

# Response Of Drumstick (*Moringa Spp.*) To Various Levels Of Nitrogen, Phosphorus And Potassium

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**Abstract**—An investigation entitled “Response of drumstick (*Moringa spp.*) towards various nitrogen, phosphorus and potassium levels” was carried out to standardize the fertilizer dose of drumstick at Vegetable Research Farm, Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India in late *Kharif* season. The experiment was laid out in Randomized Block Design with Factorial concept with total twelve treatment combinations involving three levels of nitrogen *i.e.* N<sub>1</sub> (50g per tree), N<sub>2</sub> (75g per tree) and N<sub>3</sub> (100g per tree); two levels of phosphorus *i.e.* P<sub>1</sub> (50g per tree) and P<sub>2</sub> (75g per tree) and potash in two levels *i.e.* K<sub>1</sub> (50g per tree) and K<sub>2</sub> (75g per tree) in PKM-1 variety. The application of 100:75:50g NPK per tree (T<sub>11</sub>) recorded with significantly superior results on growth parameters [fresh weight of plant (kg), dry weight of plant (kg), pod length (cm), pod circumference (cm) and pod weight (g)]; yield parameters [number of pod per tree, yield of pod per tree (kg) and yield of pod per hectare (t)] and soil parameters [available nitrogen after treatment (kg/ha) and available phosphorus after treatment (kg/ha)] as compared to the other treatments.

**Index Terms**—Drumstick, Fertilizers, Growth, Soil, Tree, Vegetable, Yield.

## I. INTRODUCTION:

Drumstick (*Moringa spp.*) is an underexploited crop of Moringaceae family which is grown for its nutrient rich tender but full grown pods, leaves and flowers which are used in culinary preparations. The fruits/pods are rich in vitamin C (120 mg/100g), carotene (110 mg), phosphorus (110 mg) and

minerals like magnesium (28 mg), potassium (259 mg), sulphur (137 mg), chlorine (423 mg) etc. The crop is grown in homesteads for family uses or cultivated commercially for market. Tender leaves and flowers are good source of vitamins and minerals and have great role for combating malnutrition of urban and rural masses. Certain *Moringa* types principally grown for its foliage are reported from West Indies. Drumstick root, bark and seed have many industrial uses, too. It has been established that drumstick is important underexploited crop among vegetable crops. Nowadays, this crop is grown commercially in the South Gujarat region for its fruits/pods. As it has very good ayurvedic properties and people use its leaves, flower and dry roots for well health. Naturally, it is grown well in the fields, road side, and corner of the farm or in kitchen garden. Nitrogen, phosphorus and potassium are three essential plant macronutrients, and are taken up by crops from soils in relatively large amounts. They are essential nutrients for crop and play an important role in several physiological processes in plant (Bidari and Hebsur, 2011). Thus, knowing the importance of crop for human health and to make the crop commercially exploited, it is necessary to determine the fertilizer requirement (g NPK/tree) for better growth and development of tree.

## II. MATERIAL AND METHODOLOGY

a) Technical programme:

With the objective of working out the optimum fertilizer dose, a field experiment on drumstick var.

PKM-1 was conducted at Vegetable Research Farm, Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India during late Kharif season. The experiment was laid out in Randomized Block Design with Factorial concept which having total twelve treatment combinations involving three levels of nitrogen i.e. N<sub>1</sub> (50g per tree), N<sub>2</sub> (75g per tree) and N<sub>3</sub> (100g per tree); two levels of phosphorus i.e. P<sub>1</sub> (50g per tree) and P<sub>2</sub> (75g per tree) and potash in two levels i.e. K<sub>1</sub> (50g per tree) and K<sub>2</sub> (75g per tree). The combination of treatments comprised of 50:50:50g NPK per tree (T<sub>1</sub>), 50:50:75g NPK per tree (T<sub>2</sub>), 50:75:50g NPK per tree (T<sub>3</sub>), 50:75:75g NPK per tree (T<sub>4</sub>), 75:50:50g NPK per tree (T<sub>5</sub>), 75:50:75g NPK per tree (T<sub>6</sub>), 75:75:50g NPK per tree (T<sub>7</sub>), 75:75:75g NPK per tree (T<sub>8</sub>), 100:50:50g NPK per tree (T<sub>9</sub>), 100:50:75g NPK per tree (T<sub>10</sub>), 100:75:50: g NPK per tree (T<sub>11</sub>) and 100:75:75g NPK per tree (T<sub>12</sub>) replicated thrice.

b) Experimental details:

Newly seedling planted at the spacing of 4.0 m × 2.0 m were selected for the investigation and total five plants were selected per treatment to record the observations. The plant protection measures were managed throughout the experiment as and when required. The pruning of trees was done at the intervals of six months after sowing and the height of tree *i.e.* 2.5-3.0 m was maintained.

