Annals of Arid Zone 48(2): 119-123, 2009

Dry Matter Partitioning, Nutrient Content and Uptake by Colocynth (*Citrullus colocynthis* L.) in Relation to Spacing and Nitrogen under Rainfed Conditions

R.N. Kumawat, S.S. Mahajan and R.S. Mertia
Central Arid Zone Research Institute, Regional Research Station, Jaisalmer 345 001, India

Abstract: A field experiment was conducted during the kharif seasons of 2005 and 2006 at Chandan Farm, CAZRI, RRS, Jaisalmer, to study the effect of row spacing and nitrogen levels on dry matter partitioning, nutrient content and uptake of colocynth. The total dry matter accumulation and its distribution in leaf, vine, rind, pulp, cotyledon and testa was significantly higher in plants sown at 75 cm over 50 and 150 cm spacings. The oil content in seed and oil yield (kg ha^{-1}) increased at 75 cm spacing by 2.3% and 16.1%, respectively, over 50 cm plant spacing. The contents of N and P in all plant parts increased significantly with gradual increase in spacing from 50 to 150 cm. The uptake of N and P was significantly higher at 75 cm spacing. Application of 40 kg N ha^{-1} increased total dry matter production from 1388 to 2251, dry fruit yield from 590 to 1256, seed yield from 264 to 509 and oil yield from 71 to 128 kg ha^{-1} over control and significantly increased content of N and P in leaf, vine, rind and cotyledon and uptake of N and P.

Key words: Colocynth, dry matter, nitrogen, nutrient content and uptake, spacing.

Oilseeds occupy an important position in the Indian agricultural economy, next to food grains. However, this sector did not receive the desired attention during the phase of green revolution. Thus, Government of India in May 1986 appointed a Technological Mission to enhance oilseed production under the Oilseeds Production Program. Despite all efforts, the production of vegetable oil from all the sources is stagnated around 7-8 mt against demand of 12.4 mt during 2006-07 (Anonymous, 2008). The deficit of about 5 mt would be met by imports. Therefore, to meet huge domestic demand and to reduce import of vegetable oil, it is necessary to exploration of new oil seed crops that could supply edible oil. In western Rajasthan cultivation of colocynth provides food, oil and protein for human consumption, feed and fodder for live stock, and chemicals for agro-pesticide industries (Kumawat *et al.*, 2006) besides supplying compounds for pharmaceutical and nutraceutical industry. The perennial vine grows naturally in the arid zones during monsoon and bears fleshy pepo during September to December. On dry weight basis colocynth fruits contain 50% seeds rich in oil (26.6%) and protein (13.5%) (Sawaya *et al.*, 1986). The oil of colocynth resembles in composition with sunflower and is being used as cooking oil in African and Middle Eastern countries (Schafferman *et al.*, 1998). However, in India colocynth oil is considered non-edible and is employed in soap and automobile industries (Kumawat *et al.*, 2005). Yield of vegetable oil to the tune of 250-400 L ha^{-1} has been reported from Israel (Schafferman *et al.*, 1998). Mertia and Gupta (1994) from Jaisalmer reported production of 4400 kg seeds yielding 1000-1175 L ha^{-1} vegetable oil from colocynth under rainfed conditions. The available evidences indicate its potential as an alternate crop for oilseeds. Being an underutilized crop, little research has been done to standardize cultural practices of colocynth. Among the cultural schedule finding optimum plant population and the level of fertilizer is perhaps most important (Singh and Chhonkar, 1986). Competitive capacity of plant for nutrients, moisture and light entirely depends on density of plants. Thus optimization of spacing and nitrogen levels are considered important factors for realization of higher yield and nutrient uptake. The impact of both N rate and plant density on cultivated cucurbits has been reported in the literature frequently, yet there is insufficient knowledge about their impact on colocynth. Keeping this in view, an experiment was conducted to study the effect of plant spacings and nitrogen levels on the dry matter partitioning and nutrient uptake by colocynth.

