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EFFECT OF DIFFERENT PHOSPHORUS AND ZINC LEVELS ON YIELD AND QUALITY OF FORAGE SORGHUM

BHANUPRAKASH N.[1], J. S. YADAV[2], ANIL KUMAR[3], SATPAL[4], AKSHIT[1]* AND SURBHI[5]

[1]Department of Agronomy, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India
[2]Regional Research Station, Bawal, CCS Haryana Agricultural University
[3]Bajra Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India
[4]Forage Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India
[5]College of Agriculture, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India
(e-mail : akshitrathore43@gmail.com)

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SUMMARY

A field experiment was carried out at RRS, Bawal (Haryana), India to evaluate the phosphorus and zinc fertilization effect on yield and quality of forage sorghum (*Sorghum bicolor* L.) during *Kharif,* 2018 with variety HJ 541, experiment was laid out in split plot design. Treatments comprised of four phosphorus levels in main plot *i.e.* Control, 7.5 kg P_2O_5/ha, 15 kg P_2O_5/ha and 22.5 kg P_2O_5/ha and four zinc levels in sub plot *viz.* Control, 0.50 % foliar spray of $ZnSO_4$ at 20-25 DAS, 0.75 % foliar spray of $ZnSO_4$ at 20-25 DAS and 25 kg $ZnSO_4$/ha as basal dose. It was observed that significantly higher plant height and number of tillers/meter row length were recorded with application of 22.5 kg P_2O_5 $ha^{-1}$and 25 kg @ $ZnSO_4$/ha at 20, 40 and 60 DAS over comtrol. Further, the green and dry fodder yield of sorghum was significantly influenced by different levels of phosphorus. Application of 22.5 kg P_2O_5 ha^{-1} recorded significantly higher the green and dry fodder yield over 7.5 kg P_2O_5/ha, 15 kg P_2O_5/ha and control treatments. The basal application of $ZnSO_4$ @ 25 kg/ha recorded significantly higher green and dry fodder yield of forage sorghum over foliar applications of $ZnSO_4$ @ 0.50 %, 0.75 % and control. Crude protein content of forage sorghum was improved progressively with increasing levels of phosphorus and zinc.

Key words : Forage sorghum, phosphorus, zinc, green fodder and dry fodder

Livestock is an integral part in agriculture sector and it plays a vital role in Indian rural economy. Adequate feeding and balanced nutrition to livestock is the strategic factor for improved animal production on sustainable basis. The substantial livestock pressure on the limited land resources in the country demands for increasing the fodder production. Sorghum (*Sorghum bicolor* L.) is an important fodder crop after maize in C_4 type plants and it is a good feed source that can be grazed, cut down as fresh, made into hay or ensiled. Growing of fodder sorghum can double livestock milk production than those stuck to low yielding and disease susceptible napier grass. India accounts for 535.78 million livestock population which is highest in world as per 20th livestock census (Anonymous, 2019). Though, India accounts among highest cattle population country, but productivity of livestock is low here because of the poor feeding sources which has been identified as one of the major components in achieving the desired potential (Satpal *et al.,* 2015). There is tremendous pressure on the availability of feed and fodder for the livestock in current scenario. Primary nutrients (N, P and K) play an important role in the growth and development of sorghum (Satpal *et al.,* 2020). Further management of primary and secondary and micro nutrients can be an aspect to work out with for achieving the optimum fodder production in a sustainable manner, like application of phosphorus and zinc in sorghum has the potential to increase the fodder yield, as most of soil in Haryana are medium to low in their availability.

Phosphorus (P) is one of the essential elements that are necessary for plant development and growth and is second only to nitrogen among mineral nutrients most commonly limiting the growth of crops (Xie *et al*., 2019). Application of phosphorus fertilizer directly contributes to the quantity and quality of fodder production. Phosphorus is an integral part of nucleic acid and essential for cellular respiration and metabolic activity. It is involved in many enzymatic reaction,

CO_2 fixation, sugar metabolism, energy storage and transfer. Judicious use of phosphorus and it agronomic management will help in increasing per hectare yield (Ros *et al.*, 2020). Phosphorus application gradually increased plant height, stem diameter, number of leaves per plant, leaf area per plant and fodder yield (Khalid *et al.*, 2003). Zinc is an essential micronutrient and a cofactor for about more than 300 enzymes and involved in cell division, nucleic acid metabolism and protein synthesis. Cakmak (2000) has speculated that stress due to zinc deficiency may inhibit the activities of a number of antioxidant enzymes in plants, resulting in extensive oxidative damage to membrane lipids, chlorophyll and nucleic acids. Zinc has a major role in carbohydrate metabolism, and it is also a structural component of a large number of proteins, such as transcription factors and metalloenzymes at various levels (Figueiredo *et al.*, 2012). Further, zinc is required in the biosynthesis of tryptophan, a precursor of the auxin-indole-3-acetic acid (Oosterhuis *et al.*, 1991).