c) Manure and fertilizer application:

The experimental soil was black and clayey with poor drainage condition. The application of fully decomposed Farm Yard Manure (8 kg/tree) enriched with *Azotobacter* + PSB + KMB (2 ml each) was applied at the time of pit preparation. Fertilizer application was given as per the treatments during all the years of experiment. Nitrogen was applied in the form of urea in four equal splits *viz.*, (1<sup>st</sup> at time of pit preparation along with phosphorus and potash, 2<sup>nd</sup> after 30 days after sowing, 3<sup>rd</sup> after six months along with phosphorus and potash and 4<sup>th</sup> after 30 days after third split).

d) Methodology of observations recorded:

The plant spread before and after pruning (m) at the middle of trunk and pod length (cm) were measured with the help of measure tap and measuring scale, respectively. Fresh weight (kg), dry weight (kg), pod weight (g) and pod yield per tree (kg) were recorded by weighing balance. Then, pod yield per hectare was obtained by converting the data of pod yield per tree. However, the pod circumference (cm) was noted with the help of digital vernier caliper (Absolute digematic caliper mitu Toyo Co. Japan) at the middle of the fruit/pod. The number of pods per tree was obtained by summing up the harvested pod numbers at each picking from five tagged plants. Available nitrogen content, phosphorus content and potash content in the soil, before and after the treatments were estimated by using standard procedures suggested by Association of Official analytical collaboration (A.O.A.C. 1995). Statistical analysis of the data pertaining to growth parameters, yield parameters, soil parameters and economics were analyzed as per the methods described by Panse and Sukhatme (1985).

III. RESULTS:

A. Growth parameters:

1) Plant spread before pruning (m)

The treatment effect was found to be non significant during all the years as well as in pooled analysis. The plant spread before pruning was noted from 1.94 m to 2.22 m in pooled analysis. The interaction effect of year × treatment was found non-significant.

The effect of various levels of nitrogen, phosphorus and potassium and their interaction on plant spread before and after pruning (m) of drumstick is presented in table 1.

2) Plant spread after pruning (m)

The treatments could not produce significant effect during all the years and in pooled analysis, too. The plant spread after pruning was recorded front 1.75 m to 1.95 m in pooled analysis. The interaction effect of year × treatment also could not produce significant result.

Table 1: Effect of various levels of nitrogen, phosphorus and potassium and their interaction on plant spread before and after pruning (m) of drumstick

TREATMENT		Before pruning (m)				After pruning (m)			
		2018	2019	2020	Pooled	2018	2019	2020	Pooled
T <sub>1</sub>	50:50:50g per tree	2.21	2.50	1.75	2.06	2.15	2.62	1.05	1.94
T <sub>2</sub>	50:50:75g per tree	2.26	2.22	1.79	2.10	2.20	2.30	0.91	1.81
T <sub>3</sub>	50:75:50g per tree	2.31	2.20	1.89	2.17	2.42	2.45	0.90	1.92
T <sub>4</sub>	50:75:75g per tree	2.39	2.42	1.88	2.22	2.32	2.41	1.12	1.95
T <sub>5</sub>	75:50:50g per tree	2.17	2.30	1.72	2.02	2.13	2.27	1.10	1.83
T <sub>6</sub>	75:50:75g per tree	2.27	2.38	1.81	2.11	2.26	2.31	1.06	1.87
T <sub>7</sub>	75:75:50g per tree	2.07	2.24	1.67	1.94	2.09	2.23	1.01	1.78
T <sub>8</sub>	75:75:75g per tree	2.12	2.27	1.70	1.98	2.13	2.25	1.08	1.82
T <sub>9</sub>	100:50:50g per tree	2.21	2.30	1.71	2.04	2.07	2.27	1.06	1.80
T <sub>10</sub>	100:50:75g per tree	2.36	2.35	1.81	2.18	2.15	2.38	1.11	1.88
T <sub>11</sub>	100:75:50g per tree	2.15	2.26	1.71	2.00	2.13	2.28	1.05	1.82
T <sub>12</sub>	100:75:75g per tree	2.07	2.19	1.67	1.94	2.11	2.25	0.89	1.75
S.Em.±		0.125	0.094	0.066	0.052	0.098	0.104	0.055	0.048
CD at 5%		NS	NS	NS	0.15	NS	NS	NS	NS
Y × T									
S.Em.±					0.0102				0.083
CD at 5%					NS				NS
CV%		9.78	7.07	6.48	7.48	7.78	7.73	9.31	7.74

3) Fresh weight of plant (kg)

The treatment effect was found significant during all the years as well as in pooled analysis. Maximum fresh weight of plant (42.02 kg) was recorded in T<sub>11</sub> in all three years of experiments and in pooled analysis, also which was on same bar with T<sub>6</sub>, T<sub>9</sub> T<sub>10</sub> in 2019 and 2020. While in pooled analysis, it was at par with T<sub>9</sub>. The interaction effect of year × treatment was found with non-significant result.

