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Response of Finger Millet to Inorganic Fertilizers under Dolakha Condition of Nepal

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ABSTRACT

A field experiment was carried out during 2020, 2021 and 2022 to study the response of finger millet on fertilizer doses at Hill Crops Research Program, Kabre, Dolakha. The field experiment consists of seven fertilizer treatments with different nutrient combination doses, replicated thrice and laid out in randomized complete block design. The tested variety was Kabre Kodo-2. Seven fertilizer treatments were 5 t FYM /ha (farmers practice), 30:30:30 N:P_2O_5:K_2O kg/ha, 30:60:30 N:P_2O_5:K_2O kg/ha, 60:30:30 N:P_2O_5:K_2O kg/ha, 60:60:30 N:P_2O_5:K_2O kg/ha, 90:30:30 N:P_2O_5:K_2O kg/ha and 90:60:30 N:P_2O_5:K_2O kg/ha, respectively. The results of the experiment showed that grain yield, stover yield and number of heads/m^2were significantly affected by fertilizer doses ($p<0.05$). Kabre Kodo-2 variety of finger millet produced the highest grain yield (4.98 t/ha) and straw yield (8.27 t/ha) with the application 90:60:30 N:P_2O_5:K_2O kg/ha and was at par with 60:30:30 N:P_2O_5:K_2O kg/ha, 90:30:30 N:P_2O_5:K_2O kg/ha and 60:60:30 N:P_2O_5:K_2O kg/ha. These results clearly indicated that 60:30:30 N:P_2O_5:K_2O kg/ha could be recommended for finger millet cultivation under Dolakha condition and in areas with similar soil types and ecology of Nepal.

Keywords: Fertilizer, Finger millet, Kabre Kodo-2, Yield

सारांश

कोदोमा मलखादको मात्राको प्रतिक्रिया अध्ययन गर्न पहाडीबाली अनुसन्धान कार्यक्रम, काब्रे, दोलखामा एक खेतबारीमा परिक्षण गरिएको थियो । उक्त खेतबारीमा गरिएको परिक्षणमा सातवटा मलखाद उपचारहरू समावेश थिए जसमा विभिन्न खाधतत्वहरुको मात्राको समिश्रण थिए र तीनवटा रेप्लिकेशनमा आर.सी बि.डी डिजाइनमा रेखांकन गरि परिक्षण संचालन गरिएको थियो । काब्रे कोदो-२ जातमा सन् २०२०, २०२१ र २०२२ मा परिक्षण संचालन गरिएको थियो । सातवटा मलखाद उपचारहरू: गोठेमल ५ टन/हे, ३०:३०:३० के.जी ना.फ.पो./हे, ३०:६०:३० के.जी ना.फ.पो./हे, ६०:३०:३० के.जी ना.फ.पो./हे, ६०:६०:३० के.जी ना.फ.पो./हे, ९०:३०:३० के.जी ना.फ.पो./हे, ९०:६०:३० के.जी ना.फ.पो./हे थिए । परिक्षणको नतिजाहरुले मलखादको मात्राले दाना उत्पादन, पराल उत्पादन र बाला प्रति प्लट लाई प्रत्यक्ष असर पारेको पाइयो । काब्रे कोदो २ ले ९०:६०:३० के.जी ना.फ.पो./हे मलखाद हाल्दा सबै भन्दा बढि उत्पादन (४.९८ टन/हे) दिएको पाइयो तर यो ६०:३०:३० के.जी ना.फ.पो./हे, ९०:३०:३० के.जी ना.फ.पो./हे, र ६०:६०:३० के.जी ना.फ.पो./हे सग खासै फरक पाइएन । यी नतिजाहरुले कोदो बालीलाई ६०:३०:३० के.जी ना.फ.पो./हे, मलखाद हाल्नको लागि सिफारिस गर्न उपयुक्त हुने निस्कर्षमा पुग्यायो ।

