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ECONOMIC IMPACT OF MACRO AND MICRO-NUTRIENTS MANAGEMENT ON OKRA PRODUCTION

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ABSTRACT

Economic impact of macro and micro-nutrients management on okra yield was studied for two consecutive years (2009 and 2010). Three okra varieties (Bemisal, Sabz pari and Reshum) were tested against various application rates of NPK (0-0-0, 25-25-25, 50-25-25, 75-37-37, 100-50-50, 125-62-62 and 150-75-75 kg ha^{-1}), Zn and B (0-0, 10-1.5, 10-2.0, 15-1.5, 15-2.0, 20-1.5 and 20-2.0 kg ha^{-1}) under field conditions. The highest net income (Rs.174923.30 ha^{-1}) and subsequent benefit: cost ratio (1:1.70) were observed from the plots treated with NPK @ 125-62-62 kg ha^{-1}, while increase in NPK rate i.e upto 150-75-75 kg ha^{-1} did not prove economical with net income of Rs. 152546.09 and benefit: cost ratio of 1:1.40. That was possibly due to the adverse effect of excessive amout of NPK on fruit yield as well as increase in cost of production. The economic analysis of Zn and B application indicated that 20-2 kg ha^{-1} of Zn and B was more effective to produce higher yield and give highest net income of Rs.131986 ha^{-1}. Subsequent benefit cost ratio (1:1.48) was also large enough with 20-2.0 kg ha^{-1}. Decreasing Zn and B levels to 20-2 kg ha^{-1} slightly reduced the net income (Rs. 130290) but improved the benefit cost ratio (1:1.50). The study suggests that the crop may be fertilized with Zn and B @ 20-1.5 kg ha^{-1} in addition to application of recommended NPK fertilizers. The comparative economics of okra varieties under NPK levels showed that Sabz pari proved to be more NPK responsive, resulting overall average net returns of Rs. 127563 ha^{-1} with higher benefit: cost ratio of 1:1.41 than Bemisal and Reshum. Sabz pari was also found to be more responsive to Zn and B application with net returns of Rs. 134814 ha^{-1} (BCR 1:1.62), as compared to other okra varieties.

Keywords: Boron, cost benefit ratio, NPK, okra yield, Zn.

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Monech.) is adapted to a wide range of soils however, it thrives best in fertile soil with an adequate amount of organic matter (Tindall, 1983; Nonnecke, 1989). Among the factors associated with successful cultivation of okra, the appropriate nutrient application is vital. Nitrogen has been

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shown as an essential element and an important determinant in growth and development of plants. It plays a major role in chlorophyll, protein, nucleic acid, hormone and vitamin synthesis and also helps in cell division and cell elongation. Several research workers have reported linear increase in green pod yield of okra with the application of nitrogen from 56 to 150 kg ha^{-1} (Singh, 1995). Like nitrogen application phosphorus has also been found effective for fruit development in okra (Jam *et al*., 1990; Mohanta, 1998).

Among micronutrients, zinc (Zn^{2+}) and boron (B) play an important role in plant root development and higher crop yields. Severe Zn^{2+} deficiency may cause the crop failure; this deficiency is characterized by the development of broad bands of strip tissue on each side of the midrib of the leaf (Asad and Rafique, 2002). A Zn^{2+} deficient plant also appears to be stunted. Almost 50 percent of the world soils are Zn^{2+} deficient (Torun *et al.,* 2001); as a result, approximately 2 billion people suffer from Zn deficiency all over the world (Asad and Rafique, 2002). Similarly, boron is a non-metal micronutrient element, tourmaline, a complex borosilicate is the main boron-containing mineral found in most soils. Release of boron from this mineral is quite slow (Singh *et al.,* 2002). Boron availability decreases with increasing soil pH, thus it is often inadequately available in calcareous soils. Boron uptake by plants correlates extractable soil boron (Rashid, 1996). Boron is also associated with sugar translocation and its requirements vary greatly from crop to crop (Gunes and Alpaslan, 2000). The boron recommendations for soil applications are 1 to 2 kg for highly responsive crops and 0.5 to 1 kg per acre for medium responsive crops (Sayed, 1998). The experiments on the effect of nutrients management are conducted generally, but little work has been done on the impact of nutrients on some economic parameters of okra. Selvi *et al.* (2004) reported that higher net returns from okra were obtained under integrated nutrient management such as application of Zn^{2+} and B alongwith NPK fertilizers. The highest pod yield (20.67 tons ha^{-1}) was recorded for NPK + micronutrients. Kumar and Sen (2005) used Zn^{2+} at the rates of 10, 15, 30 and 45 kg ha^{-1} as $ZnSO_4$ and reported that all the treatments significantly increased the values of all parameters compared with the un-treated control. Zn applied at 30 kg ha^{-1} gave highest yield (14.20 q ha^{-1}) and net return (Rs. 50235 ha^{-1}) and B:C ratio (2.14). Present study was therefore conducted to examine the economic impact of macro- and micro-nutrients management on okra production.