The deficiency of zinc in soil will lead to poor fodder yield and quality along with poor uptake of zinc. Since, zinc is also a major nutrient in animal nutrition; if we apply zinc at proper rate to soil the deficiency of zinc in animal can also be rectified. Zinc availability in soils and its absorption and translocation in plants is influenced by all other plant nutrients.

The development of crop production technologies is the master key to unlock the yield potential of crops. Fodder as a group of crop differs from food and commercial crops in several aspects, the principles and practices of their cultivation vary accordingly and one of the way among them is increase in yield through nutrient management. Keeping these views, the present study has been planned to evaluate the effect of phosphorus and zinc fertilization on yield and quality of fodder sorghum.

MATERIALS AND METHODS

The experiment was carried out at Regional Research station, Bawal, Chaudhary Charan Singh Haryana Agricultural University is situated in semi-arid, sub-tropics at 28.5° N latitude and 76.350° E longitude at an altitude of 266 meters above mean sea level. Bawal has a typical semi-arid climate with hot and dry summers and extremely cold winters. The meteorological data during the crop season *i.e kharif* 2018 has been depicted in Fig. 1. The soil of the Haryana is derived from Indo-Gangetic alluvium and

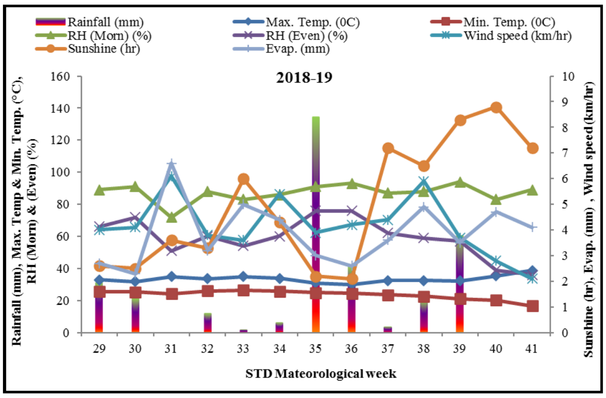

Fig. 1. Meteorological data during the crop season (*Kharif*-2018).

is sandy loam in texture. Four representative soil samples were taken from different places in the experimental field from 0- 30 cm depth before sowing of the crop. A composite sample was prepared and estimated for the physico-chemical properties of the soil of the experimental plot. It was analyzed from soil samples the soil of experimental field was sandy loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus, high in available potassium and medium in zinc.

The experiment was laid out in split plot design and treatments comprised of various sources of nutrients *i.e.* different levels of phosphorus and zinc, their combinations were tested in this study. Fertilizer application was made as per the treatment. Different doses of phosphorus and $ZnSO_4$ and half dose of nitrogen were applied at the time of sowing through urea, DAP and $ZnSO_4$ as a basal application. The remaining dose of nitrogen was top dressed at 30 DAS through urea fertilizer and also applied 0.50 % and 0.75 % of $ZnSO_4$ as foliar spray at 25 DAS. Single cut fodder sorghum variety HJ 541 was sown by *pora'* method with hand plough in rows 30 cm apart using a seed rate of 50 kg/ha.

The mean plant height was worked out for each treatment by taking height of five plants from ground level to the top of the main shoot from each plot at 20, 40, 60 DAS and at cutting of fodder sorghum. Number of tillers per running meter row length was recorded by counting the tillers from three randomly selected spots of one meter row in each plot at 20, 40, 60 DAS and at cutting stage in each experimental plot. These were averaged and expressed as number of tillers/meter row length. For recording green fodder yield, the crop was cutting at 85 DAS and then harvested fodder was weighed *in situ* in kg/ plot and then fodder yield was calculated in quintals per hectare (q/ha). To assess dry matter yield a random sample of 500 g green fodder was taken from each plot at the time of harvesting. These samples were first dried under the sunlight then in an electric oven at a temperature of 60-70^{0} C till constant weight was realized. On the moisture basis of these samples, the green fodder yield was calculated into dry matter yield (q/ha). Crude protein content (%) was calculated on the basis of nitrogen content in dry matter determined by calorimetric method (Linder, 1944), by the following formula:

Crude protein (%) = N (%) x 6.25

To find out HCN content 0.2 g of fresh sample of sorghum was weighed and transferred to test tube. Then took strips of filter paper (Whatman. No-4) is impregnate with alkaline picrate solution and placed these strips in test tube containing the sample. Added 3-4 drops of chloroform in the test tube and sealed immediately. Incubated these test tubes at 35-40°C for 24 hrs. Taken out strips placed in 50 ml beaker and added 20 ml of distilled water and mulch it with glass rod to extract color of strips. Centrifuged at 5000 rpm for 15-20 minutes take supernatant and read at 515 nm using spectrophotometer against blank. Standard HCN solutions were prepared using KCN as standard (Gilchrist *et al*, 1967). All the experimental data for various yield and quality parameters were statistically analyzed using OPSTAT software.

RESULTS AND DISCUSSION

Plant Height

A critical examination of data revealed that there was a progressive increase in plant height from 20 days after sowing (DAS) upto cutting of the crop. The significant difference was reported by the application of different phosphorus and zinc levels (Table 1). Application of 22.5 kg P_2O_5/ha resulted in significantly taller plants over all other treatments at all the stages of crop growth (35.77, 69.15, 139.02 and 185.53 cm at 20, 40 and 60 DAS and at cutting, respectively) followed by 15 kg P_2O_5/ha and lowest was recorded in control. Increased levels of phosphorus resulted in increased plant height and enhanced vegetative growth of plant. Increasing level of phosphorus significantly increased the plant height was also observed by Roy *et al.* (2015). Enhanced growth and fodder yields in sorghum due to P fertilization of current study was supported by findings of Satpal *et al.* (2017).

TABLE 1
Effect of phosphorus and zinc levels on periodical changes in plant height (cm) of fodder sorghum

Treatments	Plant height (cm)			
	20 DAS	40 DAS	60 DAS	At cutting
Phosphorous levels				
P_1- Control	27.93	59.09	125.66	169.93
P_2- 7.5 kg/ha	30.78	63.33	132.23	176.86
P_3- 15 kg/ha	33.55	67.23	136.21	182.89
P_4- 22.5 kg/ha	35.77	69.45	139.02	185.53
SEm ±	0.57	0.75	0.89	0.73
CD at 5%	1.83	2.02	2.57	2.23
Zinc levels				
Z_1- Control	29.11	61.04	128.01	172.68
Z_2- 0.50 % foliar $ZnSO_4$	31.14	64.28	133.92	178.93
Z_3- 0.75 % foliar $ZnSO_4$	32.68	65.4	135.01	180.13
Z_4- 25 kg basal $ZnSO_4$	34.69	68.18	137.75	182.48
SEm ±	0.28	0.52	0.65	0.59
CD at 5%	0.91	1.74	2.03	1.89

Soil application of $ZnSO_4$ @ 25 kg/ha recorded significantly higher plant height in fodder sorghum at all the growth stages of crop (34.69, 68.18, 137.75 and 182.48 cm at 20, 40, 60 DAS and at cutting, respectively) over foliar applications of $ZnSO_4$ @ 0.50 %, 0.75 % and control whereas, foliar treatments remained at par with each other at 40, 60 DAS and at cutting stage, respectively (Table 1).

Number of tillers per meter row length

The data on number of tillers meter row length as influenced by different levels of phosphorus and zinc are presented in Table 2. The effect of treatments on number of tillers meter row/length was revealed that application of phosphorus @ 22.5 kg P_2O_5/ha resulted in significantly higher tillers meter row length over all other treatments at 20, 40 and 60 DAS (9.52, 10.11 and 10.29, respectively) but found non-significant at cutting stage of crop.

The application of $ZnSO_4$ @ 25 kg/ha as basal dose recorded significantly maximum number of tillers per meter row/length in fodder sorghum at 20, 40 and 60 DAS (9.28, 9.73 and 9.97, respectively) over foliar applications of $ZnSO_4$ @ 0.50 %, 0.75 % and control whereas, foliar treatments were found at par among themselves at 20, 40 and 60 DAS, respectively and it was found non-significant at cutting stage of crop. Increase in growth parameters was mainly due to

TABLE 2
Influence of phosphorus and zinc levels on periodical changes in number of tillers per meter row length of fodder sorghum

