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Effect of NPK Doses on the Yield of Dragon Fruit (*Hylocereus costaricensis* [F.A.C. Weber] Britton & Rose) in Chittagong Hill Tracts

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Abstract: An experiment was conducted comprising seven fertilizer treatments viz., $T_1 = N_{810}P_{465}K_{375}$, $T_2 = N_{675}P_{390}K_{310}$, $T_3 = N_{540}P_{310}K_{250}$, $T_4 = N_{400}P_{230}K_{185}$, $T_5 = N_{270}P_{155}K_{125}$, $T_6 = N_0P_0K_0$, T_7 = native fertility and 20 kg cowdung manure per pillar containing four plants was applied for all the treatments except T_7, at Hill Agricultural Research Station, Raikhali, Chandraghona, Kaptai, Rangamati Hill District, Bangladesh during two consecutive years 2011-12 and 2012-13 to recommend the proper NPK fertilizer dose for higher yield and quality of dragon fruit in Chittagong Hill Tracts. There were significant differences in terms of plant height, plant circumference, number of fruits, average individual fruit weight, fruit size, TSS, edible portion and fruit yield. The maximum number of fruits per pillar (50.00), average individual fruit weight (316.40 g), fruit length (9.27 cm), fruit breadth (7.81 cm) and fruit yield (31.64 t/ha) were observed in T_3. The minimum number of fruits per pillar (27.00), average individual fruit weight (241.80 g) and fruit yield (12.88 t/ha) was found in native fertility (T_7). The highest TSS (16.09%) was recorded in native fertility (T_7) and lowest (13.38%) in T_1.

Key words: Dragon fruit · Pitaya · NPK · Hilly areas · Yield

INTRODUCTION

Dragon fruit, also known as pitaya (*Hylocereus costaricensis* [F.A.C. Weber] Britton & Rose) is a climbing fast growing perennial vine cactus species which is originated in Mexico and Central and South America [1-3]. It is introduced to Chittagong Hill Tracts (CHT) as well as in Bangladesh few years back. Bangladesh Agricultural Research Institute (BARI) has recently released BARI Dragon fruit-1 as a high yielding variety of dragon fruit in Bangladesh. It is favorite to many because of its ornamental characters and fruit quality. It is a long day plant with beautiful night blooming flower that is nicknamed as "Noble Woman" or "Queen of the Night". Usually flowering starts from April to November sometimes extending till December and occurs in four to six flushes [4]. Its fruit is the most beautiful in the family Cacataceae with an immense shape, bright red skin studded with green scales, no surface spines and red flesh with tiny readily swallowed black seeds [5-8]. Average fruit weight is 360 g [9]. The fruit is non climacteric with best flavor when harvested at full red color [10]. The juicy flesh of the fruit is delicious in taste which contains 70-80% of the ripe fruit. The biggest advantage of this crop is that once planted, it will grow for about 20 years and one hectare could accommodate 1000 to 2000 dragon fruit plants. It produces fruit in the second year after planting and attain in full production within five years. It is considered as fruit of future [6] and widely used as juice and in fruit salads at restaurants [9]. Its interest has emerged due to their agronomy, industrial and medicinal importance and economic potential and currently being marketed worldwide [5, 11-13]. The red fleshed varieties of Dragon fruit are rich in antioxidants. It is rich with beta carotene, lycopene, vitamin E [14], vitamin C, phosphorus and calcium helps to develop strong bones, teeth and skin [6] and contain essential fatty acids, *i.e.*, 48% linoleic acid and 1.5% linolenic acid

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in black seeds [15]. It is a potential source of betalins for the food industries [16]. It is being grown commercially in Israel, Vietnam, Taiwan, Nicaragua, Australia and the United States [17].

The use of inorganic fertilizers on crops highly influenced on the growth and productivity of crops [18, 19] as inadequate levels of the primary nutrients like Nitrogen, Phosphorus and Potassium are the reasons for poor fruit setting, low crop yield [20-22] and substantial depletion of nutrients occurred with the yields where no NPK fertilizer was applied [23, 24]. Application of chemical fertilizers helps in maintaining soil fertility and sufficient amount of nutrients necessary for better growth and development of plant [25]. Dragon fruit requires judicious application of fertilizer for higher yields. The recommendations of fertilizer rates vary widely [6]. Tri *et al.*, [26] suggested 540 g N, 720 g P_2O_5, 300 g K_2O and 20 kg manure per plant per year in four installments for at least three years mature plants. In Bangladesh there are no recommended NPK fertilizer doses for Dragon fruit cultivation as it is very new crop to the country. This experiment result will help to Dragon fruit growers having recommended NPK fertilizer doses for higher yield and quality fruits in Bangladesh.