INTRODUCTION

Finger millet (*Eleusine coracana* (L.) Gaertn) is the fourth most important cereal crop in Nepal in terms of area and production after rice, maize and wheat. It plays an important role in the livelihood of mid

hills people. The area of cultivation of finger millet in Nepal was 227934 ha with a production of 310847 mt and the yield of 1.36 t/ha (MoALD 2024). Agro-ecologically most of the finger millet growing area lies under mid hill which accounts 77% of the total area of finger millet followed by mountain (20%) and very limited area in terai which covered only 3%. Among the seven provinces, Gandaki province has 33.2 % of Nepal's total finger millet coverage, followed by Koshi Province (26.7%), Bagmati province (22.6%), Karnali province (7.1%), Sudurpaschim province (5.9%), Lumbini province (3.9%) and Madhesh province (0.62%) (MoALD 2022). Out of the total area under millet cultivation, 85% is relayed with maize in Nepal (Karki et al 2014).

It is pre-dominantly grown under maize/millet relay system in mid-hills of western, central and eastern regions where as in the hilly areas of mid and far western region, it is grown as mono crop. It is very important in subsistence farming systems, where it is cultivated in marginal land without external inputs and provides a sustaining diet for rural people. People mainly consume it as thick porridge, pancakes and roasted thick breads. About one-fourth of the domestic production is utilized in beverage production (Ghimire et al 2017). Most of the imported finger millet are used in city and mainly for beverage production as its other food items are not popular in urban areas.

The productivity of finger millet in farmer's field is very low and one of the factors for low yield is associated with nutrient management. Location and variety specific nutrient management is necessary to harness production potential. There is very limited study on fertilizer response study in finger millet. Therefore, this study was carried out with the objective to know the fertilizer response by finger millet under loamy soil of Mid hill, Hill crops Research Program (HCRP), Kabre, Dolakha condition.

MATERIALS AND METHODS

Experimental site and climatic condition

A field experiment was conducted at Hill Crops Research Program, Baiteshwor-4, Kabre, Dolakha of Nepal during summer season of 2020, 2021 and 2022. Agro climatically, this location represents mid hill region of Nepal and characterized by warm temperate climate with moderate rainfall. Geographical sites are located at 86^0 9'E Longitude and 27^0 38'N Latitude. It lies with elevation of 1740 m above mean sea level. Initial experimental soil texture was sandy loam and soil pH was highly acidic (4.68±0.09), soil organic matter content 2.23±0.18% (low), total nitrogen (N) content 0.10%± 0.01% (low), available phosphorus (P_2O_5) content 82.03±7.54ppm (very high) and exchangeable potassium (K_2O) content 213.46±20.31ppm (high). The total nitrogen was determined by Kjeldhal distillation unit (Bremner and Mulvaney 1982), available phosphorus ($P_)$ by modified Olsen's method (Olsen et al 1954) by using spectrophotometer and available potassium(K) by ammonium acetate method (Jackson 1967). Organic matter was determined by Walkely and Black method (Walkely and Black 1934), pH (1:1 soil: water suspensions) by Beckman Glass Electrode pH meter (Jackson 1973) and soil texture by hydrometer method (Bouyoucos 1927). Based on many years data average annual rainfall was 2323 mm. Similarly, average minimum temperature was 7.0°C and average maximum temperature 27.5^0C. Generally, November and December fall under drought.

Experimental set up and cultural practices

The field experiment consists of seven fertilizer treatments, replicated thrice and laid out in randomized complete block design. The tested variety was Kabre Kodo-2 Seven organic and inorganic fertilizer treatments were 5 t FYM /ha, 30:30:30 N:P_2O_5:K_2O kg/ha, 30:60:30 N:P_2O_5:K_2O kg/ha, 60:30:30 N:P_2O_5:K_2O kg/ha, 60:60:30 N:P_2O_5:K_2O kg/ha, 90:30:30 N:P_2O_5:K_2O kg/ha and 90:60:30 N:P_2O_5:K_2O kg/ha. Among the organic and inorganic fertilizers, total dose of FYM, P and K were applied at transplanting time and half dose of N applied at transplanting time and remaining half dose applied after weeding at tillering stage. Seedlings were raised in nursery bed with ample dose of compost application. Thirty-five days old seedlings were transplanted with spacing of row to row 10 cm and plant to plant 10 cm. Weeding was done at tillering stage.