Materials and Methods

The experiment was conducted at Chandan Farm, CAZRI Regional Research Station, Jaisalmer, Rajasthan, during kharif 2005 and 2006. The mean weekly minimum and maximum temperatures during the crop season of first year fluctuated from 2 to 29°C and 25 to 42°C and from 6 to

31°C and 22 to 43°C, respectively, during second year. Likewise, maximum and minimum relative humidity (RH) ranged from 42 to 87% and 14 to 54%, respectively, during first year and from 53 to 91% and 25 to 75%, respectively, during second year. During the crop season 206 mm rainfall was received in 2005 and 292 mm in 2006. The soil of the experimental site was sandy with $CaCO_3$ concretions below 50 cm, had 0.08% organic carbon, 72.80 kg ha^{-1} available N, 6.45 kg ha^{-1} available P and 215.78 kg ha^{-1} available K with pH of 9.2. Four intra-row spacings (50, 75, 100 and 150 cm) were tested in the main plots and 4 nitrogen levels (0, 20, 40 and 60 kg ha^{-1}) in the sub-plots. The experiment was laid out in split plot design with 3 replications. The rows were 2.5 m apart in all the treatments and there were four rows in each of the sixteen treatments. The respective gross and net plot size was 10 x 6 m and 5 x 3 m, respectively. A uniform dose of 40 kg P_2O_5 ha^{-1} was applied through single super phosphate to all the treatments. Nitrogen was supplied through urea (46% N) at the time of sowing in first year and deeply placed around plant in second year at the onset of monsoon in the month of July.

The seeds of the colocynth were sown manually at the onset of monsoon on 4th August 2005 by placing three seeds per hole at a depth of 5 cm and plants were thinned to one per hill 10 days after emergence. The second year study was conducted on the ratoons of the plants sown during previous year. Above ground plant biomass from 1st and 4th row of each treatment in each year was used to determine plant dry matter and nutrient content. In the first year, samples were collected at 50, 75, and 100 days after sowing (DAS) and at harvest (12-12-2005). During the second year, where plants were grown from ratoon, samples were collected at 50, 75, and 100 days from regeneration date (15th July) and at harvest (25-11-2006). Two plants per treatment were cut at ground level to record dry matter and yield. Each sample was separated into leaves, stems and fruits. The fruits were peeled off manually and dried in oven at 60°C for 72 hours to determine weight and proportion of rind, pulp and seed to total fruit weight. For determination of weight and proportion of testa and cotyledon to total seed, 20 seeds from each treatment were decoated manually and averaged to get proportion per seed. Oven dried (65°C for 48 hours) ground samples of leaf, vine, rind, pulp, testa and cotyledon were analyzed for N and P content (Jackson, 1973). For determination of oil, seeds were dried overnight at 50°C and ground in a Mortar-pestle. Five grams of seed powder was mixed with 100 ml of petroleum ether (40-60°C) and the oil fraction was weighed to calculate oil content in seeds.

Results and Discussion

Dry matter partitioning

Total dry matter accumulation and its partitioning into different plant parts, viz. leaf, vine, rind, pulp, cotyledon and testa per ha increased significantly with increase in plant spacing up to 75 cm (Table 1). However, dry matter accumulation in fruits (1048 and 1045 kg ha^{-1}) and its parts (rind, pulp and seed) were at par with plant spacing of 75 and 100 cm. Plants at 75 cm spacing recorded 16.3, 13.9, 13.8, 15.8 and 15.2% higher dry matter in leaf, vine, seed, fruit and plant, respectively, than at 50 cm. At 150 cm spacing, lower dry matter production in plant parts was recorded. The dry matter accumulation and its distribution into different parts increased due to higher availability of moisture and nutrients. However, dry matter accumulation per unit area was highest (2173 kg ha^{-1}) at 75 cm due to higher plant population compared to 100 and 150 cm. Plants at wider spacing (150 cm) failed to compensate the loss in dry matter incurred due to lower plant population per ha, despite higher individual plant biomass. Similar findings were also reported by Singh and Chhonkar (1986) in musk melon.