Treatments	Number of tillers/ meter row length			
	20 DAS	40 DAS	60 DAS	At cutting
Phosphorous levels				
P_1- Control	7.97	8.22	8.53	8.74
P_2- 7.5 kg/ha	8.53	9.01	9.32	9.53
P_3- 15 kg/ha	9.13	9.67	9.81	10.03
P_4- 22.5 kg/ha	9.52	10.11	10.29	10.37
SEm ±	0.08	0.1	0.12	0.14
CD at 5%	0.26	0.31	0.37	NS
Zinc levels				
Z_1- Control	8.32	8.74	8.95	9.16
Z_2- 0.50 % foliar $ZnSO_4$	8.59	9.19	9.45	9.51
Z_3- 0.75 % foliar $ZnSO_4$	8.65	9.31	9.61	9.86
Z_4- 25 kg basal $ZnSO_4$	9.28	9.73	9.97	10.14
SEm ±	0.04	0.06	0.08	0.16
CD at 5%	0.14	0.19	0.23	NS

higher uptake of zinc and involved in metabolic activities of plant which leads to higher photosynthetic efficiency of plant. Similar outcomes were also reported by Chaab *et al.* (2011).

Green fodder yield

The application of different phosphorus levels recorded significantly higher green fodder yield. Significantly higher green fodder yield (436.6 q/ha) was recorded by application of 22.5 kg P_2O_5/ha and it was followed by 15 kg P_2O_5/ha (421.1 q/ha) and lowest was recorded in control treatment (329.9 q/ha) as stated in Table 3. It might be due to beneficial effect of higher level of phosphorus on growth and development by way of increased root proliferation thus by increased uptake of nutrient and improving photosynthetic efficiency of fodder sorghum. The results of present investigation are in close agreement with the findings of Duhan (2013) and Roy *et al.* (2015).

The soil application of $ZnSO_4$ @ 25 kg/ha recorded significantly maximum green fodder yield of sorghum (408.1 q/ha) over foliar applications of $ZnSO_4$ @ 0.50 % (391.2 q/ha), 0.75 % (394.2 q/ha) and control (376.1 q/ha) whereas, foliar treatments remained at par with each other. Application of $ZnSO_4$ @ 25 kg/ha was found beneficial in increasing the yield attributing characters over foliar application treatments and control (Table 3). The positive response of higher zinc level on above yield attributes to overall progress in crop growth enable the plant to absorb more nutrients and moisture as it was evident from

TABLE 3
Effect of different phosphorus and zinc levels on green and dry fodder yield (q ha^{-1}) of fodder sorghum

Treatments	Green fodder yield (q ha^{-1})	Dry fodder yield (q ha^{-1})
Phosphorous levels		
P_1- Control	329.9	75.1
P_2- 7.5 kg ha^{-1}	382.0	85.7
P_3- 15 kg ha^{-1}	421.1	92.1
P_4- 22.5 kg ha^{-1}	436.6	95.2
SEm ±	2.29	0.64
CD at 5%	10.49	2.24
Zinc levels		
Z_1- Control	376.1	83.2
Z_2- 0.50 % foliar $ZnSO_4$	391.2	86.1
Z_3- 0.75 % foliar $ZnSO_4$	394.2	86.7
Z_4- 25 kg basal $ZnSO_4$	408.1	92.1
SEm ±	2.46	0.73
CD at 5%	7.24	2.15

the enhanced uptake of nutrients by fodder sorghum which ultimately leads to more vegetative growth. Similar findings were also reported by Sutaria *et al.* (2013), Kumar *et al.* (2016), Choudhary *et al.* (2017) and Khinchi *et al.* (2017).

Dry fodder yield

The data presented in Table 3. Revealed that dry fodder yield of sorghum significantly increased with the application of different levels phosphorus and zinc over control. Significantly higher dry fodder yield (95.2 q/ha) was recorded by the application of 22.5 kg P_2O_5/ha followed by 15 kg P_2O_5/ha (92.1 q/ ha) and lowest was recorded in control (75.1 q/ha). Basal application of $ZnSO_4$ @ 25 kg/ha recorded significantly higher dry fodder yield of sorghum (92.1 q/ha) over foliar applications of $ZnSO_4$ @ 0.50 % (86.1 q/ha), 0.75 % (86.7 q/ha) and control (83.2 q/ ha) whereas, foliar treatments remained at par with each other.

