed density and forage yield.

The study was conducted during the *rabi* season of 2020-2021 at Bhojla Research Farm (25°30′49.5″ N latitude, 78°33′11.9″ E longitude and 223 m MSL) of Rani Lakshmi Bai Central Agricultural University, Jhansi. The experimental site lies under the Bundelkhand agroclimatic zone (VI) of Uttar Pradesh. The region is situated in a semi-arid climate, witnessing heavy summer and winter. The average maximum and minimum temperatures were 27.7 and 10.3°C, respectively. The highest maximum temperature was recorded in the last week of March (34.8°C) and the lowest happened in the last week of December (5.2°C), with 15.6 mm of rainfall during the crop growth period.

The soil of the experimental plot was sandy clay loam with pH 7.6, medium in organic C (0.66%) and zinc (0.44 ppm); medium in available N (258.6 kg ha^{-1}), P (17.8 kg ha^{-1}), and K (257.6 kg ha^{-1}). The experimental units were arranged in a split-plot design with three replications. The treatments consisted of two cropping systems (*i.e*., sole oat and oat + berseem) in main plots and four nutrient management practices [*i.e*., control (without fertilizer), RDF (recommended dose of fertilizer), RDFZn (RDF + $ZnSO_4$) and RDFnZnO (RDF + nano Zinc Oxide)] under sub-plots. Kent and Bundel Berseem-2 (JHB-146) were the varieties of oat and berseem, respectively, used in this study. The seeds of the oat were sown manually at a distance of 20 cm in the sole oat (26 November 2020). For intercropping, the seeds of oat and berseem were also sown manually in a ratio of 4:2, respectively. The recommended dose of fertilizers was applied at the rate of 120 kg N ha^{-1} through urea and DAP, 60 kg P_2O_5 ha^{-1} through DAP and 40 kg K_2O ha^{-1} through MOP. Half of N and full doses of P and K were applied as basal dose and the remaining half of N was applied in splits after every irrigation. The recommended dose of zinc sulfate heptahydrate salt @ 20 kg ha^{-1} was broadcasted as a basal dose in RDF + $ZnSO_4$ treatment. Oat and berseem seeds were primed with nZn @ 250 ppm particles 24 hours before planting for RDF + nZn. Harvesting was done after 65 DAS and successive harvesting was carried out 25 days after each harvest. A total of three forage harvests were taken and the yield was estimated treatment-wise from a net plot area of 24 m^2.

Observations on weed density and weed biomass were recorded 35 days after sowing (DAS). The observation on weed density was recorded using five random quadrants (0.25 m^2 each) from each plot. The individual weed species were identified and collected for biomass estimation. Weed biomass from 5 random quadrates were cut close to the ground level at 35 DAS, and then oven dried at 65°C till to get a constant dry weight. The harvesting of sole oat and oat + berseem intercropping system was carried out separately for green fodder yield and expressed in tonnes ha^{-1}. Dry fodder yield was obtained after drying at 65ºC in a hot air oven.

All data were analyzed to test the significance of treatment differences using split plot design (Gomez and Gomez, 1984). Analysis of variance test was performed using the proc glimmix package in statistical analysis systems (v 9.3, SAS Institute Inc, Cary, NC). For the analysis, the treatments (main and sub-plot) were considered as fixed effects and replication as a random effect. All the statistical significance was determined at α 0.05. Mean separation was done using Fisher's least significant difference test ($\alpha = 0.05$).

The major weed species observed in this experiment were grassy weed and Bermuda grass [*Cyanodon dactylon* (L.) Pers.], broadleaf weeds; common lambsquaters (*Chenopodium album* L.), corn spurry (*Spergula arvensis* L.), honey clover (*Melilotus albus* Medik.) and bur medic (*Medicago polymorpha* L.) and volunteer weeds; Lentil (*Lens culinaris* Medik.) and green gram [*Vigna mungo* (L.) Hepper]. The individual effect of the cropping system was significant for both weed density (p = 0.004) and biomass (p = 0.007). Similarly, the effect of zinc application was also found significant for weed density ($p < 0.0001$) and weed biomass ($p < 0.0001$). The interaction effect of the cropping system-by-nutrient management effect was not significant for the weed density (p = 0.87) and weed biomass (p = 0.11).

The weed density (150 m^{-2}) and weed biomass (26.1 g m^{-2}) in the intercropping system were found to be significantly lower than the sole cropping system (186 m^{-2} and 34.5 g m^{-2}, respectively; Table 1). The low weed density and biomass in intercropping systems compared to sole could be due to higher competition for soil moisture and nutrients, and the suppression of

Table 1. The effect of intercropping systems and nutrient management practices on weed density and biomass in a semi-arid region

Treatments	Weed density (No. m^{-2})	Weed biomass (g m^{-2})
Cropping systems (CS)		
Sole Oat	13.61 (186** ± 10.5†)a‡	3.06 (34.5 ± 3.7)a
Oat + Berseem	12.23 (150 ± 10.5)b	2.72 (26.1 ± 2.4)b
P value	0.0045	0.007
Nutrient management (NM)		
Control	11.13 (124 ± 9.7)c	2.40 (19.2 ± 1.2)d
RDF	13.24 (175 ± 10.8)b	2.72 (31.4 ± 3.1)c
RDFZn	14.69 (215 ± 8.9)a	2.96 (45.13 ± 3.5)b
RDFnZn	12.61 (158 ± 8.6)b	3.49 (25.6 ± 1.8)a
P value	< 0.0001	< 0.0001