MATERIALS AND METHODS

Two field experiments were conducted to investigate the effect of various application rates of macro and micronutrients on okra production. Both experiments were identical in nature. Expt.1 was conducted in 2009, whereas Expt. 2 was conducted in 2010. Land was prepared properly at required depth for better development and for equal distribution of irrigation and fertilizers. Pure seed of three okra varieties (Bemisal, Sabzpari and Reshum) was sown on ridges at the distance of 60 cm between rows and 30 cm between plants. In both experiments eight irrigations were applied i.e. first after 21 days of sowing and subsequent irrigations when felt necessary. The crop was kept weeds free by giving one hoeing with spade before the 1st irrigation and four hoeings with 3, 6, 9 and 12 weeks interval. Nitrogen was applied through urea during 1st, and 3rd irrigation by broadcasting methods. Phosphorus was applied through triple super phosphate (TSP), before sowing, while K^+ was applied thrugh sulphate of potash (SOP). The tender young pods were harvested on every alternate day.

Economic analysis

The revenue productivity was calculated by multiplying physical productivity with price. Benefit cost ratio was estimated.

RESULTS

Fruit yield (tons ha^{-1})

Fruit yield ha^{-1} of tested okra varieties was significantly ($P<0.05$) influenced by NPK, Zn and B application rates. The results (Table 1) indicated that the fruit yield harvested form variety Sabz pari (12.125 tons ha^{-1}) was markedly higher as compared to other two varieties i.e. Bemisal (11.108 tons ha^{-1}) and Reshum (10.555 tons ha^{-1}). The NPK application rates greatly influenced the okra yield ha^{-1}. The highest average fruit yield (15.424 tons ha^{-1}) was achieved from the plots receiving NPK @ 125-62-62 kg ha^{-1}, while fruit yield constantly decreased to 14.540, 13.687, 11.776, 9.109 and 7.894 tons ha^{-1} when NPK were applied @ 150-75-75, 100-50-50, 75-37-37, 50-25-25 and 25-25-25 kg ha^{-1}, respectively. The lowest okra fruit yield (6.409 tons ha^{-1}) was recorded from the control plots, where these macronutrients were not applied. In case of Zn and B application, the effect of different rates of these micronutrients on the fruit yield ha^{-1} was significant ($P<0.05$) and on an average, the maximum okra fruit yield (12.277 tons ha^{-1}) was harvested from the plots given @ 20-2.0 kg ha^{-1} Zn and B, while the okra fruit yield was decreased to 12.080, 11.584, 11.386, 11.019 and 10.595 tons ha^{-1} when the Zn and B were applied @ 20-1.5, 15-2.0, 15-1.5, 10-2.0 and 10-1.5 kg ha^{-1}, respectively. The lowest fruit yield (9.897 tons ha^{-1}) was obtained from the treatment plots where Zn and B were not incorportated. The interactive effect showed that highest okra fruit yield (16.685 tons ha^{-1}) was achieved from the interaction of variety Sabz pari × 125-62-62 kg NPK ha^{-1} and minimum (6.324 tons ha^{-1}) in interaction of variety Bemisal × 0 kg NPK ha^{-1} (control). In case of variety × Zn and B interaction, Sabz pari × 20-2.0 kg ha^{-1} resulted maximum fruit yield (13.206 tons ha^{-1}) and minimum (9.282 tons ha^{-1}) in interactions of variety Reshum × 0 kg ha^{-1} Zn and B. The interactive effect of NPK × Zn and B indicated that fruit yield was highest (16.819 tons ha^{-1}) under interaction of NPK @ 125-62-62 kg ha^{-1} × Zn and B @ 20-2.00 kg ha^{-1} and lowest (5.637 tons ha^{-1}) in interaction of 0 kg ha^{-1} Zn and B × 0 kg ha^{-1} NPK (control).

