__Original Research Article__

Nitrogen and irrigation management practices affected the nutrient concentration of moth bean under arid ecosystem

ABSRACT

Efficient utilization of water and fertilizer is important for maximizing yield for moth bean production through improving the nutrient use efficiency under arid ecosystem. The aim of this study was to evaluate the effects of irrigation and nitrogen fertilizers on growth, yield and nutrient content of moth bean in the western zone of Rajasthan during the growing seasons of 2020 &2021. Treatments included three levels of nitrogen (N1:15 kg N as basal + foliar spray of urea (2%) at flowering stage, N:2 15 kg N + foliar spray of urea (2%) at pod development stage and N3: 15 kg N + foliar spray of urea (2%) at flowering and pod development stages) and levels three levels of irrigation (I1: single irrigation at branching stage, I2: two irrigation at branching + pod development stages and I3: two irrigation at flowering + pod development stages) were laid down in factorial combinations of randomized block design with replicated thrice. The results revealed that 15 kg N + foliar spray of urea (2%) at flowering and pod development stage recorded significantly higher nitrogen, phosphorus and potassium content in seed and haulm over 15 kg N + foliar spray of urea (2%) at flowering stage and 15 kg N + foliar spray of urea (2%) at pod development stage. However, the phosphorus content in seed and haulm was not significantly influenced by N3 and statistically equivalent with N2 and N1 during 2020 and 2021. Potassium content in seed showed significant enhancement underN3, while K content in haulm was not affected significantly during 2020 and pooled basis.Further, irrigation management practices did not show any significant improvement on N, P, K content in seed and haulm during years of 2020 and 2021. While, N content in seed and haulm was significantly improved under I2 over I3 and I1 on pooled basis. Thus, the research article investigated the influence of nitrogen levels and irrigation scheduling on nutrient concentration in moth bean in arid ecosystem.

Keywords: Nitrogen, irrigation, foliar spray, urea, nutrient content and moth bean

Introduction

Mothbean (Vigna aconitifolia) is an important leguminous crop cultivated in arid and semi-arid regions, known for its resilience and ability to thrive in low-input agricultural systems. It is native crop of Indian subcontinent and widely cultivated in India, Sri Lanka, China, Pakistan, and also grown in the South-Western states of the USA and in Canada (Kochhar, 2016; Munro *et al*., 1998).Mothbean, also known as kidney bean, dew bean, dew gram, moth, mat, mat bean. It is a drought-tolerant pulse crop cultivated for its high protein content and adaptability to adverse growing conditions. *Vigna aconitifolia* is grown from sea-level up to an altitude of 1300 m and it does outstandingly well in arid and hot regions (NARO, 2020; Kochhar, 2016; Brink *et al*., 2006). It performs better under average temperature is 24–32°C with a well-distributed annual rainfall of 500–750 mm. The plant provide yield even with as little as 50–60 mm in 3–4 showers during the growing period (Brink *et al*., 2006). Moth bean can grow on a variety of soils. However, it is particularly suitable for dry light sandy soils and does not tolerate water logging. It is somewhat salt tolerant and can grow on a wide pH range (3.5–10).Due to multipurpose use, it provides hot-season pasture and hay for livestock as well as seeds/pods for human consumption (Saravanan *et al.,* 2015). The immature pods and seeds are part of the Indian diet. The green pods can be boiled as a vegetable. At maturity, the seeds can be cooked or fried, and they can be ground and mixed with flour to make dhal and unleavened bread (Brink *et al.,* 2006). Moth bean can be grown for green manure and as a cover crop. It is capable of sustaining under long dry spells and high temperatures beyond 40°C. Thus, the erratic and low rains hardly 130 mm with long dry spells of 30-35 days interval between two rain and high temperatures beyond 40°C during crop season affect its growth and productivity drastically often restricting the productivity much below its potential (>200 Kg/ha).Plants cannot take up all the nitrogen applied to the soil as a fertilizer leading to runoff and groundwater contamination. Thus, nitrogen management in light soils needs careful attention due to high potentials for leaching losses of nitrate with water flow. The sandy soils have low water holding capacity which favors the negative charged nitrate (NO_3^-) ions to leach in deeper layer below the root zone in light sandy soils. The soil organic matter content in light textured soil is generally lower then from fine textured soil. The SOM content is the mains source of nitrogen which supplies nitrogen slowly to the crops as per their demand. The SOM content in soils is space for holding the water and nutrient in the soil and supplying the nutrient to soil solution as per need of the crops. Nitrogen availability is often a limiting factor for high productivity in legume crops. Hence, nitrogen fertilizers are commonly applied to legume crops in countries where they are readily available.The crop yield drastically decreases either under excess water as well as water deficit conditions. Water stress is more common and important in the rain fed arid conditions that reduce the productivity of crops. Water stress during the active crop growth phase results into cessation of growth as it influences the photosynthesis and other physiochemical processes and or death, by desiccation. Irrigation management strategies have become more vital aspect of research in arid region to improve the productivity. The ideal scheduling of irrigation enhances the crop yield though efficient utilization of irrigation water on most critical stages under water stress situation which is depends upon the soil, climate and plant characteristics. Water stress reduced the total chlorophyll and relative water content significantly in different genotypes of moth bean and reduction was more pronounced in late flowering genotypes (Garg *et al*., 2004). The overall objective of this work is to improving nutrient content through enhancing nutrient use efficiency with better agronomic management practices in moth bean. This would be a major advance in profitability for the moth bean industry in India and would significantly improve the ecological footprint of the crop.