**Numbers inside the parenthesis are original values; † standard error of mean; ‡ different letters indicating the significance

weeds by intercrop berseem. The better ground coverage by the crops under the intercropping system probably inhibited the weed seedling emergence and subsequent growth, resulting in lower weed density and biomass. The intercrop also reduced light penetration, which hinders the photosynthetic efficiency of weeds. Similar findings were observed by Ahmad *et al*. (2021) where intercropping significantly reduced the weed density and biomass as compared to sole cropping.

Among the fertilizer treatments, RDFnZn treatment significantly reduced the weed density (158 m^{-2}) and weed biomass (25.6 g m^{-2}) than RDFZn (215 m^{-2} and 45.13 g m^{-2}, respectively) and RDF (175 m^{-2} and 25.6 g m^{-2}, respectively) treatments (Table 1). This might be due to greater Zn availability and uptake by the crop in the case of RDFnZn treatments compared to other treatments (Yasari *et al*., 2022). The enhanced crop growth might have greatly suppressed the weed population. Overall, intercropping practice, along with nano zinc application, effectively suppressed the weed population.

The effect of the cropping system and nutrient management on green fodder yield and dry fodder yield was recorded (Table 2). The findings revealed that the individual as well as interaction effects of the cropping system and nutrient management were significant for green fodder (GFY) and dry fodder (DFY) yield. The results demonstrated that a higher GFY (45.1 t ha^{-1}) was recorded for the intercropping system as compared to sole cropping (38.2 t ha^{-1}). Likewise, higher DFY was also obtained with the intercropping system (7.3 t ha^{-1}) than with sole cropping (6.4 t ha^{-1}). The higher yield under the intercropping system might be due to increased availability of nutrients and N supply from berseem, which could have increased the growth of oat crops, leading to an increase in fodder production.

In the case of nutrient management, RDFnZn treatment produced a higher GFY (54.3 t ha^{-1}) and DFY (9.4 t ha^{-1}) as compared to RDFZn (51 and 8.8 t ha^{-1}), RDF (45.2 and 6.9 t ha^{-1}) and control (16.1 and 2.3 t ha^{-1}) treatments. Similar findings were also obtained by Tondey *et al.* (2021), where ZnONPs (20 mg L^{-1}) increased the yield parameters and CP content as compared with $ZnSO_4$ and without fertilizer treatments. Zinc plays a crucial role in the production of tryptophan and the biosynthesis of cytokinins and gibberellins. This might have increased the chlorophyll content and improved the crop growth and photosynthetic efficiency and, consequently, fodder yields (Kumawat *et al*., 2017).

The interaction of the intercropping system with RDFnZn treatment also enhanced GFY and DFY by 80.27 and 83.83% as compared to the control, 5.06 and 4.04% compared to RDFZn in the intercropping system. The complementary effect and weed smothering by legume

Table 2. The effect of cropping systems and nutrient management on green fodder yield (GFY) and dry fodder yield (DFY) of sole oat and oat + berseem

Treatments		GFY (t ha^{-1})	DFY (t ha^{-1})
Cropping systems (CS)			
Sole		38.2 ± 4.7b	6.4 ± 0.08†b‡
Oat + Berseem		45.1 ± 4.3a	7.3 ± 0.08a
P value		0.0001	0.01
Nutrient management (NM)			
Control		16.1 ± 2.1d	2.3 ± 0.03d
RDF		45.2 ± 1.2c	6.9 ± 0.008c
RDFZn		51.0 ± 1.5b	8.8 ± 0.03b
RDFnZn		54.3 ± 1.4a	9.4 ± 0.02a
p-value		<0.0001	<0.0001
Interaction effect			
CS	**NM**		
Sole	Control	11.3 ± 0.8g	1.6 ± 0.02f
	RDF	42.5 ± 0.3e	6.8 ± 0.007d
	RDFZn	47.6 ± 0.6d	8.1 ± 0.01c
	RDFnZn	51.2 ± 0.7c	9.0 ± 0.01b
Oat + berseem	Control	20.9 ± 0.4f	3.0 ± 0.01e
	RDF	47.8 ± 0.7d	7.0 ± 0.01d
	RDFZn	54.4 ± 0.3b	9.5 ± 0.01ab
	RDFnZn	57.3 ± 0.1a	9.9 ± 0.009a
p-value		<0.0001	<0.0001

†standard error of mean, ‡ different letters indicating significance

fodder, along with better availability and absorption of nutrients through nano zinc application, could have collectively led to higher fodder production in the intercropping system. This is a kind of first report on the effect of intercropping [oat-berseem intercropping (4:2)] and nano zinc application on weed population density and yield of oats in the Bundelkhand region.

