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Influence of Irrigation, Nitrogen Stress and Method of Application on Dry Matter Partitioning, Source : Sink Ratio and Nutrient Uptake of Yard Long Bean [*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt]

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ABSTRACT

An investigation was carried out at the College of Agriculture, Vellayani, Kerala, to assess the impact of varying irrigation interval, nitrogen stress and method of application of nutrients (soil, soil + foliar) on dry matter partitioning, source : sink ratio and nutrient uptake of yard long bean. Daily irrigation recorded significantly superior total dry matter production and partitioning of photosynthates towards the source while a better (lower) source : sink ratio (0.75) was recorded by irrigation once in three days at 20 mm depth (I_3). Nitrogen and phosphorus uptake were significantly improved in treatments receiving daily irrigation, while K uptake was observed to be superior in irrigation once in three days and daily irrigation. Application of N @ 30 kg ha^{-1} recorded significantly superior total dry matter production and partitioning of photosynthates towards the source while N level of 25 per cent less than RD resulted in a lower source sink ratio (0.79). Soil application (M_1) was found to be superior over soil + foliar application (M_2) in total dry matter production, dry matter partitioning towards the sink, uptake of nutrients and in creating a better (lower) source : sink ratio.

Keywords: Dry matter partitioning, Foliar application irrigation, nitrogen level, nutrient uptake source : sink ratio

I. INTRODUCTION

Yard long bean [*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt] is an important vegetable crop of Kerala in coverage and preference. It is a vigorous climbing annual, growing to a height of three to four meters and produces very long, slender and succulent pods which may be white, light green, dark green or brownish red in colour. The pods are rich in protein (23.52 -26.27%), iron, calcium, phosphorus, vitamin A, vitamin C and dietary fibre (Ano and Ubochi, 2008). Compared to grain cowpea, the indeterminate growth habit of yard long bean results in variation in response to irrigation and nitrogen levels. Reduction in crop productivity due to enhanced leafiness is a common problem encountered by yard long bean farmers. Inducing a stress in crop management by increasing irrigation interval and controlled nutrient application can reduce the excess foliage growth and will help to prolong the reproductive phase. The present study attempts to find out the effect of irrigation and nutrient management practices in the source : sink relationships and nutrient uptake of yard long bean.

II. MATERIALS AND METHODS

The field experiment was conducted during the summer 2014 (24th January 2014 to 16th May), at the Instructional Farm, College of Agriculture, Vellayani, Kerala. The experiment was laid out in split plot design with four replications. Four different levels of irrigation formed the main plot treatments, *viz.,* daily irrigation at 10 mm depth (I_1), irrigation in alternate days at 20 mm depth (I_2), irrigation once in 3 days at 20 mm depth (I_3) and irrigation once in 3 days up to flowering and then in alternate days at 20 mm depth (I_4). Combinations of nitrogen levels and method of application formed the sub plot treatments. The N levels tested were: recommended dose (RD) of nitrogen (N_0: 30 kg ha^{-1}) and 25 per cent less of recommended dose of N (N_1: 22.5 kg ha^{-1}). The application methods tried were M_1: soil application of N and K in 4 splits (basal, at 20, 30 and 40 DAS) and M_2: soil application of one-third of N and K as basal followed by foliar application of complex fertilizer 13:0:45 @ 0.5 per cent at fortnightly interval. Farm yard manure and full P were applied as basal dose, uniformly for all treatments.

The *adhoc* recommendation for yard long bean under Kerala situation is 30:30:20 kg N:P_2O_5:K_2O ha^{-1} in addition to organic manure dose of 20 t ha^{-1}.

Yard long bean variety *Vellayani Jyothika* was selected for the study. The sub plot size was 3 m x 3.60 m. The seeds were dibbled at 45 cm spacing @ two per hole at a depth of 5 cm in furrows taken 1.5 m apart within each sub plot. The crop was thinned two weeks after emergence and a single plant was maintained. The pre-experiment soil was analyzed for high organic carbon (0.9%) medium nitrogen (413.95 kg ha^{-1}), high phosphorus (151.4 kg ha^{-1}) and medium potassium (178.98 kg ha^{-1}).