There was a straight effect of macronutrient application, but apart from the varieties, highest tested NPK application rate of 150-75-75 kg ha^{-1} showed adverse effects on fruit yield as compared to 125-62-62 kg ha^{-1}, which suggests that 125-62-62 kg ha^{-1} is an optimum rate for the tested okra varieties. Among varieties, Sabz pari showed peak performance with highest fruit yield under all circumstances as compared to rest of the tested varieties. Higher Zn and B level of 20-2.0 kg ha^{-1} showed its superiority to affect the fruit yield positively, but statistically the differences in fruit yield were non-significant (P>0.05), when compared with the performance under Zn and B @ 15-2.0 kg ha^{-1}, this suggest, that Zn and B @ 15-2.0 kg ha^{-1} is an optimum level for okra production. The effect of years on the fruit yield ha^{-1} of different okra varieties was examined and the results (Table 2) indicated that apart from the varieties, the average fruit yield ha^{-1} was higher during 2010 (11.371 tons ha^{-1}) as compared to the yield obtained in 2009 (11.148 tons ha^{-1}). Statistically, the differences in fruit yield ha^{-1} of okra were significant between years (P<0.05) and non-significant (P>0.05) for interaction of years and varieties.

Benefit cost ratio (BCR)

The economic impact of different NPK application rates on the net income and subsequent cost benefit ratio was assessed and the data (Table 3) indicated that highest net income (Rs.174923.30 ha^{-1}) and subsequent cost benefit ratio (1:1.70) was resulted by the okra crop when fertilized with NPK @ 125-62-62 kg ha^{-1}, while increasing NPK fertilizers upto 150-75-75 kg ha^{-1} did not prove economical with net income of Rs. 152546.09 and cost benefit ratio of 1:1.40, when compared with NPK level of 125-62-62 kg ha^{-1}. This was mainly happened due to adverse effect on fruit yield and increase production costs. Moreover, with decrease NPK rates, i.e. 100-50-50, 75-37-37, 50-25-25 and 25-25-25 kg ha^{-1}, the net incomes were also reduced to Rs. 149783.39, 121850.61, 79970.70 and 60007.22 ha^{-1}, respectively as compared to control (Rs.45213 ha^{-1}), while the subsequent cost benefit ratios were 1:1.55, 1:1.35, 1:0.95 and 1:0.73, respectively as compared to control (1:0.64). It was concluded that for obtaining economically efficient okra production, the crop may be fertilized with NPK level of 125-62-62 kg ha^{-1}.

Zn and B impact on BCR

The economic impact of different Zn and B application rates on the net income and subsequent cost benefit ratio was also examined and the data (Table 4) showed that highest net income (Rs.131986 ha^{-1}) and subsequent cost benefit ratio (1:1.48) was resulted by the okra crop when Zn and B were given @ 20-2.0 kg ha^{-1}, while decreasing Zn and B rates down to 20-1.5 kg ha^{-1} slightly reduced the net income (Rs. 130290) but improved the cost benefit ratio (1:1.50). This was mainly happened due to non-significant effect of highest Zn and B rates on fruit yield and increase costs on Zn and B. The decreasing Zn and B rates down to 15-2.0, 15-1.5, 10-2.0 and 10-1.5 kg ha^{-1} resulted in decreased net incomes i.e. Rs. 122212, 120498, 114742 and 108810 ha^{-1}, respectively as compared to control (Rs.106496 ha^{-1}), while the subsequent cost benefit ratios were 1:1.42, 1:1.43, 1:1.37 and 1:1.33, respectively as compared to control (1:1.49). It was concluded that for efficient okra cultivation and achieving economically high net returns and cost benefit ratio, the crop may be fertilized with Zn and B @ 20-1.5 kg ha^{-1} in addition to recommended rates of NPK fertilizers.

Table 1. Interactive effect of macro and micronutrients on fruit yield (tons ha^{-1}) of okra.