4) Dry weight of plant (kg)

The effect of treatments was able to produce significant effects during all the years as well as in pooled analysis. The maximum dry weight of plant (4.71 kg) was recorded in T<sub>12</sub> which was on same bar

with T<sub>4</sub>, T<sub>9</sub> and T<sub>11</sub>. The interaction effect of year × treatment was found to be non-significant.

The higher doze of fertilizer may have lead consequent availability of plant nutrients and attributed to increased plant height, spread and dry and fresh weight of plant/tree. Another fact is that, the application of NPK might have showed synergetic effect by accelerating the synthesis of chlorophyll and amino acids which are associated with major plant processes (Dar *et al.*, 2010). This is in conformity with the findings of Venkadeswaran *et al.* (2014) in okra.

Data pertaining to the fresh weight and dry weight of plant (kg) are significantly influenced by different levels of nitrogen, phosphorus and potassium and their interaction is depicted in table 2.

Table 2: Effect of various levels of nitrogen, phosphorus and potassium and their interaction on fresh weight and dry weight of plant (kg) of drumstick

Treatment		Fresh weight of plant (kg)				Dry weight of plant (kg)			
		2018	2019	2020	Pooled	2018	2019	2020	Pooled
T <sub>1</sub>	50:50:50g per tree	33.59	33.56	33.63	33.59	3.11	2.77	2.71	2.86
T <sub>2</sub>	50:50:75g per tree	34.57	34.56	34.62	34.59	3.49	3.12	3.03	3.21
T <sub>3</sub>	50:75:50g per tree	38.49	37.99	37.26	37.92	3.85	3.51	3.35	3.57
T <sub>4</sub>	50:75:75g per tree	38.07	37.91	37.96	37.98	4.86	4.55	4.11	4.51
T <sub>5</sub>	75:50:50g per tree	38.21	37.77	37.52	37.83	3.82	3.49	3.25	3.52
T <sub>6</sub>	75:50:75g per tree	41.18	41.19	41.17	41.18	3.80	3.49	3.14	3.48

T <sub>7</sub>	75:75:50g per tree	39.80	39.53	39.59	39.64	3.57	3.24	3.01	3.27
T <sub>8</sub>	75:75:75g per tree	40.19	39.92	39.71	39.94	4.04	3.74	3.52	3.77
T <sub>9</sub>	100:50:50g per tree	41.42	41.59	41.93	41.65	4.56	4.26	3.93	4.25
T <sub>10</sub>	100:50:75g per tree	40.44	41.21	41.43	41.03	4.23	3.86	3.52	3.87
T <sub>11</sub>	100:75:50g per tree	41.95	41.92	42.20	42.02	4.53	4.19	3.56	4.09
T <sub>12</sub>	100:75:75g per tree	40.61	40.52	40.52	40.55	5.11	4.81	4.21	4.71
S.Em.±		1.190	1.328	1.301	0.594	0.279	0.200	0.217	0.115
CD at 5%		3.49	3.89	3.82	1.68	0.82	0.59	0.64	0.32
Y × T									
S.Em.±					1.029				0.1985
CD at 5%					NS				NS
CV%		5.28	5.90	5.78	4.57	11.86	9.25	10.90	9.15

### 5) Pod length (cm)

The treatments effect was found significant during all the year except in pooled analysis. Maximum pod length (53.38 cm) was noticed in T<sub>11</sub> which was at par with T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub> and T<sub>12</sub>. The interaction effect of year × treatment was not able to produce significant result.

### 6) Pod circumference (cm)

The treatments effect was recorded with significant results during all the years and in pooled analysis. Maximum pod circumference (1.26 cm) was noticed in T<sub>11</sub>, which was at par with T<sub>12</sub>. The interaction effect of year × treatment was found non-significant. The increase in pod length and pod circumference may be due to the increased nutrition to the pods with increase in levels of nitrogen and increased synthesis of chlorophyll and amino acids (Dzevelin, 1973). These results are in line with the findings of Rani *et al.* (2012) in pointed gourd and Shamima *et al.* (2013) in bitter gourd.

### 7) Pod weight (g)

The treatments effect on net weight of pod was found to be significant in all years as well as in pooled analysis. Maximum pod weight (42.02 g) was noted in T<sub>11</sub> which was on same bar with T<sub>6</sub>, T<sub>9</sub>, T<sub>10</sub> and T<sub>12</sub>. The interaction effect of year × treatment was not able to produce significant effect.