Observation, data recording and data analysis

Agronomic and morphological data such as plant height (cm), days to 50% heading, days to 75% maturity, heads number/m^2, finger no. per head, thousand grains weight (g), grain moisture content (%), grain yield (t/ha), and stover yield (t/ha) were recorded. Analysis of variance (ANOVA) was carried out to assess the treatments effects and mean comparisons among treatment means were estimated by the least significant difference (LSD) test at 5% levels of significance (Gomez and Gomez 1984).

RESULTS

Effect of organic and inorganic fertilizers on growth, yield attributes and disease severity

There was significant effect of organic and inorganic fertilizers doses on days to 50% heading during 2021 and 2022 and no significant effect during 2020 (**Table 1**). Increased P slightly shortened the heading days at low N fertilizer dose. The days to 75% maturity was not affected by the fertilizer application. The plant height was significantly affected by fertilizer treatments during 2020 but not during 2022 (**Table 2**). During 2020, the highest plant height was recorded on 90:30:30 N:P_2O_5:K_2O kg/ha treatment and was not significantly different from 90:60:30 N:P_2O_5:K_2O kg/ha, 60:30:30 N:P_2O_5:K_2O kg/ha and 60:60:30 N:P_2O_5:K_2O kg/ha. The shortest plant height was recorded on 5 t FYM/ha. Increased doses of N had significantly increased plant height.

Table 1. Effect of organic and inorganic fertilizers on phenology of finger millet at HCRP, Kabre, Dolakha during 2020 to 2022

Treatments	DTH				DTM			
	2020	2021	2022	Mean	2020	2021	2022	Mean
5 t FYM/ha	93	92	99	94.7	140	133	143.3	138.8
30:30:30 N:P_2O_5:K_2O/ha	94	90	99	94.4	137	134	143.3	138.2
30:60:30 N:P_2O:K_2O/ha	95	91	96	94.0	139	134	142.7	138.6
60:30:30 N:P_2O_5:K_2O /ha	94	91	99	94.7	140	135	142.7	139.1
60:60:30 N:P_2O_5:K_2O /ha	93	90	99	94.1	137	133	143	137.6
90:30:30 N:P_2O_5:K_2O /ha	93	90	96	93.0	139	133	143	138.2
90:60:30 N:P_2O_5:K_2O /ha	92	91	98	93.6	139	133	143	138.3
Grand Mean	93	91	98	94.0	139	133	143	138.3
P value	0.38	0.01	<0.01		0.28	0.3	0.74	0.5
LSD (0.05)		0.93	1.16					
CV(%)	1.38	0.6	1.0		0.82	1.0	0.6	

Note:DTH=Days to 50% heading, DTM=Days to 75% maturity, LSD=Least significant difference at 5% level, CV%=Coefficient of variance

Fertilizers application significantly influenced on numbers of heads /m^2 on both years (**Table 2**). The mean data showed that the highest no. heads were recorded in 90:60:40 N:P_2O_5:K_2O kg/ha and the lowest were recorded from 30:60:30 N:P_2O_5:K_2O kg/ha. Increased dose from 30 to 60 kg N/ha or 90 kg N/ha has significantly increased no. of heads/m^2. The thousands grain weight was not influenced by the fertilizer doses both years (**Table 3**). The Disease severity response was significantly affected by the fertilizer doses during 2020 and 2021 but not during 2022. Leaf blast score was significantly increased with increased N doses (90 kg N/ha) but neck blast was not affected.

Table 2. Effect of organic and inorganic fertilizers application on plant height and no. of heads of finger millet at HCRP, Kabre, Dolakha during 2020 to 2022

Treatments	Plant height (cm)			No. of heads/m2		
	2020	2022	Mean	2020	2022	Mean
5 t FYM/ha	80.9	82.2	81.6	135.7	161.0	148.4
30:30:30 N:P_2O_5:K_2O/ha	90.8	83.3	87.1	158.7	151.0	154.9
30:60:30 N:P_2O_5:K_2O/ha	88.2	81.7	85.0	145.0	149.7	147.4
60:30:30 N:P_2O_5:K_2O /ha	93.0	75.3	84.2	152.0	171.0	161.5
60:60:30 N:P_2O_5:K_2O /ha	91.5	87.3	89.4	186.3	162.0	174.2
90:30:30 N:P_2O_5:K_2O /ha	94.5	83.7	89.1	162.3	163.0	162.7
90:60:30 N:P_2O_5:K_2O /ha	94.0	89.3	91.7	165.0	171.0	168.0
Grand Mean	90.5	83.2	86.9	157.9	161.2	159.6
P value	0.006	0.79		0.012	0.04	
LSD (0.05)	6.25			33.4	11.3	
CV (%)	3.9	13.1		11.9	5.5	