Total dry matter production and its partitioning into different plant parts varied significantly with increase in nitrogen from 0 to 60 kg ha^{-1} (Table 1). Increase in nitrogen levels from 0 to 40 kg ha^{-1} significantly increased plant dry matter from 1388 to 2251 kg ha^{-1}, dry fruit yield from 590 to 1256 kg ha^{-1} and seed yield from 264 to 509 kg ha^{-1}. Further increase in nitrogen level recorded reduction in dry matter accumulation in plant as well as into seed and fruits. However, 60 kg N ha^{-1} recorded significantly higher dry matter accumulation in leaves and vines than rest of the nitrogen levels. The high leaf area of plant is associated with more number of fruits (Knavel, 1991). Increase in nitrogen beyond 40 kg ha^{-1} decreased number of fruits per plant due to shift of sex ratio in favor of staminate flowers (Robinson and Decker-Walters, 2004). At harvest, fruits contributed more than 50% in the total biomass of plant and lower number of fruits with 60 kg N ha^{-1} might be ascribed to lower dry matter

Table 1. Effect of spacings and nitrogen levels on dry matter accumulation and its partitioning in different parts of colocynth at harvest (Average of 2005 and 2006)

Treatments	Dry matter yield (kg ha^{-1})									Oil in seed (%)	Oil yield (kg ha^{-1})
	Leaf	Vine	Rind	Pulp	Coty-ledon	Testa	Seed	Fruit	Plant		
Spacing (cm)											
50	337.7	643.1	261.9	258.8	152.2	232.3	384.5	905.1	1885.9	25.04	96.01
75	392.6	732.2	299.2	311.4	177.8	259.9	437.7	1048.4	2173.2	25.62	111.46
100	352.7	621.4	287.7	322.1	183.3	251.9	435.2	1044.9	2019.0	25.80	111.84
150	263.1	436.4	216.4	272.1	135.2	170.2	305.4	794.0	1493.5	25.98	78.65
CD at 5 %	20.0	34.5	18.8	16.0	8.8	8.6	18.0	54.4	94.4	0.61	4.85
Nitrogen (kg ha^{-1})											
0	264.3	533.9	172.3	153.2	119.5	144.8	264.4	589.8	1388.0	26.72	70.54
20	325.7	595.5	261.6	279.4	171.8	230.7	402.6	943.5	1864.7	25.98	104.54
40	363.0	632.2	354.1	392.8	207.3	301.7	509.0	1255.9	2251.0	25.06	127.54
60	393.2	671.5	277.1	339.0	149.8	237.1	387.0	1003.1	2067.8	24.68	95.35
CD at 5%	18.6	33.7	17.2	15.4	8.2	8.3	17.2	52.7	88.6	0.34	4.97

(kg ha^{-1}) in seed, fruit and plant than 40 kg N ha^{-1}. The significantly higher dry matter in leaves with 60 kg N could be attributed to higher leaf N content compared to other N levels.

Content and yield of oil

The oil content in seeds also varied among different sowing spacings (Table 1) and was highest at 100 cm. Compared to control (25.0%), intra row plant spacing of 100 cm recorded 3% higher oil content in the seeds. However, oil content among 75, 100 and 150 cm was found to be non significant with each other. The oil yield per ha increased significantly with the increase in plant spacing only up to 75 cm at which oil yield per ha was 16.1% higher compared to 50 cm plant spacing. The higher oil content in the seeds with increased spacing (50 to 100 cm) could be attributed to increased proportion of cotyledon (40.12 to 42.18%) with simultaneous decreased proportion of the testa (59.88 to 57.22%). The higher proportion of the cotyledon might have increased the oil content of the seeds.

The increase in nitrogen levels from 0 to 60 kg ha^{-1} decreased the oil content in seed from 26.7 to 24.7% (Table 1). The oil yields per hectare recorded significant increase only up to 40 kg N ha^{-1}. Compared to control (71 kg ha^{-1}), oil yield increased by 80.3% with the application of 40 kg N ha^{-1}. Further increase in nitrogen level recorded oil yield even less than that recorded at 20 kg N ha^{-1}. The increasing nitrogen levels decreased the oil content of the seeds because of increased concentration of crude protein in the seeds. Analogous results were reported by Appelquist (1968) for rape (*Brassica napus*). Further, the proportions of testa to total seed weight increased (54.53 to 61.17%) with successive increase in the nitrogen levels from 0 to 60 kg ha^{-1}. The decreased proportion of the cotyledon (45.47 to 38.83%) might have decreased the concentration of oil in the seeds with increasing nitrogen levels.