The optimum supply of nitrogen along with phosphorus and potassium might have accelerated synthesis of chlorophyll, amino acids, effective utilization of carbohydrates and other organic factors

contributed for the increased pod weight. These results are in conformity with the findings of Rani *et al.* (2012) in pointed gourd, Shamima *et al.* (2013) in bitter gourd and Das *et al.* (2015) in bottle gourd.

The data pertaining to the pod length (cm), pod circumference (cm) and pod weight (g) are presented numerically in the table 3.

### B. Yield Parameters:

#### 1) Number of pods per tree

The treatments effect on number of pod per tree was found to be significant in all three years of experiment and in pooled analysis. Maximum number of pods per tree (280.78) was noted with the treatment T<sub>12</sub> which was at par with T<sub>9</sub> and T<sub>11</sub>. The interaction effect of year × treatment was found to be non-significant.

The increase in number of pods per tree might be due to the increase in number of nodes on account of increased number of primary and secondary branches due to increased NPK levels. The higher number of branches and nodes per plant could be also attributed to the higher pod number. Moreover, increased balanced C:N ratio might have increased the synthesis of carbohydrates with ultimate improvement in yield and yield attributes *i.e.* number of pods per tree. Similar findings were reported by Yadav and Yadav (2010) in okra and Das *et al.* (2015) in bottle gourd.

The data pertaining to different yield parameters [number of pods per tree, pod yield per tree (kg) and pod yield per hectare (t)] are tabulated in table 4.

Table 3: Effect of various levels of nitrogen, phosphorus and potassium and their interaction on pod length (cm), pod circumference (cm) and pod weight (g) of drumstick

TREATMENT		Pod length (cm)				Pod weight (cm)				Pod weight (g)					
		2018	2019	2020	Pooled	2018	2019	2020	Pooled	2018	2019	2020	Pooled		
T <sub>1</sub>	50:50:50g per tree	39.96	40.03	39.20	39.73	1.03	1.02	1.02	1.03	33.59	33.56	33.63	33.59		
T <sub>2</sub>	50:50:75g per tree	40.86	40.96	40.37	40.73	1.05	1.05	1.04	1.05	34.57	64.56	34.62	34.59		
T <sub>3</sub>	50:75:50g per tree	40.06	40.33	39.91	40.10	1.00	0.99	0.99	0.99	38.49	37.99	37.26	37.92		
T <sub>4</sub>	50:75:75g per tree	42.58	42.93	42.58	42.70	1.11	1.10	1.09	1.10	38.07	37.91	37.96	37.98		
T <sub>5</sub>	75:50:50g per tree	43.83	44.81	44.94	44.53	1.01	1.00	1.00	1.00	38.21	37.77	37.52	37.83		
T <sub>6</sub>	75:50:75g per tree	45.20	45.10	44.21	44.84	1.11	1.13	1.15	1.13	41.18	41.19	41.17	41.18		
T <sub>7</sub>	75:75:50g per tree	45.07	45.23	44.58	44.96	1.13	1.13	1.12	1.13	39.80	39.53	39.59	39.64		
T <sub>8</sub>	75:75:75g per tree	48.98	48.82	47.56	48.45	1.05	1.04	1.02	1.04	40.19	39.92	39.71	39.94		
T <sub>9</sub>	100:50:50g per tree	50.84	50.88	50.24	50.65	1.10	1.10	1.09	1.10	41.42	41.59	41.93	41.65		
T <sub>10</sub>	100:50:75g per tree	51.10	51.19	50.31	50.87	1.12	1.11	1.13	1.11	40.44	41.21	41.43	41.03		
T <sub>11</sub>	100:75:50g per tree	53.92	53.77	52.47	53.38	1.27	1.25	1.27	1.26	41.95	41.92	42.20	42.02		
T <sub>12</sub>	100:75:75g per tree	52.19	52.16	50.81	51.72	1.22	1.22	1.21	1.22	40.61	40.52	40.52	40.55		
S.Em.±		1.783	1.616	1.681	0.841	0.017	0.016	0.01	0.008	1.190	1.928	1.301	0.594		
CD at 5%		5.23	4.74	4.93	NS	0.05	0.05	0.04	0.02	3.49	3.89	3.82	1.68		
Y × T															
S.Em.±						1.457					0.014				1.029
CD at 5%						NS					NS				NS
CV%		6.68	6.04	6.38	5.02	2.66	2.55	2.36	2.13	5.28	5.90	5.78	4.57		

2) Pod yield per tree (kg)

Significant difference in the terms of pod yield per tree was noted among the different treatments during all years as well as in pooled analysts. The maximum pod yield per tree (12.98 kg) was recorded with treatment T<sub>11</sub> (100:75:50g NPK per tree) which was at par with T<sub>9</sub>, T<sub>10</sub> and T<sub>12</sub>. However, minimum pod yield per tree (7.57 kg) was observed with T<sub>2</sub> (50:50:75g NPK per tree). The interaction effect of year × treatment was not able to produce significant effect.