Note: LSD=Least significant difference at 5% level, CV%=Coefficient of variance

Table 3. Effect of organic and inorganic fertilizers application on thousand grains weight, leaf blast and neck blast on finger millet at HCRP, Kabre, Dolakha during 2020 to 2022

Treatments	TGW (g)			Leaf blast (1-5)				Neck blast (1-5)		
	2020	2022	Mean	2020	2021	2022	Mean	2021	2022	Mean
5 t FYM/ha	3.98	3.00	3.49	2.0	2.5	2.8	2.4	2.3	2.5	2.4
30:30:30 N:P_2O_5:K_2O/ha	4.00	2.67	3.34	2.7	2.8	2.5	2.7	2.2	2.5	2.4
30:60:30 N:P_2O_5:K_2O/ha	4.23	3.00	3.62	2.0	2.8	2.5	2.4	2.2	2.2	2.2
60:30:30 N:P_2O_5:K_2O /ha	4.15	3.00	3.58	3.3	2.8	2.3	2.8	2.5	2.3	2.4
60:60:30 N:P_2O_5:K_2O /ha	3.75	3.00	3.38	2.7	3.3	2.3	2.8	2.2	2.2	2.2
90:30:30 N:P_2O_5:K_2O /ha	3.85	3.67	3.76	3.3	3.3	2.2	2.9	2.2	2.0	2.1
90:60:30 N:P_2O_5:K_2O /ha	4.17	3.00	3.59	3.3	3.2	2.2	2.9	2.3	2.0	2.2
Grand Mean	4.02	3.05	3.54	2.8	3.0	2.4	2.7	2.3	2.2	2.3
P value	0.58	0.80		0.006	0.02	0.64		0.33	0.7	
LSD (0.05)				0.79	0.47					
CV (%)	8.5	24.50		16.1	8.9	19.9		8.8	20.6	

Note: TGW= Thousand grains weight, g=gram, LSD=Least significant difference at 5% level, CV%=Coefficient of variance

Effect of organic and inorganic fertilizers on grain and stover yield

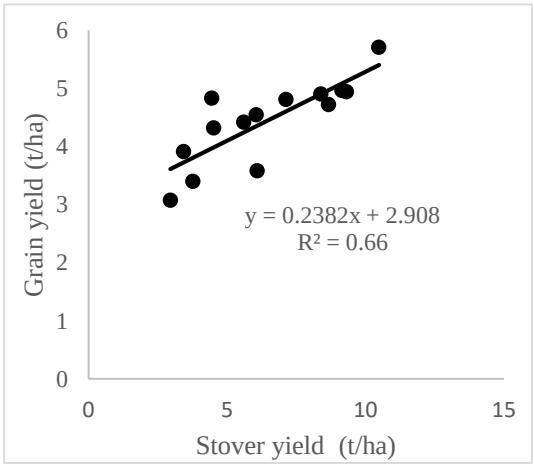
The highest mean grain yield (4.99 t/ha) was obtained from 90:60:30 N:P_2O_5:K_2O kg/ha and was not significantly different from 90:30:30 N:P_2O_5:K_2O kg/ha, 60:30:30 N:P_2O_5:K_2O kg/ha and 60:60:30 N:P_2O_5:K_2O kg/ha treatment (**Table 4**). Kabre Kodo 2 variety of finger millet significantly increased grain yield up to 60 kg N/ha. The lowest grain yield was obtained from 5 t FYM/ha. Similarly, fertilizer doses significantly influenced on stover yield of finger millet. The highest mean stover yield was obtained from 90:60:30 N:P_2O_5:K_2O kg/ha followed by 90:30:30 N:P_2O_5:K_2O kg/ha. Increased nitrogen dose (90 kg N/ha) had significantly increased stover yield. There was positive correlation on plant height and stover yield,

grain yield and stover yield, thousand grains weight and grain yield, grain yield and no. of heads/m^2 and thousand grains weight (**Figure 1**).