Material and methods: -

A field experiment conducted to evaluate the effect of nitrogen levels and irrigation scheduling on nutrient content (N, P, & K) of moth bean under hyper arid condition of western Rajasthan during kharif 2020 and 2021 at Bikaner. The regioncomes underagro climatic zone “hyper arid partially irrigated western plain” of Rajasthan. It is situated at $28^0$10’ N latitude, $73^0$18’ E longitude and 223.88 meter above mean sea level. The experimental location is characterized by typically tropical arid climate with very hot and dry summer with an average temperature of 40^o c and relative humidity of 10-20 % (March-June), cool winteraverage minimum temperature 4°C and average maximum relative humidity 70% (October to February) and wet monsoon season (July to Sept). The average annual rainfall is 300 mm of which 90% is received in monsoon season (July to Sept). The meteorological data prevailing, during the experimental period, are shown in Fig 1. Before the commencement of the experiment, soil sampling was done in a zigzag pattern from a depth of 15 cm. The chemical properties of the soil are as low in organic carbon&nitrogen, medium in phosphorous and high in potassium.The moth bean was sown in lines with spacing 30x10 (30cm row to row and 10 cm plant to plant) using seed rate of 15 kg ha^{-1}. Prior to sowing, recommended dose of mineral NP fertilizers were applied as basal application using Urea and Di-ammonium phosphate at rates of 15 kg N/ha and 40 kg P_2O_5/ha. Nitrogen applied to all the plot at uniform dose of 15 kg N ha^{-1} through DAP as basal application at the time of seeding followed by spray of urea as per the proposed treatment at different growth stages. The size of the plots was 32.4 m^2 (6.0x5.4 m) and net plot size for observation was 16.8 m^2 (4.2x4 m)maintained with double bunds (1 m wide) boundaries which were compacted to reduce the lateral movement of irrigation.Irrigations was applied in each experimental unit through surface flood irrigation, which involved delivering water to the experimental units by sub water channels from main water channels. Pendimethalin was applied a pre-emergence herbicide followed by hand weeding at 30-35 DAS to control weeds, While, all other agriculturalpracticeswereuniform across the experimental treatments except for irrigation. For plant chemical analysis the seed and haulm samples collected at harvest were oven dried at 70ºC till constant weight was achieved. The dried samples were finely ground and passed through 40 mesh sieve and used for determination of nutrient content (N, P, K) as per method furnished in Table 1.

Table 1. Chemical methods for plant nutrient analysis

S. No.	Nutrient	Method	Reference
1.	Nitrogen	Nesseler's reagent colorimetric method	Lindner (1944)
2.	Phosphorus	Ammonium Vanadomolybdo-phosphoric acid yellow colour method	Richards (1968)
3	Potassium	Triple acid digestion method	(Jackson 1973)

A two-way ANOVA on observed traits, including nitrogen phosphorus and potassium content in seed and haulm were performed to compare the effect of nitrogen application and irrigation scheduling in mothbean.All effects were statistically significant at the 0.05 level of significance.