MATERIALS AND METHODS

The experiment was conducted at Hill Agricultural Research Station, Raikhali, Chandraghona, Kaptai, Rangamati Hill District, Bangladesh during 2011-12 and 2012-13 to optimize NPK doses on the growth and yield of dragon fruit in Chittagong Hill Tracts. The experimental site belongs to AEZ 29 with the predominant plain soil having sandy clay loam, 1.44% organic matter, 0.07% nitrogen, 25 ppm phosphorus, 0.15 meq/l potassium per 100 g soils and its pH was 5.72. BARI Dragon fruit-1 was used in the experiment. Four plants per pillar were transplanted in June, 2009 maintaining 2.5 m × 2.0 m spacing. The experimental design was a randomized complete block with seven treatments of the following doses of fertilizers: T_1 = $N_{810}P_{465}K_{375}$ (50% more than recommended dose), T_2 = $N_{675,}P_{390}K_{310}$ (25% more than recommended dose), T_3 = $N_{540}P_{310}K_{250}$ (recommended by Tri *et al.* [26]), T_4 = $N_{400}P_{230}K_{185}$ (25% lower than recommended dose), T_5 = $N_{270}P_{155}K_{125}$ (50% lower than recommended dose), T_6 = $N_0P_0K_0$ (application of cowdung manure only), T_7 = native fertility. 20 kg cowdung manure per pillar was applied for all the treatments except T_7. The fertilizers were applied in four installments. The first (40% N, 30% P and all the cowdung) was applied immediately after last harvest (early October) of the previous season, the second (30% N, 20% P, 15% K) two months later (early December), the third (10% N, 40% P, 40% K) just before flowering (late April) and the fourth contain the remaining fertilizers when young fruits are developing (June) according to Tri *et al.* [26]. Intercultural operations like weeding, irrigation, pruning, disease and insect management were done as per necessary. Data on growth, yield and yield contributing characters were taken duly. Data were statistically analyzed using computer MSTATC program.

RESULTS AND DISCUSSION

The data on growth, yield and yield contributing characters of dragon fruits as influenced by different NPK treatments are presented in Table 1 to Table 3 and Figure Fig.1.

Table 1: Effect of NPK doses on the growth and flowering of dragon fruits

							Plant Canopy (cm)							
	Plant height (cm)			Plant circumference (cm)			North-South			East-West			Days to 1st flowering	
Treatment	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13
T_1	393.47 a	401.9 a	397.69	19.00 a	19.47 a	19.24	208.30 a	229.00 a	218.65	190.00	186.00	188.00	30 May	28 May
T_2	376.70 ab	393.3 a	385.00	18.00 b	18.77 a	18.39	200.00 ab	193.00 b	196.50	190.00	192.70	191.35	22 May	18 May
T_3	383.42 ab	394.0 a	388.71	18.00 b	18.42 ab	18.21	196.70 ab	196.70 b	196.70	185.00	187.30	186.15	12 May	6 May
T_4	383.30 ab	396.7 a	390.00	17.00 c	17.12 bc	17.06	190.00 b	193.70 b	191.85	181.70	195.00	188.35	15 May	8 May
T_5	356.70 ab	361.3 ab	359.00	16.00 d	17.06 bc	16.53	196.70 ab	195.70 b	196.20	183.30	188.00	185.65	15 May	7 May
T_6	356.70 ab	377.1 ab	366.90	16.13 cd	16.78 bc	16.46	196.70 ab	192.60 b	194.65	183.30	196.00	189.65	10 May	7 May
T_7	340.00 b	341.7 b	340.85	15.0 e	16.17 c	15.59	191.70 b	190.00 b	190.85	186.70	183.00	184.85	8 May	3 May
Mean	370.03	380.86	375.45	17.02	17.68	17.35	197.14	198.65	197.90	185.71	189.71	187.71		
LSD (0.05)	42.86	41.22		0.89	1.56		14.82	27.78		8.82	28.70			
CV (%)	6.51	6.08		2.95	4.95		4.23	7.86		2.67	8.50			