The dry matter production was recorded during the final harvest. The observational plants were uprooted from each plot carefully without damaging the roots and separated into leaves, stem and roots. They were dried under shade separately and then oven dried at 80 ± 5° C for about 10 hours until two consecutive weights were the same. The final weight of individual parts were recorded and totaled to get the total dry matter production and expressed in q ha^{-1}. Similarly the dry matter production of pods was recorded and expressed as dry matter production of the sink and the ratio of source : sink worked out. The ratio between leaf dry weight and pod dry weight is expressed as source : sink ratio and this ratio assumes more significance in explaining the partitioning of assimilates from the source to economically important parts.

After the final harvest, the plant parts (leaf, stem, root and pod) were analyzed for major nutrients. Nutrient uptake was calculated by multiplying the percentage nutrient content with total dry matter production and expressed in kg ha^{-1}. Nutrient uptake by the source and sink were calculated separately.

III. RESULTS AND DISCUSSION

Dry matter partitioning and Source: sink ratio

Daily irrigation at 10 mm depth (I_1) was significantly superior to other treatments on leaf, stem and total dry matter production. Root and pod dry matter production were not influenced by irrigation levels. Irrigating at 20 mm depth once in three days (I_3) recorded ideal source : sink ratio (0.75) while daily irrigation at 10 mm depth (I_1) recorded the highest ratio. When an optimum LAI is achieved, a reduction in source : sink ratio is always considered as ideal in productivity enhancement. The optimum development of photosynthetic apparatus (leaf) and leaf dry matter production with a better partitioning of photosynthates to the economic part (pod dry matter) in I_3 resulted in better source : sink ratio.

Application of N @ 25 per cent less of RD (N_1) recorded a better (lower) source : sink ratio over RD N (N_0). The total dry matter production and leaf dry matter production was superior in RD N (30 kg ha^{-1}) and the pod dry matter production was non-significant between two N levels. This resulted in reduced source : sink ratio in 25 per cent less of RD N (22.5 kg N ha^{-1}). This observation indicates that the recommended dose of 30 kg N ha^{-1} enhanced the leafiness (evident from the leaf dry matter production) and did not contribute to yield. Geetha (1999) also observed that increasing N from 20 to 40 kg ha^{-1} enhanced the vegetative growth without any improvement in yield.

Dry matter accumulation in pods and total dry matter production were influenced by method of nutrient application, where soil application (M_1) was observed to be superior to soil + foliar application (M_2). Soil + foliar application of N and K (M_2) significantly increased the source : sink ratio over soil application alone. Higher quantities of N and K available to the crop in soil application might have enhanced the total dry matter production. Reduced source : sink ratio was recorded for soil application of nutrients. The higher quantities of nutrients available in soil application did not cause any variation on source (leaf dry matter) but enhanced the pod dry matter yield leading to ideal source : sink ratio.

Considering the I x N interaction, i_1n_1 produced significantly superior stem dry matter production whereas i_1n_0 recorded the highest pod dry matter which was on par with i_4n_0, i_3n_1 and i_2n_1. i_3n_1 registered the lowest source : sink ratio (0.70) while i_2n_0 recorded the highest ratio which was on par with i_1n_0 and i_4n_1.

Regarding I x M i_1m_1 recorded significantly superior stem dry matter production whereas, in pod, i_3m_1 was superior and was on par with i_4m_1. i_3m_1 was found to produce better source : sink ratio (0.68).

Table 1.Effect of irrigation, nitrogen levels and method of application on dry matter partitioning, q ha^{-1}