Result and discussion: -

Nitrogen content: -

N content in seed: -

Nitrogen management options significantly affected N content in seed of moth bean (Table 2). The treatment N3(15 kg N ha^{-1} + 40 kg P_2O_5 with foliar spray urea @ 2% at flowering and pod development stages) recorded significantly maximum value of N content in seed during both the years of experimentation and pooled basis, which was significantly higher by 7.23 5.38 & 6.35 and 8.23, 6.32 & 5.26 per cent over N2 and N1 during 2020, 2021 and pooled basis, respectively. The increment in N content might be due to more and continuous availability of nitrogen through soil and foliar application, which is associated with an increase in protoplasm, cell division, and cell enlargement, resulting in higher absorption of nutrients ((Khan *et al.,* 2018 and Pal *et.al.*, 2019). Moreover, significant variation in N content in seed was observed under irrigation scheduling practices. The N content was not enhanced significantly during both the years of experimentation. However, the N content was significantly improved under treatment I2 (irrigation at branching and pod formation stages) on pooled data basis, which was increased by 5.69 percent over I1 (irrigation at branching stage)., However, it was statistically on par with I3 (irrigation at flowering and pod development stages) on pooled basis. Adequate water management, particularly through irrigation scheduling, plays a pivotal role in optimizing crop yield and nutritional quality.The higher N, P and K content in grain with two irrigations may be due to higher soil moisture content which facilitate the nutrients to bring into soil solution. These results are in agreement with those obtained bySingh *et al*. 2018 and Maske *et al.*, 2020.

N content haulm: -

The N content in haulm was significantly influenced by different nitrogen management levels. The higher value of N content in haulm recorded with N3 (15 kg N ha^{-1} + 40 kg P_2O_5 with foliar spray urea @ 2% at flowering and pod development stages). The percent increase in the N content was 6.69, 8.52 &7.74 and 5.41, 7.50&6.42 % over N1 and N2 during 2020, 2021 and pooled basis, respectively. The N content in haulm increased with higher nitrogen rate might be primarily due to an increase in the chlorophyll content of leaves, which leads to a higher photosynthetic rate, and ultimately plenty of photosynthates available during grain development (El-Sanatawy*et al.* 2012).Further, irrigation scheduling approaches was not showed any significant variation on N content in haulm during both the years of experimentation. While irrigation practices were significantly improved the N content on pooled data basis. The maximum value of N content recorded under treatment I2 (Irrigation at branching and pod formation stages) which was significantly higher by 8.12 percent over I1 (irrigation at branching stage). However, it was statistically equivalent with I3 (irrigation at flowering and pod development stages) on pooled basis.The increase in N content in haulm may be due to more availability of N in soil solution with two irrigations. The observed results are in close conformity those of Paramesh *et al.,* 2014 and Maske *et al.,* 2020.

Table 2 Effect of nitrogen and irrigation management on nitrogen content in grain and haulm of moth bean

Treatments	Grain	Haulm

	2020	2021	Pooled	2020	2021	Pooled
Nitrogen Management						
N1	3.29b	3.17b	3.23b	1.90b	1.83b	1.87b
N2	3.33b	3.20b	3.27b	1.93ab	1.85b	1.89b
N3	3.51a	3.44a	3.48a	2.03a	1.96a	1.99a
Irrigation Management						
I1	3.27a	3.14a	3.20b	1.90a	1.83a	1.87b
I2	3.49a	3.43a	3.46a	2.01a	1.92a	1.97a
I3	3.38a	3.24a	3.31a	1.95a	1.88a	1.92a

Phosphorus content: -

P content in seed: -

Nitrogen management levels recorded significant improvement in P content in grain of moth bean (Table 2). The P content in grain was not significantly influenced under different nitrogen management options during both the years of experimentation, however, pooled data shows significant improvement in P content of grain with N3 (15 kg N ha^{-1} + 40 kg P_2O_5 with foliar spray urea @ 2% at flowering and pod development stages) over N2 (15 kg N ha^{-1} + 40 kg P_2O_5 with foliar spray urea @ 2% at pod development stage) and N1 (15 kg N ha^{-1} + 40 kg P_2O_5 with foliar spray urea @ 2% at flowering stage).Nitrogen, obtained through nitrogen fixation and soil uptake, serves as a catalyst for various metabolic processes that contribute to enhanced phosphorus uptake, transport, and incorporation into seeds. These results are in line with Britz*et. al*. 2023

Further, irrigation management option did not show any significant impact on P content in grain of moth bean during both the years as well as pooled basis.