Varieties	NPK rates	Zn and B (kg ha^{-1})							
		0-0	10-1.5	10-2.0	15-1.5	15-2.0	20-1.5	20-2.0	Avg.
Bemisal	F1=0-0-0	5.562	5.952	6.173	6.395	6.507	6.785	6.897	6.324g
	F2= 25-25-25	6.855	7.335	7.610	7.882	8.022	8.362	8.498	7.795f
	F3= 50-25-25	7.905	8.458	8.775	9.070	9.252	9.647	9.802	8.987e
	F4= 75-37-37	10.193	10.905	11.315	11.725	11.925	12.437	12.640	11.591d
	F5= 100-50-50	11.877	12.708	13.183	13.606	13.897	14.409	14.727	13.487c
	F6= 125-62-62	13.387	14.322	14.858	15.393	15.662	16.330	16.598	15.221a
	F7= 150-75-75	12.618	13.502	14.008	14.510	14.765	15.395	15.647	14.349b
	Avg.	9.771d	10.455c	10.846c	11.226b	11.433b	11.909a	12.116a	11.108b
Sabz pari	F1=0-0-0	6.063	6.487	6.727	6.972	7.093	7.395	7.517	6.893g
	F2= 25-25-25	7.472	7.995	8.295	8.590	8.743	9.115	9.265	8.496f
	F3= 50-25-25	8.615	9.222	9.565	9.910	10.082	10.512	10.683	9.798e
	F4= 75-37-37	11.113	11.890	12.333	12.780	13.000	13.557	13.778	12.636d
	F5= 100-50-50	12.948	13.855	14.370	14.888	15.148	15.797	16.053	14.723c
	F6= 125-62-62	14.592	15.613	16.195	16.778	17.720	17.802	18.092	16.685a
	F7= 150-75-75	13.753	14.718	15.268	15.817	16.092	16.780	17.055	15.640b
	Avg.	10.651f	11.397e	11.822d	12.248c	12.554b	12.994a	13.206a	12.125a
Reshum	F1=0-0-0	5.285	5.653	5.865	6.077	6.180	6.447	6.552	6.008g
	F2= 25-25-25	6.512	6.967	7.228	7.488	7.620	7.945	8.073	7.405f
	F3= 50-25-25	7.510	8.035	8.337	8.635	8.787	9.162	9.312	8.540e
	F4= 75-37-37	9.685	10.363	10.752	11.137	11.330	11.815	12.010	11.013d
	F5= 100-50-50	11.282	12.073	12.525	12.978	13.202	13.767	13.992	12.831c
	F6= 125-62-62	12.715	13.607	14.115	14.623	14.875	15.515	15.768	14.460a
	F7= 150-75-75	11.988	12.825	13.307	13.785	14.025	14.625	14.863	13.631b
	Avg.	9.282e	9.932d	10.304c	10.675b	10.860b	11.325a	11.510a	10.555c
Mean	F1=0-0-0	5.637	6.031	6.255	6.481	6.593	6.876	6.988	6.409g
	F2= 25-25-25	6.916	7.432	7.711	7.987	8.128	8.474	8.612	7.894f
	F3= 50-25-25	8.010	8.572	8.892	9.212	9.373	9.773	9.932	9.109e
	F4= 75-37-37	10.331	11.053	11.667	11.881	12.085	12.603	12.809	11.776d
	F5= 100-50-50	12.036	12.879	13.359	13.842	14.082	14.684	14.924	13.687c
	F6= 125-62-62	13.564	14.514	15.056	15.598	15.869	16.549	16.819	15.424a
	F7= 150-75-75	12.787	13.682	14.194	14.704	14.961	15.600	15.855	14.540b
	Overall Avg.	9.897d	10.595c	11.019c	11.386b	11.584b	12.080a	12.277a	11.263

Factors	S.E.	F-Value	P-Value	LSD 0.05
Varieties(A)	0.0414	977.65	0.0000	0.1812***
NPK rates (B)	0.0632	8776.90	0.0000	0.2241***
Zn-B rates(C)	0.0632	470.55	0.0000	0.2241***
AxB	0.1095	13.35	0.0000	0.3150***
AxC	0.1095	0.76	0.6871	0.3150NS
BxC	0.1672	6.52	0.0000	0.4284NS

Table 2. Interactive effect of years and varieties on the fruit yield (tons ha^{-1}) of okra.