3) Pod yield per hectare (t)

Significant difference in the terms of pod yield was observed among the different treatments during all the years as well as in pooled analysis. Maximum pod

yield per hectare (16.22 t) was recorded in T<sub>11</sub> (100:15:50g NPK per tree) which was on same bar with T<sub>9</sub>, T<sub>10</sub> and T<sub>12</sub>. The interaction effect of year × treatment could not produce significant effect.

These nutrients play an important role in root development which leads to increased branches, number of leaves, plant height and spread, number of flowers and fruit setting. This might be due to more balanced C:N ratio, more supply of nutrients, faster enhancement of reserve food material to the buds (Dar *et al.*, 2010 and Dhawale *et al.*, 2011). The increase in yield may be due to promotion of vegetative growth thereby resulting in more yields. Phosphorus and potassium help in better growth and maturity, quality of the pod and pod yield. These nutrients have a good effect on yield contributing

traits obtaining higher pod yield. This finding has the support of Dalal and Nandkar (2010) in okra.

C. Soil parameters:

1) Available nitrogen content before and after treatment

The treatments effect on available nitrogen content before and after treatment application was found to be non significant and significant, respectively in all three years. However, it produced significant result in pooled analysis. Available nitrogen content before and after (273.01 and 321.92 kg/ha) was noted in T<sub>11</sub> in pooled analysis, respectively. The interaction effect of year × treatment produced non-significant result.

2) Available phosphorus content before and after treatment

Significant difference was observed among different treatments in the terms of available phosphorus before and after the application of treatment in pooled

analysis of the experiment. Available phosphorus before and after (46.92 and 60.05 kg/ha) was noted in T<sub>11</sub> in pooled analysis, respectively. The interaction effect of year × treatment was found non-significant.

3) Available potash content before and after treatment

The treatments effect on available potash content before and after the application of treatment could not produce significant results in all three years. However, it produced significant result in pooled analysis. Available potash content before and after (282.70 and 315.33 kg/ha) was noted in T<sub>11</sub> in pooled analysis, respectively. The interaction effect of year × treatment produced non-significant result.

The effect of various levels of nitrogen, phosphorus and potassium and their interaction on available nitrogen content, phosphorus content and potassium content before and after the treatment is presented in table 5, table 6 and table 7, respectively.

Table 4: Effect of various levels of nitrogen, phosphorus and potassium and their interaction on yield parameters of drumstick

TREATMENT		Number of pods per tree				Yield of pod per tree (kg)				Yield of pod per hectare (t)			
		2018	2019	2020	Pooled	2018	2019	2020	Pooled	2018	2019	2020	Pooled
T <sub>1</sub>	50:50:50g per tree	250.72	190.23	155.16	198.70	8.43	8.11	6.52	7.69	10.54	10.14	8.15	9.61
T <sub>2</sub>	50:50:75g per tree	243.09	180.22	143.66	188.99	8.43	7.91	6.38	7.57	10.54	9.89	7.98	9.47
T <sub>3</sub>	50:75:50g per tree	264.37	198.57	160.77	207.90	10.26	9.55	7.61	9.14	12.83	11.94	9.51	11.43
T <sub>4</sub>	50:75:75g per tree	304.06	237.22	204.77	248.68	11.55	11.42	9.14	10.70	14.44	14.28	11.43	13.38
T <sub>5</sub>	75:50:50g per tree	284.69	225.71	191.88	234.09	10.77	10.83	8.82	10.14	13.46	13.54	11.02	12.67
T <sub>6</sub>	75:50:75g per tree	274.37	209.68	173.40	219.15	11.33	10.97	8.76	10.35	14.17	13.71	10.95	12.94
T <sub>7</sub>	75:75:50g per tree	297.88	235.23	200.00	244.37	11.82	11.81	9.43	11.02	14.77	14.77	11.79	13.78
T <sub>8</sub>	75:75:75g per tree	302.59	238.57	204.52	248.56	12.23	12.10	9.63	11.32	15.29	15.12	12.04	14.15
T <sub>9</sub>	100:50:50g per tree	309.48	238.98	216.17	269.88	12.87	13.25	10.55	12.22	16.08	16.56	13.019	15.28
T <sub>10</sub>	100:50:75g per tree	319.27	249.33	214.50	261.03	12.94	13.05	10.45	12.15	16.17	16.32	13.06	15.18
T <sub>11</sub>	100:75:50g per tree	325.04	261.37	225.34	270.59	13.72	13.92	11.30	12.98	17.15	17.40	14.13	16.22
T <sub>12</sub>	100:75:75g per tree	337.17	270.16	235.02	280.78	13.70	13.90	10.87	12.82	17.13	17.38	13.58	16.03
S.Em.±		13.073	15.831	11.171	6.844	0.761	0.742	0.652	0.354	0.951	0.928	0.815	0.443