Treatments	Leaf	Stem	Root	Pod	Total
Irrigation Levels					
I_1 - Daily at 10 mm depth	11.74	22.93	1.38	13.71	49.76
I_2 – Alternate days at 20 mm depth	10.97	22.53	1.51	13.29	48.29
I_3 - Once in three days, 20 mm depth	10.11	20.15	1.41	13.60	45.28
I_4 - I_3 up to flowering followed by I_2	11.23	21.39	1.44	13.46	47.51
SEm (±)	0.128	0.387	0.392	0.251	0.273
CD (0.05)	0.290	0.876	NS	NS	0.619
Nitrogen Levels					
N_0 - RD N	11.49	21.87	1.47	13.49	48.33
N_1 - 25 % less of RD N	10.53	21.63	1.40	13.53	47.10
SEm (±)	0.109	0.196	0.500	0.149	0.335
CD (0.05)	0.221	NS	NS	NS	0.679
Method of application					
M_1 - Soil application	11.03	21.85	1.42	14.26	48.57
M_2 – Soil + foliar application	10.99	21.64	1.45	12.77	46.85
SEm (±)	0.109	0.196	0.500	0.149	0.335
CD (0.05)	NS	NS	NS	0.302	0.679

Table 2. Interaction effect of irrigation, nitrogen and method of application on dry matter partitioning, q ha^{-1}

Treatments	Leaf	Stem	Root	Pod	Total
I x N					
i_1 n_0	12.35	22.52	1.47	14.07	50.41
i_1 n_1	11.14	23.33	1.29	13.35	49.11
i_2 n_0	11.57	22.85	1.48	12.67	48.58
i_2 n_1	10.37	22.20	1.53	13.90	48.00
i_3n_0	10.55	20.29	1.39	13.18	45.42
i_3 n_1	9.67	20.01	1.44	14.03	45.15
i_4 n_0	11.52	21.80	1.53	14.05	48.90

i_4 n_1	10.94	20.97	1.35	12.86	46.13
SEm (±)	0.218	0.393	0.100	0.298	0.669
CD (0.05)	NS	0.796	NS	0.604	NS
I x M					
i_1 m_1	11.90	23.55	1.35	14.08	50.88
i_1 m_2	11.59	22.30	1.40	13.34	48.64
i_2 m_1	10.89	22.59	1.56	13.99	49.02
i_2 m_2	11.05	22.47	1.46	12.58	47.56
i_3 m_1	10.01	20.21	1.39	14.74	46.37
i_3 m_2	10.21	20.09	1.43	12.47	44.20
i_4 m_1	11.34	21.07	1.37	14.23	48.00
i_4 m_2	11.12	21.71	1.50	12.69	47.03
SEm (±)	0.218	0.393	0.100	0.298	0.669
CD (0.05)	NS	0.796	NS	0.604	NS
N x M					
n_0 m_1	11.71	22.31	1.47	13.92	49.41
n_0 m_2	11.28	21.42	1.47	13.07	47.24
n_1 m_1	10.35	21.40	1.37	14.60	47.73
n_1 m_2	10.71	21.86	1.44	12.47	46.47
SEm (±)	0.154	0.278	0.071	0.21	0.473
CD (0.05)	0.313	0.563	NS	0.427	NS
I x N x M					
i_1 n_0 m_1	12.57	23.40	1.54	14.43	51.95
i_1 n_0 m_2	12.12	21.64	1.40	13.71	48.87
i_1 n_1 m_1	11.22	23.69	1.17	13.73	49.82
i_1 n_1 m_2	11.06	22.97	1.41	12.96	48.4
i_2 n_0 m_1	11.98	23.70	1.48	12.86	50.02
i_2 n_0 m_2	11.16	22.01	1.49	12.49	47.15
i_2 n_1 m_1	9.79	21.47	1.64	15.12	48.03
i_2 n_1 m_2	10.95	22.93	1.42	12.68	47.98
i_3 n_0 m_1	10.73	20.72	1.38	13.96	46.80
i_3 n_0 m_2	10.37	19.87	1.40	12.40	44.04
i_3 n_1 m_1	9.30	19.71	1.40	15.52	45.94
i_3 n_1 m_2	10.04	20.31	1.47	12.53	44.35
i_4 n_0 m_1	11.57	21.41	1.48	14.42	48.89
i_4 n_0 m_2	11.46	22.19	1.57	13.69	48.91
i_4 n_1 m_1	11.10	20.72	1.26	14.04	47.12
i_4 n_1 m_2	10.78	21.23	1.45	11.69	45.15
SEm (±)	0.309	0.555	0.141	0.421	0.947
CD (0.05)	0.627	1.126	NS	NS	NS