Varieties	Years			Mean
	2009		2010	
Bemisal	11.001		11.221	11.11 b
Sabz pari	11.991		12.25	12.12 a
Reshum	10.451		10.660	10.555 c
Mean	11.148 b		11.37 a	-
Factors	S.E.	F-Value	P-Value	LSD 0.05
Varieties(A)	0.0414	977.65	0.0000	0.1812***
Years(B)	0.0338	58.47	0.0000	0.1663***
AxB	0.0585	0.10	0.9043	0.2149NS

Table 3. Economic analysis of NPK fertilizers applied to okra.

NPK rates	Total costs (Rs.)	Fruit yield (kg ha^{-1})	Total Income (Rs ha^{-1})	Net Income (Rs ha^{-1})	BCR
F1=0-0-0	70149.00	6409.00	115362.00	45213.00	1:0.64
F2= 25-25-25	82084.78	7894.00	142092.00	60007.22	1:0.73
F3= 50-25-25	83991.30	9109.00	163962.00	79970.70	1:0.95
F4= 75-37-37	90117.39	11776.00	211968.00	121850.61	1:1.35
F5= 100-50-50	96582.61	13687.00	246366.00	149783.39	1:1.55
F6= 125-62-62	102708.70	15424.00	277632.00	174923.30	1:1.70
F7= 150-75-75	109173.91	14540.00	261720.00	152546.09	1:1.40

Table 4. Economic analysis of Zn and B application rates for okra.

Zn and B rates	Total costs (Rs.)	Fruit yield (kg ha^{-1})	Total Income (Rs ha^{-1})	Net Income (Rs ha^{-1})	BCR
0-0 kg ha^{-1}	71650.00	9897	178146	106496	1:1.49
10-1.5 kg ha^{-1}	81900.00	10595	190710	108810	1:1.33
10-2.0 kg ha^{-1}	83600.00	11019	198342	114742	1:1.37
15-1.5 kg ha^{-1}	84450.00	11386	204948	120498	1:1.43
15-2.0 kg ha^{-1}	86300.00	11584	208512	122212	1:1.42
20-1.5 kg ha^{-1}	87150.00	12080	217440	130290	1:1.50
20-2.0 kg ha^{-1}	89000.00	12277	220986	131986	1:1.48

Table 5. Economic analysis of okra varieties as affected by different NPK application rates.

Varieties	Total costs (Rs.)	Fruit yield (kg ha^{-1})	Total Income (Rs ha^{-1})	Net Income (Rs ha^{-1})	BCR
Bemisal	90687	11108	199944	109257	1:1.20
Sabz pari	90687	12125	218250	127563	1:1.41
Reshum	90687	10555	189990	99303	1:1.10

Table 6. Economic analysis of okra varieties as affected by Zn and B application rates.

Varieties	Total costs (Rs.)	Fruit yield (kg ha^{-1})	Total Income (Rs ha^{-1})	Net Income (Rs ha^{-1})	BCR
Bemisal	83436	11108	199944	116508	1:1.40
Sabz pari	83436	12125	218250	134814	1:1.62
Reshum	83436	10555	189990	106554	1:1.28

BCR of varieties under NPK impact

The comparative economic analysis of varieties fertilized with different NPK rates was performed and the data (Table 5) showed that Sabz pari proved to be more NPK responsive okra variety with overall average net returns of Rs. 127563 ha^{-1} and high cost benefit ratio of 1:1.41; variety Bemisal ranked second with net returns of Rs. 109257 ha^{-1} with cost benefit ratio of 1:1.20. However, okra variety Reshum ranked third with overall average net returns of Rs. 99303 ha^{-1} with cost: benefit ratio of 1:1.10. It was concluded that for obtaining high net returns and cost effective results in okra production, variety Sabz pari may preferably be cultivated.

BCR of varieties under Zn-B impact

The economic analysis of varieties supplied with various Zn and B rates was performed and the data (Table 6) indicated that okra variety Sabz pari showed more positive response to Zn-B application with overall average net returns of Rs. 134814 ha^{-1} with cost benefit ratio of 1:1.62; and variety Bemisal ranked second with net returns of Rs. 116508 ha^{-1} with cost benefit ratio of 1:1.40. However, okra variety Reshum ranked third with overall average net returns of Rs.106554 ha^{-1} with cost: benefit ratio of 1:1.28. It was concluded that for obtaining high net returns and cost effective results in okra production, variety Sabz pari may be given preference on varietal selection for commercial okra production.