Note: Mean values in a column having the dissimilar letter/letters indicate significant differences at 0.05 levels of significance (DMRT)

T_1 = 50% more than recommended dose, T_2 = 25% more than recommended dose, T_3 = Recommended dose (Tri *et al.* [26]), T_4 = 25% less than recommended dose, T_5 = 50% less than recommended dose, T_6 = Manure only, T_7 = Native fertility

Table 2: Effect of NPK doses on the yield contributing characters of dragon fruits

	Number of fruit/ pillar			Average individual fruit weight (g)			Fruit size					
							Length (cm)			Breadth (cm)		
Treatment	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
T_1	33.33 ab	52.00 ab	42.67	290.50 ab	262.80 a-c	276.65	8.77 ab	8.73 ab	8.75	7.65 ab	7.37 ab	7.51
T_2	33.67 ab	55.00 a	44.33	283.70 bc	254.10 bc	268.90	9.10 ab	8.53 b	8.82	7.30 bc	7.13 b	7.22
T_3	39.67 a	60.33 a	50.00	323.60 a	309.20 a	316.40	9.30 a	9.23 a	9.27	7.88 a	7.73 a	7.81
T_4	27.33 bc	41.33 bc	34.33	317.10 a	301.40 ab	309.25	9.23 a	9.27 a	9.25	7.75 ab	7.50 a	7.63
T_5	25.67 bc	41.67 bc	33.67	274.10 bc	251.10 bc	262.60	8.73 ab	8.43 b	8.58	7.37 bc	7.27 b	7.32
T_6	25.00 bc	41.67 bc	33.34	273.90 bc	275.80 a-c	274.85	9.10 ab	8.50 b	8.80	7.17 c	7.37 b	7.27
T_7	19.00 c	35.00 c	27.00	253.60 c	230.00 c	241.80	8.52 b	8.33 b	8.43	7.47 a-c	7.07 b	7.27
Mean	29.10	46.71	37.91	288.07	269.19	278.63	8.96	8.72	8.84	7.51	7.35	7.43
LSD (0.05)	8.54	11.91		31.92	49.26		0.58	0.54		0.43	0.59	
CV (%)	16.49	14.33		6.23	10.29		3.63	3.50		3.22	4.50	

Note: Mean values in a column having the dissimilar letter/letters indicate significant differences at 0.05 levels of significance (DMRT)

T_1 = 50% more than recommended dose, T_2 = 25% more than recommended dose, T_3 = Recommended dose (Tri *et al.* [26]), T_4 = 25% less than recommended dose, T_5 = 50% less than recommended dose, T_6 = Manure only, T_7 = Native fertility

Table 3: Effect of NPK doses on the qualitative characters of dragon fruits

	TSS (%)			Edible portion (%)		
Treatment	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
T_1	13.33 ab	13.43 b	13.38	79.67 ab	79.23 ab	79.45
T_2	13.00 b	13.78 b	13.39	79.67 ab	79.56 ab	79.62
T_3	13.33 ab	13.83 b	13.58	79.33 ab	82.32 a	80.83
T_4	13.67 ab	13.92 b	13.80	80.33 ab	81.50 a	80.92
T_5	15.33 a	15.39 a	15.36	80.67 ab	82.72 a	81.70
T_6	15.67 a	16.00 a	15.84	81.33 a	81.88 a	81.61
T_7	15.67 a	16.50 a	16.09	79.00 b	76.00 b	77.50
Mean	14.29	14.69	14.49	80.00	80.46	80.23
LSD (0.05)	2.26	1.33		2.05	4.20	
CV (%)	8.91	5.09		1.44	2.94	

Note: Mean values in a column having the dissimilar letter/letters indicate significant differences at 0.05 levels of significance (DMRT)

T_1 = 50% more than recommended dose, T_2 = 25% more than recommended dose, T_3 = Recommended dose (Tri *et al.* [26]), T_4 = 25% less than recommended dose, T_5 = 50% less than recommended dose, T_6 = Manure only, T_7 = Native fertility