Nutrient content and uptake

Successive increase in plant spacing from 50 to 150 cm improved N and P content in leaf, vine, rind, pulp, cotyledon and testa, being highest at 150 cm spacing (Table 2). Plants in plots with

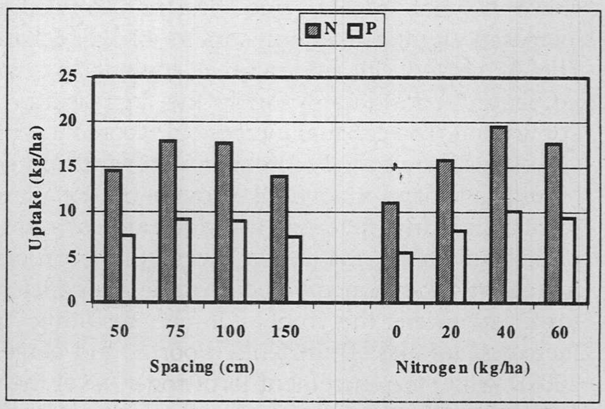

Fig. 1. Effect of spacings and nitrogen levels on N and P uptake by colocynth at harvest (Average of 2005 and 2006).

Table 2. Effect of spacings and nitrogen levels on N and P content in different parts of colocynth at harvest (av. of 2005 and 2006)

Treat-ments	Nitrogen content (%)						Phosphorus content (%)					
	Leaf	Vine	Rind	Pulp	Coty-ledon	Testa	Leaf	Vine	Rind	Pulp	Coty-ledon	Testa
Spacing (cm)												
50	0.75	0.65	0.29	0.32	3.12	0.61	0.37	0.35	0.19	0.19	1.22	0.38
75	0.83	0.71	0.32	0.34	3.17	0.62	0.40	0.38	0.22	0.20	1.29	0.44
100	0.89	0.73	0.36	0.37	3.29	0.67	0.41	0.40	0.24	0.22	1.38	0.48
150	0.98	0.77	0.40	0.40	3.54	0.72	0.44	0.47	0.26	0.25	1.42	0.50
CD at 5%	0.04	0.03	0.01	0.01	0.07	0.01	0.02	0.02	0.01	0.005	0.02	0.01
Nitrogen (kg ha^{-1})												
0	0.79	0.66	0.27	0.32	3.16	0.61	0.38	0.35	0.20	0.19	1.19	0.39
20	0.85	0.70	0.33	0.35	3.26	0.65	0.40	0.40	0.22	0.21	1.30	0.41
40	0.88	0.73	0.38	0.38	3.34	0.67	0.42	0.43	0.24	0.22	1.40	0.45
60	0.93	0.75	0.39	0.38	3.38	0.68	0.42	0.43	0.25	0.23	1.42	0.55
CD at 5%	0.03	0.03	0.01	0.01	0.05	0.01	0.01	0.02	0.01	0.004	0.02	0.01

150 cm spacing recorded 31, 18, 38, 25, 13, and 18% higher N and 19, 34, 37, 33, 16 and 32% higher P content in leaf, vine, rind, pulp, cotyledon and testa, respectively, over plants sown with 50 cm spacing. The uptake of N and P (kg ha^{-1}) in these plant parts however, did not increase gradually with successive increase in spacing. The total uptake of N and P was significantly higher at 75 and 100 cm (**Fig. 1**). Plants at 75 cm spacing had increased uptake of N (22%) and P (25%) over 50 cm.