HCN content

HCN content (ppm) of fodder sorghum increased significantly with the application of different levels of phosphorus fertilizer over control. Application of phosphorus 22.5 kg P_2O_5/ha recorded in significant HCN content (ppm) than other treatments at 40, 60, 75 DAS and at cutting stage of fodder sorghum (105.66, 49.87, 19.86 and 8.34 ppm. However, it was

TABLE 4
Periodical changes in HCN content of fodder sorghum as affected by phosphorus and zinc levels

Treatments	HCN content (ppm)				Crude protein (%)
	45 DAS	60 DAS	75 DAS	At cutting	
Phosphorous levels					
P_1- Control	93.01	42.83	13.93	6.13	7.23
P_2- 7.5 kg/ha	98.89	46.06	17.08	7.09	7.61
P_3- 15 kg/ha	102.35	48.15	18.36	7.68	7.86
P_4- 22.5 kg/ha	105.66	49.87	19.86	8.34	8.08
SEm ±	1.01	0.42	0.37	0.17	0.10
CD at 5%	3.09	1.29	1.09	0.48	0.37
Zinc levels					
Z_1- Control	97.76	45.41	16.79	6.77	7.52
Z_2- 0.50 % foliar $ZnSO_4$	98.81	45.97	17.43	6.91	7.63
Z_3- 0.75 % foliar $ZnSO_4$	98.93	46.31	17.78	7.12	7.76
Z_4- 25 kg basal $ZnSO_4$	99.01	46.35	17.92	7.23	7.88
SEm ±	0.73	0.38	0.33	0.14	0.08
CD at 5%	NS	NS	NS	NS	0.22

below critical limit (200 ppm). Similar results were reported by Satpal *et al*., (2018). The application of $ZnSO_4$ 25 kg/ha and foliar treatments found non-significant in HCN content (ppm) of fodder sorghum at all growth stages (Table 4). These results confirm the findings of Chaudhary *et al.,* (2018). The HCN content at different growth stages of forage sorghum at various levels of phosphorus and zinc are depicted in Fig. 3 & 4, respectively.

Crude protein content

Crude protein content (%) of fodder sorghum increased with the application of various levels of phosphorus and zinc fertilizers over control. The higher crude protein content of fodder sorghum (%) was recorded with the application of 22.5 kg P_2O_5/ha (8.08%) and it was followed 15 kg P_2O_5/ha (7.86 %) and lowest was recorded in control (7.23%). The soil application of $ZnSO_4$ 25 @ kg/ha recorded higher crude protein content (7.88%) in fodder sorghum over foliar application of $ZnSO_4$ @ 0.50% (7.63%), 0.75% (7.76%) and control whereas; foliar treatments were found at par with each other. The lowest crude protein content (7.52%) was recorded in control (Table 4).

This increase in protein content with application is attributed mainly due to increment in N content in fodder which enhanced the amino acid content with the increasing level of phosphorus and zinc. The results of present investigation are in close agreement with the findings of Rashid and Iqbal (2011).

CONCLUSION

The green and dry fodder yield of sorghum was significantly influenced by different levels of phosphorus. From the study, it has been concluded that application of 22.5 kg P_2O_5/ha recorded significantly higher fodder yield over the lower doses of phosphorus. With respect to zinc, application of

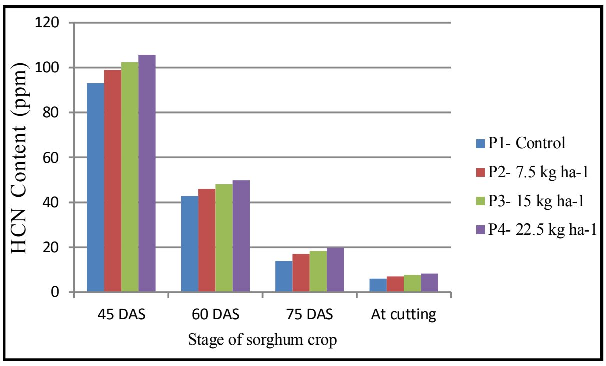

Fig. 2. Effect of Phosphorus dose on HCN content.

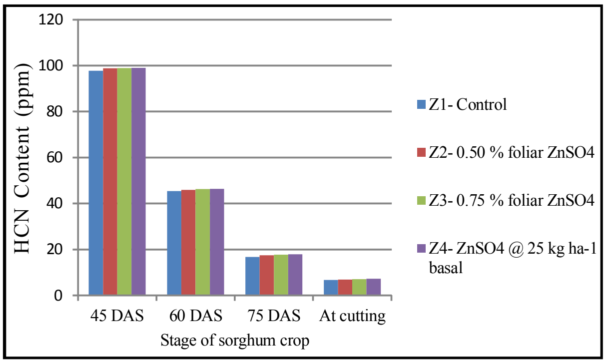

Fig. 3. Effect of Zinc dose on HCN content.

$ZnSO_4$ @ 25 kg/ha recorded significantly higher fodder yield of sorghum over foliar application of $ZnSO_4$ 0.5%, 0.75% and control; whereas, foliar treatments were at par with each other. Furthermore, application of 22.5 kg P_2O_5/ha and $ZnSO_4$ 25 kg/ha significantly improved the crude protein.

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