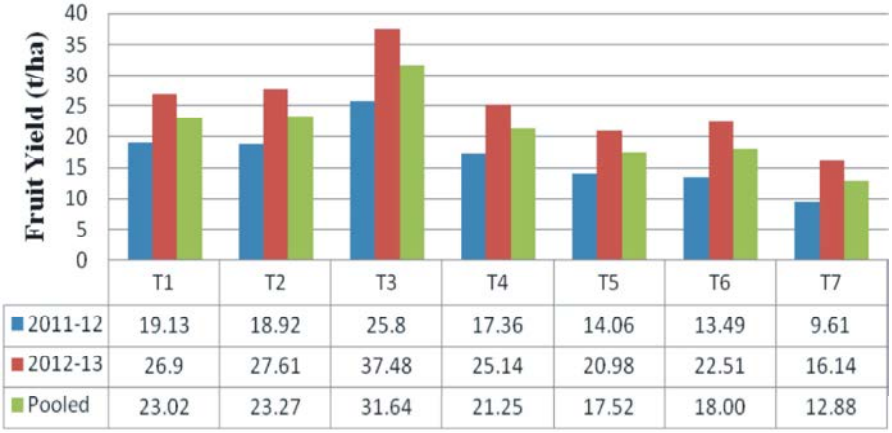

Fig 1: Effect of NPK Doses on the Fruit Yield of Dragon Fruit

T_1 = 50% more than recommended dose, T_2 = 25% more than recommended dose, T_3 = Recommended dose (Tri *et al.* [26]), T_4 = 25% less than recommended dose, T_5 = 50% less than recommended dose, T_6 = Manure only, T_7 = Native fertility

Effect of Npk Doses on the Growth and Flowering of Dragon Fruit:

Plant Height: The results revealed that there were significant differences in term of plant height among the treatments as influenced by different fertilizer doses in both the experimentation years (Table 1). The maximum plant height (397.69 cm) was observed in T_1 which was significantly similar to T_2, T_3 and T_4, whereas the minimum plant height (340.85 cm) was observed in native fertility (T_7). Law-Ogbomo and Law-Ogbomo [27] reported that NPK fertilizer applications significantly increase plant height in maize.

Plant Circumference: The plant circumference was found significantly different among the treatments (Table 1). The highest plant circumference (19.24 cm) was recorded in T_1 treatment and the lowest plant circumference (15.59 cm) in native fertility. Law-Ogbomo and Law-Ogbomo [27] reported that NPK fertilizer applications significantly increase plant stem girth in maize.

Plant Canopy: The results were depicted significant differences in case of plant canopy in north-south direction but insignificant in east-west direction (Table 1). The maximum spreading of canopy in north-south direction (218.65 cm) was noted in T_1 which was significantly higher over the other treatments and the minimum (190.85 cm) in native fertility (T_7). The plant canopy in east-west direction varied from 184.85 cm to 191.35 cm.

Days to 1st Flowering: The days to 1st flowering varied from 8th May to 30th May during 2011-12 and 3rd May to 28th May during 2012-13 (Table 1). The earliest flowering (8th May and 3rd May for the first and second year, respectively) was observed in native fertility (T_7), whereas the delayed (30th May and 28th May for the first and second year, respectively) in T_1 treatment.

Effect of NPK Doses on the Yield Contributing Characters of Dragon Fruits:

Number of Fruits per Pillar: There were observed significant differences among the treatments in both the experimentation years (Table 2). The maximum number of fruits per pillar (39.67 and 60.33 in 1st and 2nd year, respectively) was recorded in T_3 treatment followed by T_2 (33.67 and 55.00 in 1st year and 2nd year, respectively) and T_1 (33.33 and 52.00 in 1st year and 2nd year, respectively), whereas the minimum number of fruits per pillar (19.00 and 35.00 in 1st and 2nd year, respectively) in native fertility (T_7). The number of fruits per pillar in T_6 treatment was 33.34 which was significantly identical to T_4 (34.33) and T_5 (33.67). The number of fruits increased with increasing rate of fertilizers to a certain level (T_3 =$N_{540}P_{310}K_{250}$ and 20 kg cowdung per pillar) and beyond this level the number of fruits per plant tends to decrease again. This trend of increasing number of fruits to a certain level of fertilizer application was also reported by Oloyede *et al.* [28]. Lowest number of fruits in native fertility in case of mango was also reported by Sarker and Rahim [29].