CD at 5%	38.34	46.43	32.77	19.34	2.23	2.18	1.91	1.00	2.79	2.72	2.39	1.25
Y × T												
S.Em.±				11.854				0.614				0.767
CD at 5%				NS				NS				NS
CV%	7.74	11.84	9.99	8.58	11.45	11.27	12.38	9.95	11.45	11.27	12.38	9.95

Table 5: Effect of various levels of nitrogen, phosphorus and potassium and their interaction on available nitrogen content before and after (kg/ha) of drumstick

TREATMENT DOSE (Per tree)		Before treatment (kg/ha)				After treatment (kg/ha)			
		2018	2019	2020	Pooled	2018	2019	2020	Pooled
T <sub>1</sub>	50:50:50g	289.18	284.89	257.74	277.27	315.88	323.68	336.20	325.25
T <sub>2</sub>	50:50:75g	244.82	240.13	214.46	233.14	293.28	284.21	306.92	294.80
T <sub>3</sub>	50:75:50g	257.08	252.49	226.42	245.33	286.07	297.47	309.16	297.57
T <sub>4</sub>	50:75:75g	248.92	244.26	218.46	237.21	311.77	268.55	297.96	292.76
T <sub>5</sub>	75:50:50g	253.01	248.38	222.44	241.28	321.68	376.45	311.87	303.33
T <sub>6</sub>	75:50:75g	261.13	256.58	230.37	249.36	326.99	397.72	315.18	313.30
T <sub>7</sub>	75:75:50g	273.24	268.80	242.18	261.41	291.80	371.30	318.74	293.95
T <sub>8</sub>	75:75:75g	265.18	260.67	234.32	253.39	315.59	397.28	325.55	312.81
T <sub>9</sub>	100:50:50g	269.22	264.74	238.26	257.41	296.41	301.55	325.66	307.87
T <sub>10</sub>	100:50:75g	277.24	272.83	246.09	265.39	295.83	326.65	333.49	318.66
T <sub>11</sub>	100:75:50g	268.55	288.88	261.59	273.01	293.13	329.87	342.77	321.92
T <sub>12</sub>	100:75:75g	281.24	276.87	249.99	269.36	280.40	290.20	321.55	297.38
S.Em.±		9.241	18.337	16.783	6.845	8.421	8.909	8.523	7.480
CD at 5%		NS	NS	NS	19.34	24.70	26.13	25.00	21.94
Y × T									
S.Em.±					11.855				7.078
CD at 5%					NS				NS
CV%		6.02	12.06	12.27	8.04	4.82	5.12	4.61	3.98

Table 6: Effect of various levels of nitrogen, phosphorus and potassium and their interaction on available phosphorus content before and after (kg/ha) of drumstick

TREATMENT		Before treatment (kg/ha)				After treatment (kg/ha)			
		2018	2019	2020	Pooled	2018	2019	2020	Pooled
T <sub>1</sub>	50:50:50g per tree	37.66	33.66	39.06	36.79	55.55	54.56	51.60	53.87
T <sub>2</sub>	50:50:75g per tree	39.12	35.12	31.38	35.20	39.52	57.64	44.32	47.16
T <sub>3</sub>	50:75:50g per tree	38.80	34.80	33.51	35.70	43.89	52.33	46.34	47.52
T <sub>4</sub>	50:75:75g per tree	38.04	34.04	31.60	34.56	40.97	59.33	44.50	48.27
T <sub>5</sub>	75:50:50g per tree	41.21	37.21	33.95	37.46	42.44	60.70	46.82	49.99
T <sub>6</sub>	75:50:75g per tree	42.56	38.56	36.15	39.09	45.34	63.42	48.95	52.57
T <sub>7</sub>	75:75:50g per tree	42.68	38.68	38.51	39.96	49.72	58.25	51.20	53.05
T <sub>8</sub>	75:75:75g per tree	40.51	36.51	35.89	37.64	46.80	55.42	48.65	50.29
T <sub>9</sub>	100:50:50g per tree	43.89	39.89	38.35	40.71	48.26	56.52	51.07	51.95
T <sub>10</sub>	100:50:75g per tree	38.32	34.32	37.09	36.58	51.17	59.54	49.74	53.48
T <sub>11</sub>	100:75:50g per tree	54.09	38.63	48.04	46.92	57.01	62.58	60.55	60.05
T <sub>12</sub>	100:75:75g per tree	58.46	36.28	47.93	47.56	52.63	64.50	60.55	59.23
S.Em.±		1.625	1.935	1.916	1.982	1.917	1.574	2.022	1.960
CD at 5%		4.77	NS	5.62	5.81	5.62	4.62	5.93	5.75
Y × T									
S.Em.±					1.458				1.4319
CD at 5%					NS				NS
CV%		6.55	9.19	8.82	6.48	6.95	4.64	6.95	4.74