Nutrient uptake

Effect of irrigation levels

The N uptake by different plant parts and the total N uptake (169.82 kg ha^{-1}) were significantly higher in daily irrigation at 10 mm depth (I_1). Irrigating once in three days at 20 mm depth (I_3) recorded significantly superior P uptake by leaf, pod and root, whereas daily irrigation at 10 mm depth (I_1) recorded the highest uptake by stem and also the total P uptake. Daily irrigation at 10 mm depth (I_1) registered the highest K uptake by leaf and root and was on par with irrigating once in three days (I_3) in case of root K uptake. K uptake by stem was significantly superior in irrigating once in three days at 20 mm depth (I_3) while, irrigating once in three days at 20 mm depth followed by irrigating in alternate days (I_4) recorded the highest K uptake by pod (41.68 kg ha^{-1}). The total K uptake by all plant parts was superior for I_3 and was on par with I_1. The availability of adequate moisture in the root zone throughout the crop growth stage might have enhanced mineralization, solubility and availability of nutrients in this treatment. This also enhanced the total dry matter production and resulted in highest total uptake of nutrients. Observing the partitioning of nutrients in plant parts, it is evident that daily irrigation registered highest uptake values of N in different plant parts. Phosphorus and potassium uptake values of different plant parts behaved differently at different levels of irrigation.

Effect of nitrogen levels

The total N uptake and uptake of nitrogen by different plant parts were higher for recommended dose of N (N_0). According to Tanaka *et al*. (1964), the nutrient uptake is controlled by factors like nutrient availability in soil, nutrient absorption power of the roots and rate of increase in dry matter. The higher availability of N in the root zone and the higher total dry matter production enhanced the total N uptake. This increase in N uptake at higher N level was in agreement with the reports of Jyothi (1995) and Geetha (1999).

Application of N @ 25 per cent less of RD N (N_1) recorded superior P uptake by leaf, stem, pod and also the total P uptake while RD N (N_0) recorded higher P uptake by root. The nitrogen stress might have promoted N fixation and this enhanced N fixation necessitated higher production of ATP which might have resulted in higher P uptake. Kumar *et al*. (1979) observed that application of a reduced N dose of 20 kg N ha^{-1} in combination with 40 kg P_2O_5 recorded the maximum uptake of N and P in cowpea. In this experiment also N applied @ 22.5 kg ha^{-1} (25 per cent less RD N) and P @ 30 kg ha^{-1} recorded highest P uptake. Application of lesser amount of N and more of P is ideal for a leguminous crop like yard long bean.

It was also observed from the present study that potassium uptake by leaf, root, pod and total uptake increased at higher level of N (recommended dose). The higher level of N might have stimulated the uptake of K leading to higher values in N_0 (Tisdale *et al.,* 1993). Moreover, the enhanced dry matter production resulted in higher K uptake values. Similar results were reported by (Geetha, 1999) in yard long bean.

Effect of method of application

The N uptake by leaf, root and pod were higher in soil application of nutrients (M_1) while N uptake by stem was higher for soil + foliar application (M_2). Soil application of N and K (M_1) registered more P uptake over soil + foliar application (M_2) for leaf, pod and root uptake whereas, P uptake by stem was higher in soil + foliar application. Soil application recorded higher K uptake by leaf, stem and root, while it was insignificant in K uptake by pod. The total uptake of N, P and K were higher in soil application of nutrients. The increased total dry matter production and availability of more quantity of nutrients in soil application also resulted in a higher uptake of N, P and K. The uptake of N, P and K by source and N and P by sink were also found to be superior in soil application, while K uptake by sink was non-significant.

Thus from the experiment it was concluded that irrigating at an interval of 3 days at 20 mm depth during summer months along with the application of nitrogen @ 22.5 kg ha^{-1} as soil application in split doses (10, 20, 30 and 40 days after sowing) provides an ideal source : sink ratio for yard long bean.