The study revealed that oat + berseem intercropping and nano zinc application reduced the weed density and biomass most effectively and produced maximum green and dry fodder yields. Therefore, the intercropping of oat + berseem along with nano zinc application could be a promising management practice for optimum fodder production in water-scarce areas like Bundelkhand.

Acknowledgment

The authors are thankful to the Vice Chancellor, RLBCAU and Director, ICAR-IGFRI, Jhansi, for providing the necessary facilities and financial assistance for carrying out this study.

References

Ahmad, S., N.H. Mir and S.S. Bhat. 2021. Intercropping in almond orchards with grasses/legumes enhanced soil fertility and weed suppression in a temperate region. *Range Management and Agroforestry* 42: 30-37.

Al Jabri, H., M. H. Saleem, M. Rizwan, I. Hussain, K. Usman and M. Alsafran. 2022. Zinc oxide nanoparticles and their biosynthesis: overview. *Life* 12: 594-622.

Chaudhary, M., K. K. Dwivedi, R. P. Sah, R. Gajghate, S. Ahmed and K. K. Singh. 2021. Zinc biofortification of fodder oat (*Avena sativa* L.) through bioinoculant and synthetic fertilizers. *Range Management and Agroforestry* 42: 181-185.

Gomez, K. A. and A. A. Gomez. 1984. *Statistical Procedures for Agricultural Research*. John Wiley & Sons. New York, USA.

Government of India (GoI). 2019. Share of Agriculture and Livestock Sector in GDP. https://www.nddb.coop/information/stats/GDPcontrib (accessed on 12 July, 2021).

Hedayetullah, M. and P. Zaman. 2022. *Forage Crops of the World, Volume I: Major Forage Crops; Volume II: Minor Forage Crops*. CRC Press, Waretown, USA.

Iqbal, A., M. A. Iqbal, I. Hussain, M. H. Siddiqui, M. Nasir, J. Ahmad and Y. Ali. 2018. Seed blending of oat (*Avena sativa* L.) and canola (*Brassica napus* L.) under variable seed proportions enhanced forage productivity and nutritional quality. *Pakistan Journal of Botany* 50: 1985-1990.

Kumar, B., S. Karmakar, D. K. Choudhary and P. Mahapatra. 2015. Weed control in forage oat through conservation agriculture. *Indian Journal of Weed Science* 47: 117-120.

Kumar, S. and S. A. Faruqui. 2010. Augmentation of seed production of forage cowpea in different regions of India: Influence of cultivars and crop geometry. *Range Management and Agroforestry* 31: 116-119.

Kumar, S., P. Singh, U. Devi, K.R. Yathish, P. L. Saujanya, R. Kumar and S.K. Mahanta. 2023. An overview of the current fodder scenario and the potential for improving fodder productivity through genetic interventions in India. *Animal Nutrition and Feed Technology* 23: 631-644.

Kumawat, S. M., S. R. Kantwa, D. H. Desai, M. Arif and V. Khinchi. 2017. Responses of dual-purpose oats (*Avena sativa* L.) to sowing date, method and level of zinc with or without thiourea in irrigated arid ecosystem. *Range Management and Agroforestry* 38: 215-220.

Mir, N. H., S. Ahmad, D. K. Verma, G. Zaffar and A. U. Haq. 2018. Fodder yield and quality evaluation of some oat (*Avena sativa* L.) varieties in temperate conditions of Kashmir, India. *Range Management and Agroforestry* 39: 232-236.

Mukherjee, P. K., P. Singh, S. Sondhia and R. L. Sagar. 2019. Biology of weed flora, weed dynamics, and weed management in different fodder crops. *Indian Journal of Weed Science* 51: 54-61.

Qureshi, A., D. K. Singh and S. Dwivedi. 2018. Nano-fertilizers: a novel way for enhancing nutrient use efficiency and crop productivity. *International Journal of Current Microbiology and Applied Sciences* 7: 3325-3335.

Roy, A. K., R. K. Agrawal, N. R. Bhardwaj, A. K. Mishra and S. K. Mahanta. 2019. Indian fodder scenario: redefining state wise status. In: A. K. Roy, R. K. Agrawal, N. R. Bhardwaj (eds). *Revisiting National Forage Demand and Availability Scenario*. ICAR-IGFRI, Jhansi. pp. 1-21.

Tondey, M., A. Kalia, A. Singh, G. S. Dheri, M. S. Taggar, E. Nepovimova, O. Krejcar and K. Kuca. 2021. Seed priming and coating by nano-scale zinc oxide particles improved vegetative growth, yield and quality of fodder maize (*Zea mays*). *Agronomy* 11: 729-745.

Umair H. M., M. Aamer, M. Umer Chattha, T. Haiying, B. Shahzad, L. Barbanti, M. Nawaz, A. Rasheed, A. Afzal, Y. Liu and H. Guoqin. 2020. The critical role of zinc in plants facing the drought stress. *Agriculture* 10: 396-416.

Yasari-Al, B. A. A. and M. N. H. Al-Yasari. 2022. Response of peanut to weed control management and nano-zinc foliar application in growth, yield, and quality traits. *SABRAO Journal of Breeding and Genetics* 54: 1191-1201.