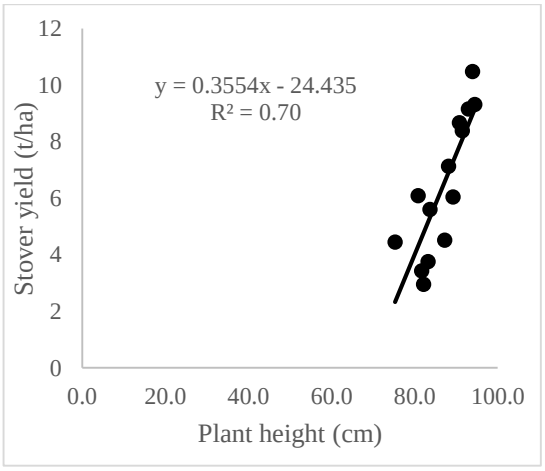
Table 4. Effect of fertilizers application on grain yield and stover yield of finger millet at HCRP, Kabre, Dolakha during 2020 to 2022

Treatments	Grain yield (t/ha)				Stover yield (t/ha)		
	2020	2021	2022	Mean	2020	2022	Mean
FYM 5 t/ha	3.586	3.00	3.074	3.220	6.094	2.955	4.525
30:30:30 N:P_2O_5:K_2O/ha	4.722	4.37	3.401	4.164	8.675	3.764	6.220
30:60:30 N:$P_2O_5K_2O$/ha	4.814	3.50	3.913	4.076	7.133	3.428	5.281
60:30:30 NP_2O_5:K_2O/ha	4.964	5.10	4.835	4.966	9.155	4.450	6.803
60:60:30 N:P_2O_5:K_2O/ha	4.906	4.85	4.32	4.692	8.394	4.522	6.458
90:30:30 N:P_2O_5:K_2O/ha	4.944	5.20	4.422	4.855	9.322	5.602	7.462
90:60:30 N:P_2O_5:K_2O/ha	5.711	4.70	4.546	4.986	10.488	6.052	8.270
Grand Mean	4.806	4.40	4.073	4.426	8.466	4.396	6.431
P value	0.002	<0.05	0.003		0.002	0.006	
LSD (0.05)	0.729	0.88	1.08		1.707	1.47	
CV (%)	8.5	11.30	15		11.3	18.9	

LSD=Least significant difference at 5% level, CV%=Coefficient of variance



a)



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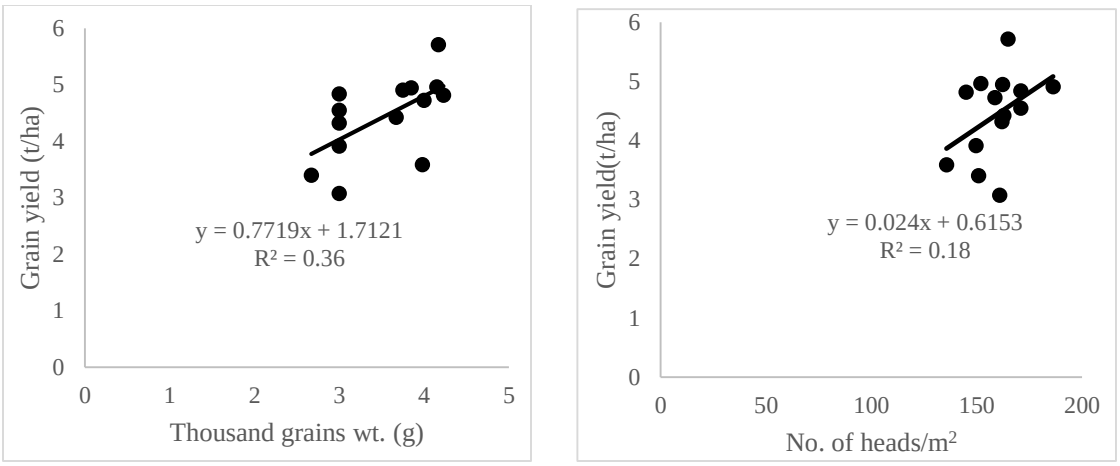

c) d)