Table 7: Effect of various levels of nitrogen, phosphorus and potassium and their interaction on available potash content before and after (kg/ha) of drumstick

TREATMENT DOSE (Per tree)		Before treatment (kg/ha)				After treatment (kg/ha)			
		2018	2019	2020	Pooled	2018	2019	2020	Pooled
T <sub>1</sub>	50:50:50g	305.72	265.72	238.06	269.83	323.97	319.48	289.78	311.08
T <sub>2</sub>	50:50:75g	276.31	272.43	226.40	258.38	312.43	320.50	247.06	293.33
T <sub>3</sub>	50:75:50g	289.31	266.32	226.72	260.78	306.32	303.60	258.16	289.36
T <sub>4</sub>	50:75:75g	280.64	272.04	227.61	260.10	312.04	304.50	250.25	288.93
T <sub>5</sub>	75:50:50g	327.65	272.36	229.29	276.43	312.36	318.25	254.21	294.94
T <sub>6</sub>	75:50:75g	293.64	271.56	231.68	265.63	311.56	320.25	262.11	297.97
T <sub>7</sub>	75:75:50g	306.64	273.15	237.14	272.31	313.15	301.62	273.97	296.24
T <sub>8</sub>	75:75:75g	297.98	279.48	238.43	271.97	319.48	322.70	266.06	302.75
T <sub>9</sub>	100:50:50g	302.22	279.35	239.81	273.79	319.35	309.40	270.02	299.59
T <sub>10</sub>	100:50:75g	310.98	271.65	237.61	273.41	311.65	306.08	277.92	298.55
T <sub>11</sub>	100:75:50g	319.64	379.64	248.80	282.70	328.31	323.94	293.73	315.33
T <sub>12</sub>	100:75:75g	315.30	292.64	253.07	287.00	332.64	324.80	281.87	313.10
S.Em.±		10.488	16.896	14.698	6.622	6.475	11.048	17.957	4.269
CD at 5%		NS	NS	NS	NS	NS	NS	NS	12.06
Y × T									
S.Em.±					11.469				7.393
CD at 5%					NS				NS
CV%		5.99	10.65	10.78	7.33	3.54	6.08	11.57	4.27

D. Economics:

It is apparent from table 8 that the treatment T<sub>11</sub> (combination of N<sub>3</sub>P<sub>2</sub>K<sub>1</sub> i.e. 100:75:50g NPK per tree) noted maximum gross return per hectare (₹ 324400) and net return per hectare (₹ 219783.64).

Table 8: Effect of various treatments on total cost (₹), gross realization (₹) and net realization (₹) of drumstick

Treatment			Total cost (₹)	Gross return (₹)	Net return (₹)	BCR
T <sub>1</sub>	N <sub>1</sub> P <sub>1</sub> K <sub>1</sub>	50:50:50g per tree	102043.35	192200.00	90156.65	0.88
T <sub>2</sub>	N <sub>1</sub> P <sub>1</sub> K <sub>2</sub>	50:50:75g per tree	102824.55	189400.00	86575.45	0.84
T <sub>3</sub>	N <sub>1</sub> P <sub>2</sub> K <sub>1</sub>	50:75:50g per tree	103801.14	228600.00	124798.86	1.20
T <sub>4</sub>	N <sub>1</sub> P <sub>2</sub> K <sub>2</sub>	50:75:75g per tree	104582.34	267600.00	163017.66	1.56
T <sub>5</sub>	N <sub>2</sub> P <sub>1</sub> K <sub>1</sub>	75:50:50g per tree	102450.93	253400.00	150949.07	1.47
T <sub>6</sub>	N <sub>2</sub> P <sub>1</sub> K <sub>2</sub>	75:50:75g per tree	103232.13	258800.00	155567.87	1.51
T <sub>7</sub>	N <sub>2</sub> P <sub>2</sub> K <sub>1</sub>	75:75:50g per tree	104208.72	275600.00	171391.28	1.64
T <sub>8</sub>	N <sub>2</sub> P <sub>2</sub> K <sub>2</sub>	75:75:75g per tree	104989.92	283000.00	178010.08	1.70
T <sub>9</sub>	N <sub>3</sub> P <sub>1</sub> K <sub>1</sub>	100:50:50g per tree	102858.57	305600.00	202741.43	1.97
T <sub>10</sub>	N <sub>3</sub> P <sub>1</sub> K <sub>2</sub>	100:50:75g per tree	103639.77	303600.00	199960.23	1.93
T <sub>11</sub>	N <sub>3</sub> P <sub>2</sub> K <sub>1</sub>	100:75:50g per tree	104616.36	324400.00	219783.64	2.10
T <sub>12</sub>	N <sub>3</sub> P <sub>2</sub> K <sub>2</sub>	100:75:75g per tree	105397.56	320600.00	215202.44	2.04

The benefit: cost ratio is numerically presented in table 8 and graphically depicted in figure 1. It is clear from the table 8 and figure 1 that the highest BCR (2.10) was noticed in the same treatment (T<sub>11</sub>) followed by T<sub>12</sub> (2.04) i.e. 100:75:75g NPK per tree.