P content in haulm: -

Different nitrogen management options were significantly influenced the P content in grain of moth bean (Table 2). On the pooled basis, the treatment N3 (15 kg N ha^{-1} + 40 kg P_2O_5 with foliar spray urea @ 2% at flowering and pod development stages) was significantly enhanced the P content in haulm b 28.57 and 8.00 percent over N1 and N2 respectively.While, P content was not significantly affected in individual year of 2020 and 2021. Adequate nitrogen supply can enhance the overall nutrient status of the plant, potentially improving the uptake and translocation of potassium. This result is consistent with the findings of Coblentz *et.a.l.*, 2004 and Xie *et al.*,2015.Moreover, Irrigation scheduling practices did not express any significant improvement in P content in haulm during both the year as well as pooled basis.

Table 3 Effect of nitrogen and irrigation management on phosphorus content in grain and straw of moth bean

Treatments	Grain			Haulm		
	2020	2021	Pooled	2020	2021	Pooled
Nitrogen Management						
N1	0.43a	0.39a	0.41b	0.22a	0.20a	0.21b
N2	0.47a	0.43a	0.45ab	0.26a	0.24a	0.25a
N3	0.51a	0.49a	0.50a	0.28a	0.26a	0.27a
Irrigation Management						
I1	0.46a	0.43a	0.45a	0.23a	0.21a	0.22a
I2	0.49a	0.47a	0.48a	0.27a	0.25a	0.26a
I3	0.45a	0.41a	0.43a	0.25a	0.24a	0.25a

Potassium content: -

K content in seed: -

Significant improvement in K content grain was recorded under different nitrogen levels applied on moth bean (Table 3). The K content in grain was significantly enhanced under the treatment of N3 (15 kg N ha^{-1} + 40 kg P_2O_5 with foliar spray urea @ 2% at flowering and pod development stages), which was significantly higher by 23.33, 23.08& 28.00% and 15.62, 14.29&16.67 % over N1 an N2 during 2020, 2021 and pooled basis, respectively. However, N2 statistically equivalent with N3 during the 2020 and pooled basis. Adequate nitrogen supply can enhance the overall nutrient status of the plant, potentially improving the uptake and translocation of potassium (Khan *et al.,* 2018). Additionally, irrigation management practices were not influenced the K content of moth bean during both the years of experimentations as well as pooled data basis.

K content in haulm: -

Nitrogen management levels observed the significant increment in the K content in the haulm of moth bean. The treatment N3 (15 kg N ha^{-1} + 40 kg P_2O_5 with foliar spray urea @ 2% at flowering and pod development stages) registered significantly higher K content in haulm over N2 an N1 during 2021. The increment in the K content was 7.81&4.54 % higher over N1 and N2, respectively. While, nitrogen levels did not show any significant improvement in the K content during 2020 and pooled basis. In addition, irrigation scheduling approaches were not proved any significant improvement in K content in haulm of moth bean.

Table 4 Effect of nitrogen and irrigation management on potassium content in grain and haulm of moth bean

Treatments	Grain			Haulm		
	2020	2021	Pooled	2020	2021	Pooled
Nitrogen Management						
N1	0.30b	0.26b	0.28b	0.71a	0.64b	0.68a
N2	0.32b	0.28b	0.30b	0.74a	0.66ab	0.70a
N3	0.37a	0.32a	0.35a	0.77a	0.69a	0.73a
Irrigation Management						
I1	0.32a	0.28a	0.30a	0.72a	0.65a	0.68a
I2	0.35a	0.31a	0.33a	0.77a	0.69a	0.73a
I3	0.32a	0.28a	0.30a	0.74a	0.66a	0.70a

Conclusion: -

The study indicated that 15 kg N ha^{-1} as basal application with two foliar sprays of urea of 2% recorded significantly higher nutrient concentration as compared to 15 kg N ha^{-1} with single spray of urea either at flowering or pod development stages. Further, two irrigations at branching + pod formation and flowering + pod formation were registered significant improvement in nutrient concentration over single irrigation at branching stage. Thus, it can be concluded that 15 kg N ha^{-1} with foliar spray of urea of 2 % at flowering and pod formation stages in combination with irrigations twice at branching + pod formation stages could be more beneficial to improvement in nutrient content of moth bean under arid conditions.

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