Figure 1. Correlation among growth parameters, yield attributes of finger millet a) grain yield and stover yield b) plant height and stover yield c) thousand grains wt. and grain yield, no. of heads/m^2 and grain yield

DISCUSSIONS

Kabre Kodo-2 variety of finger millet significantly affected by organic and inorganic fertilizer doses on days to 50% heading during 2021 and 2022. Increased Phosphorus slightly shortened the heading days at low N fertilizer dose. This could be due to the high energy level supplemented by optimum P for reproduction which placed a high energy demand on the plant while delayed flowering due to low energy levels produced by the crops in the case of the control. This was in agreement with the findings of Panhawar and Othman (2011), who suggested that phosphorus promoted root growth, tillering in cereals, and earliness in flowering and performed important functions like metabolic activities in particular synthesis of protein.

Increased doses of N fertilizers had significantly increased plant height. The plant height at 90 kg N/ha was comparable with that of 60 kg N/ha and significantly superior over 30 kg N/ha. The possible reason might be that optimum nitrogen supply might have played essential role in plant growth and development. Nitrogen plays a significant role in increasing the plant height through cytokinin production which in turn affects cell wall elasticity, increase in number of meristematic cells and cell growth (Razaq et al 2017). Increased dose from 30 to 60 kg N/ha or 90 kg N/ha has significantly increased no. of heads/m^2. Increased N doses significantly increase plant growth and increased no. of tillers which lead increased no. of heads/m^2. Similar result was reported by Hari Prasanna (2016), in which nitrogen application increased the growth, dry matter production and yield under dry/rainfed conditions.

Kabre Kodo 2 variety of finger millet significantly increased grain yield up to 60 kg N/ha. Our finding was in line with Bekele et al (2016), who found that higher grain yield was obtained with application of N ranging from 0 to 90 kg/ha. The grain yield of finger millet is contributed by yield attributes such as the average number of heads per m^2, test weight, grain and straw weight per plot. Higher yield attributes under 90 kg N/ha level might be due to fulfillment of crop need with increased nitrogen levels. The higher value of growth and yield attributes under 90 kg N/ha reflected in significantly higher grain and straw yield. These results are in the line with those reported by Parshuramkar et al (2012).

Increased nitrogen dose (90 kg N/ha) had significantly increased stover yield.. These results corroborated with the findings of Camara et al (2003) and Anil Kumar et al (2003). The increased uptake at higher levels of N application helps in improvement in production of photosynthates due to sufficient assimilation of nutrients which in turn results in vigorous plant growth and synthesizes carbohydrates and translocate them

to the developing ear heads. This makes in better filling and more grain weight at increased levels of N application leading to increased yield attributes and grain yield (Krishna et al 2019). In addition, there was positive correlation on plant height and stover yield, no. of heads/m^2, thousand grains weight, stover yield and grain yield. Nitrogen stimulates tillering, might be due to its effect on cytokine synthesis. The increase in grain yield in response with increasing rate of nitrogen could be attributed to enhanced availability of the nutrient uptake by the plants and increased photo assimilate production that would eventually lead to improved partitioning of carbohydrate to the grains.

Grain yield is a complex character depending upon a large number of environmental, morphological and physiological characters. The highest grain yield of any crop is the result of all positive relationships of the yield components. Improvement in finger millet yield with fertilizer application can be attributed to the stimulating effects of nutrients on plant growth that provides ideal condition for crop as the fertilizer N supply to plants need, which ultimately increased the grain yield of crop.

CONCLUSION

Kabre Kodo-2 variety of finger millet produced the highest grain yield (4.98 t/ha) with the application of 90:60:30 N:P_2O_5:K_2O kg/ha and was at par with 60:30:30 N:P_2O_5:K_2O kg/ha, 90:30:30 N:P_2O_5:K_2O kg/ha and 60:60:30 N:P_2O_5:K_2O kg/ha. The results clearly indicated that 60:30:30 N: P_2O_5:K_2O kg/ha could be recommended for finger millet cultivation under Kabre condition and in areas with similar soil types and ecology of Nepal. Further research on different sources and doses of organic manures and different agroecology domains are recommended.

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