Individual Fruit Weight: From the results it was revealed that the average individual fruit weight varied significantly among the treatments (Table 2). The highest average individual fruit weight (316.40 g) was weighed in T_3 followed by T_4 (309.25 g) and T_1 (276.65 g). Contrary, the lowest average individual fruit weight (241.80 g) was found in native fertility (T_7) proceeded by T_5 (262.60 g). Nasreen *et al.* [25] reported that native fertility was significantly reduced individual fruit yield comparing to treated treatments.

Fruit Size: Fruit size significantly differed among the treatments as influenced by different fertilizer doses (Table 2). The longest fruit (9.30 cm and 9.23 cm in 1st year and 2nd year, respectively) was observed in treatment T_3 that was significantly similar to T_4 (9.23 cm and 9.27 cm in 1st year and 2nd year, respectively). The shortest fruit (8.52 cm and 8.33 cm in 1st year and 2nd year, respectively) was recorded in treatment T_7 (native fertility). The maximum fruit breadth (7.88 cm and 7.73 cm in 1st year and 2nd year, respectively) was obtained in treatment T_3, whereas the minimum fruit breadth (7.30 cm and 7.13 cm in 1st year and 2nd year, respectively) in T_2.

Effect of NPK Doses on the Qualitative Characters of Dragon Fruits:

Total Soluble Solids (%): There were significant differences among the treatments on TSS (%) in both the experimentation years (Table 3). The highest TSS (16.09 %) was recorded in T_7 (native fertility) that was significantly similar to T_6 (15.84%) and T_5 (15.36%), whereas the lowest (13.38%) in T_1. The TSS (%) was increased with the decreased decreasing the dose of fertilizers and got the peak at native fertility. Robert and Wiedenfeld [30] mentioned that nitrogen application has negative effect on TSS (%). Muchow *et al.* [31], Gascho *et al.* [32] and Wrona [33] reported that the content of soluble solids or sucrose production decreases

with high application of nitrogen.

Edible Portion (%): The results depicted significant differences in terms of edible portion among the treatments in both the experimentation years (Table 3). The maximum edible portion (81.70 %) was observed in T_5 which was similarly followed by T_6 (81.61 %). The minimum edible portion (77.50 %) was found in T_7.

Effect of NPK Doses on the Fruit Yield of Dragon Fruits:

Fruit Yield: The results revealed that there was significant difference among the treatments in terms of fruit yield in two consecutive years (Figure Fig.1). The highest fruit yield (25.80 and 37.48 t/ha in 1st year and 2nd year, respectively) was observed in treatment T_3 which was followed by T_2 (18.92 and 27.61 t/ha in 1st year and 2nd year, respectively), T_1 (19.13 and 26.90 t/ha in 1st year and 2nd year, respectively) and T_4 (17.36 and 25.14 t/ha in 1st year and 2nd year, respectively). On the other hand, the lowest fruit yield (9.61 and 16.14 t/ha in 1st year and 2nd year, respectively) was found in native fertility (T_7) proceeded by T_5 (17.52 t/ha) and T_6 (18.00 t/ha). Maity *et al*. [34] noted that application of nutrients regardless of their sources and doses markedly increased the fruit yield in contrast to untreated control. Monga *et al.* [35] also found similar results where application of NPK fertilizer increased fruit yield of Kinnow mandarin significantly over control in India. Nasreen *et al.* [25] found lowest fruit yield in native fertility irrespective of years in Bangladesh. Fruit yield increased to a certain level (T_3) and then it started to reduce again. It perhaps the T_3 treatment is the highest level of NPK uptake by Dragon fruit plant for fruit yield.

CONCLUSION

The results of two consecutive years revealed that application of fertilizers at the rate of $N_{540}P_{310}K_{250}$ g/pillar along with 20 kg of cowdung manure or or $N_{135}P_{78}K_{63}$ g/plant along with 5 kg decomposed cowdung would be optimum for higher yield of dragon fruit in Chittagong Hill Tracts as well as in Bangladesh.

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