The content and uptake of N and P in plant parts varied significantly with levels of nitrogen. Application of 60 kg N ha^{-1} recorded significantly higher N content in leaf and P content in pulp and testa over rest of the levels (Table 2). However, N content in vine, rind, pulp, cotyledon and testa and P content in leaf, vine, rind and cotyledon increased significantly only up to 40 kg N ha^{-1}. The N content in rind and P content in vine influenced considerably with the increasing N application. The gradual increase in P content with successive increase in N content might be attributed to improvement in overall growth of the plant which in turn favored translocation of more photosynthates towards developing roots. Increased allocation of food material to roots in turn enhanced the root volume resulting in increased uptake of nutrients (Poorter and Nagel, 2000). With each increment in nitrogen level there was a significant increase in uptake of N and P by the plant up to 40 kg ha^{-1} (Fig. 1). Application of 40 kg N ha^{-1} increased total uptake of N and P by 75 and 85% over control, respectively. The higher uptake of N (19.51 kg ha^{-1}) and P (10.13 kg ha^{-1}) by the plant with 40 kg N ha^{-1} was attributed to higher content of N and P and also of higher dry matter yield of fruits than other levels of nitrogen.

The study infers that plant spacing at 75 cm and nitrogen at 40 kg ha^{-1} produced maximum plant dry matter, fruit and oil yield per ha from colocynth grown on sandy soils of arid north-western parts of India. The uptake of N and P (kg ha^{-1}) in total plant biomass were also observed significantly maximum with 75 cm spacing and 40 kg N ha^{-1}. In view of these findings, plant spacing of 75 cm and 40 kg N ha^{-1} appears more important than other spacings and N levels for maximum dry matter production, oil yield and uptake of nutrients of colocynth.

References

Anonymous 2008. Agricultural Minister Sharad Pawar calls for increasing edible oilseeds production. The Hindu, July 18, 2008. p. 14.

Appelquist, L.A. 1968. Lipids in Cruciferae. II. Fatty acid composition of *Brassica napus* seeds as affected by nitrogen, phosphorus, potassium and sulphur nutrition of plants. *Physiologia Plantarum* 21: 455-465.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Private Limited, New Delhi, India.

Knavel, D.E. 1991. Productivity and growth of short-internode muskmelon plants at various spacings or densities. *Journal of the American Society for Horticultural Science* 166: 926-929.

Kumawat, R.N., Mahajan, S.S., Santra, P. and Mertia, R.S. 2005. Standardization of germination methods for cultivation of colocynth (*Citrullus colocynth* L.) - A medicinal herb of desert. In *Proceedings of the National Seminar on "Botanical Products in New Millenium - Development and Challenges"*, Department of Chemistry, University of Rajasthan, Jaipur, India, p. 32-34.

Kumawat, R.N., Mahajan, S.S., Mertia, R.S. and Prajapati, C.P. 2006. *Citrullus colocynthis*: A marvel herb for botanicals and food products from Desert flora. In *Symposium Proceedings "International Conference & Expo on Botanical Products – Innovation, Challenges, Problems, Solutions and Transnational Marketing"*, Department of Chemistry, University of Rajasthan, Jaipur, India, p. 60-62.

Mertia, R.S. and Gupta, I.C. 1994. Cultivate the colocynth in waste lands. *Indian Horticulture*. April-June, 1994, p. 40-41.

Poorter, H. and Nagel, O. 2000. The role of biomass allocation in the growth response of plants to different levels of light, CO_2, nutrients and water: a quantitative review. *Australian Journal of Plant Physiology* 27: 595-607.

Robinson, R.W. and Decker–Walters, D.S. 2004. *Cucurbits*. CAB, Cambridge University Press, UK.

Sawaya, W.N., Daghir, N.J. and Khalil, J.K. 1986. *Citrullus colocynthis* seeds as a potential source of protein for food and feed. *Journal of Agricultural and Food Chemistry* 34(2): 285-288.

Schafferman, D., Beharav, A., Shabelsky, E. and Yaniv, Z. 1998. Evaluation of *Citrullus colocynthis*, a desert plant native in Israel, as a potential source of edible oil. *Journal of Arid Environments* 40(4): 431-439.

Singh, D.N. and Chhonkar, V.S. 1986. Effect of nitrogen, phosphorus, potassium and spacing on growth and yield of musk melon (*Cucumis melo* L.). *Indian Journal of Horticulture* 43(3/4): 265-269.