DISCUSSION

The economic analysis of NPK application rates indicated that highest net income and subsequent cost benefit ratio was noted in crop fertilized with NPK @ 125-62-62 kg ha^{-1}, while increasing NPK fertilizers upto 150-75-75 kg ha^{-1} did not prove economical when compared with NPK rates of 125-62-62 kg ha^{-1}. This was mainly happened due to adverse effect on fruit yield and increase in production costs. Hence, for obtaining economically efficient okra production, the crop would require NPK @125-62-62 kg ha^{-1}.The economic impact of Zn and B levels showed that highest net income and subsequent cost benefit ratio was resulted by the okra given Zn and B @ 20-2.0 kg ha^{-1}, while decreasing Zn and B rates to 20-1.5 kg ha^{-1} slightly reduced the net income but improved the cost benefit ratio. For efficient okra cultivation and achieving economically high net returns and cost benefit ratio, the crop may be fertilized with Zn and B rates of 20-1.5 kg ha^{-1} in addition to recommended NPK fertilizers. These results coincide with those of Selvi *et al.* (2004) who reported that higher net returns in okra were obtained under integrated nutrient management such as application of Zn and B alongwith recommended rates of NPK fertilizers. Babatola *et al.* (2002) reported that increasing NPK rate of fertilizer has positive effect on growth and yield parameters of okra crop. Dademal *et al.* (2004) indicate that the higher NPK fertilizer dose increased the uptake of N, P and K nutrients. Fruit yields and nutrient uptake of okra plants boosted substantially through the application of adequate quantities of NPK fertilizers (Kolawole *et al.,* 2008). Paliwal *et al*. (1999) indicated that nitrogen applied at the rates of 40, 80 and 120 kg N ha^{-1} enhanced the growth and fruit yield of okra significantly. Hooda *et al.* (1980) determined the effect of various nitrogen fertilizer rates on growth and yield of okra including 0, 150 and 300 kg N ha^{-1} and suggested that the fertilizer N significantly increase growth parameters. Singh *et al*. (2004) conducted a study on optimization rate of nitrogen, to achieve higher fruit yield of okra cv. Pusa Sawani under the semi-arid condition using N at the rates of 50, 100 and 150 kg ha^{-1}. Abbasi *et al*. (2005) who applied commercial micronutrients containing Zn and B, alone and in combination with recommended NP rates (170-85 kg ha^{-1}), to examine the growth and yield potential of okra crop.

The comparative economics of okra varieties under NPK rates showed that Sabz pari proved to be more NPK responsive resulting higher overall average net returns with high cost benefit ratio; while Bemisal ranked second in net returns as well as BCR; whereas Reshum ranked third in net returns and BCR. Okra variety Sabz pari also showed more positive response to Zn-B application as indicated from the net returns and BCR; followed by Bemisal and Reshum. For achieving high net returns and cost effective results in okra production, variety Sabz pari may be given preference on varietal selection for commercial okra production. Kumar and Sen (2005) who used Zn at the rates of 10, 15, 30 and 45 kg ha^{-1} as $ZnSO_4$ and reported that all the treatments significantly increased the values of all parameters compared to control. Zinc at 30 kg ha^{-1} recorded the highest yield (14.20 q ha^{-1}), net return (Rs. 50235 ha^{-1}) and B:C ratio (2.14). However, the variation in the economic traits may be associated with the overall soil status with the researchers being quoted above.

CONCLUSION

It is concluded that for efficient okra cultivation and achieving economically high net returns and cost benefit ratio, the crop should be fertilized with NPK @ 125-62-62 kg ha^{-1} and Zn-B @ 20-1.5 kg ha^{-1}. Application of NPK @ 150-75-75 kg ha^{-1} with Zn and B @ 20-2.0 kg ha^{-1} showed adverse effect on fruit yield and increased production costs. Regardless the nutrient application rates, okra variety Sabz pari proved to be more responsive to NPK and Zn-B application this for obtaining high net returns and cost effective results in okra production, variety Sabz pari should be given preference in selection.

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