Table 3. Effect of irrigation, nitrogen levels and method of application on uptake of nitrogen, kg ha^{-1}

Treatments	Leaf (source)	Stem	Root	Pod (sink)	Total
Irrigation Levels					
I_1 - Daily at 10 mm depth	45.12	53.15	3.41	68.13	169.82
I_2 – Alternate days at 20 mm depth	38.33	46.29	2.78	65.11	152.52
I_3 - Once in three days, 20 mm depth	33.08	48.10	3.15	57.71	142.04
I_4 - I_3 up to flowering followed by I_2	40.26	46.75	2.91	57.26	147.18
SEm (±)	0.534	0.986	0.068	1.169	1.024
CD (0.05)	1.209	2.231	0.155	2.646	2.317
Nitrogen Levels					
N_0 – Recommended N dose	44.10	49.53	3.19	64.20	161.02
N_1 - - 25 % Recommended dose	34.30	47.62	2.94	59.90	144.75
SEm (±)	0.436	0.442	0.081	0.703	1.123
CD (0.05)	0.884	0.897	0.165	1.425	2.277
Method of application					
M_1 - Soil application	41.11	47.31	3.22	68.80	160.44
M_2 – Soil + foliar application	37.29	49.84	2.90	55.31	145.33
SEm (±)	0.436	0.442	0.081	0.703	1.123
CD (0.05)	0.884	0.897	0.165	1.425	2.277

Table 4. Effect of irrigation, nitrogen levels and method of application on uptake of phosphorus, kg ha^{-1}

Treatments	Leaf (source)	Stem	Root	Pod (sink)	Total
Irrigation Levels					
I_1 - Daily at 10 mm depth	3.10	7.98	0.35	6.23	17.66
I_2 – Alternate days at 20 mm depth	3.17	6.42	0.31	5.80	15.71
I_3 - Once in three days, 20 mm depth	3.92	5.74	0.38	7.41	17.46
I_4 - I_3 up to flowering followed by I_2	3.38	5.91	0.25	5.89	15.44
SEm (±)	0.048	0.123	0.009	0.114	0.093
CD (0.05)	0.109	0.277	0.020	0.257	0.211
Nitrogen Levels					
N_0 – Recommended N dose	3.11	5.65	0.34	6.01	15.11
N_1 - - 25 % Recommended dose	3.68	7.38	0.30	6.65	18.02
SEm (±)	0.037	0.065	0.012	0.067	0.113
CD (0.05)	0.075	0.132	0.024	0.136	0.228
Method of application					
M_1 - Soil application	3.89	6.05	0.34	6.77	17.05
M_2 – Soil + foliar application	2.90	6.98	0.30	5.89	16.08
SEm (±)	0.037	0.065	0.012	0.067	0.113
CD (0.05)	0.075	0.132	0.024	0.136	0.228

Table 5. Effect of irrigation, nitrogen levels and method of application on uptake of potassium, kg ha^{-1}

Treatments	**Leaf (source)**	**Stem**	**Root**	**Pod (sink)**	**Total**
Irrigation Levels					
I_1 - Daily at 10 mm depth	47.31	69.67	4.27	38.14	159.40
I_2 – Alternate days at 20 mm depth	32.45	60.22	2.97	41.21	136.85
I_3 - Once in three days, 20 mm depth	36.45	78.33	4.15	41.29	160.23
I_4 - I_3 up to flowering followed by I_2	25.84	63.58	3.15	41.68	134.26
SEm (±)	0.474	1.178	0.117	0.760	0.984
CD (0.05)	1.071	2.664	0.264	1.719	2.226
Nitrogen Levels					
N_0 - RD N	38.33	67.57	3.83	44.07	153.81
N_1 - 25 % less of RD N	32.70	68.33	3.44	37.09	141.56
SEm (±)	0.446	0.668	0.133	0.467	1.106
CD (0.05)	0.904	NS	0.270	0.946	2.242
Method of application					
M_1 - Soil application	36.19	72.04	3.91	40.40	152.55
M_2 – Soil + foliar application	34.84	63.86	3.36	40.75	142.82
SEm (±)	0.446	0.668	0.133	0.467	1.106
CD (0.05)	0.904	1.355	0.270	NS	2.242

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