The various fertility levels when applied individually, highest fertility level gave significantly highest net returns as well as B: C ratio. Similar findings have been reported by Sharma *et al.* (2010) in okra.

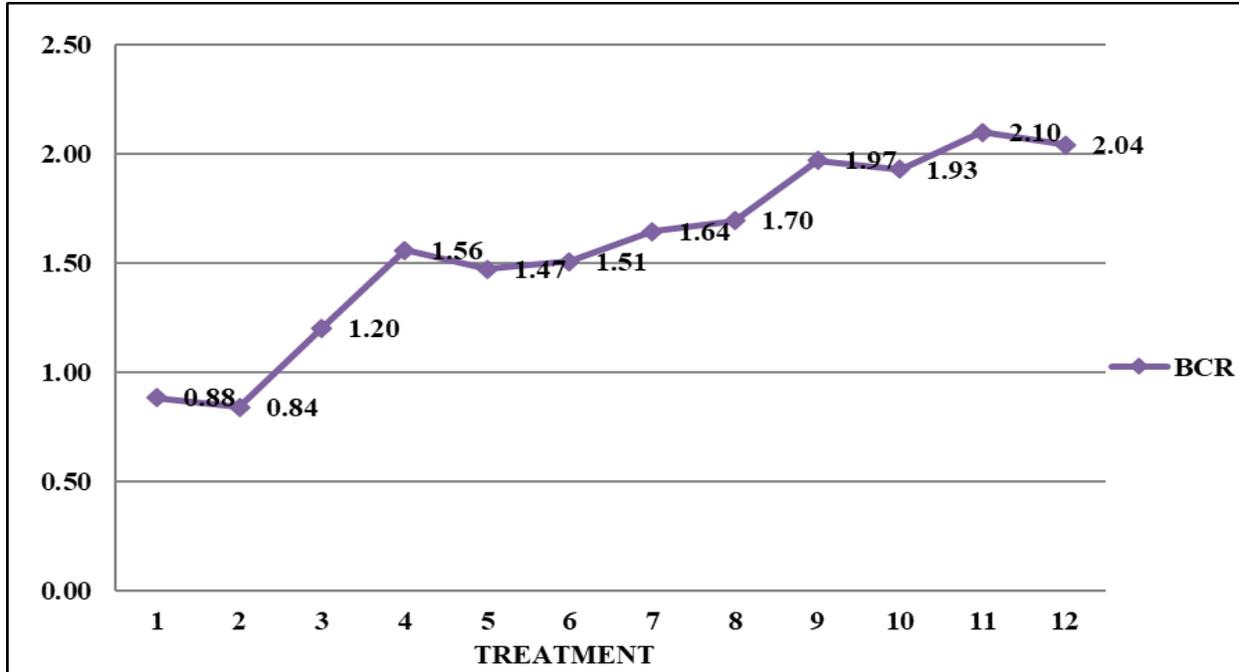


Figure 1: Effect of various treatments on benefit:cost ratio of drumstick

IV. CONCLUSION

The experiment concludes that the application of 100:75:50g NPK per tree in drumstick is on same bar with 100:50:50g NPK per tree which increases growth parameters *i.e.* plant spread, fresh and dry weight of plant, pod length, pod circumference, pod weight as well as the number of pods per tree, pod yield per tree and per hectare as compared to the other treatments.

V. RECOMMENDATION

The farmers of South Gujarat region growing drumstick are recommended to apply 100:75:50g NPK (217.30g Urea, 468.7g SSP and 83.30g MOP) per tree as per the following schedule in addition to common pit application of 8 kg/tree FYM enriched with Azotobactor + PSB + KMB (2ml of each) for obtaining higher yield and income as well.

Application schedule	Fertilizer	Quantity
First (Time of planting in pit)	25.00g N 37.50g P <sub>2</sub> O <sub>5</sub> 25.00g K <sub>2</sub> O	54.30g Urea 234.35g SSP 41.65g MOP
Second (30 days after planting)	25.00g N	54.30g Urea

Third (6 month interval after pruning )	25.00g N 37.50g P <sub>2</sub> O <sub>5</sub> 25.00g K <sub>2</sub> O	54.30g Urea 234.35g SSP 41.65g MOP
Forth (30 days after pruning )	25.00g N	54.30g Urea

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