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Assessment Effect of Vermicompost on Quantitative and Qualitative Characteristics of Mung Bean (*Vigna radiata* L.) Under Different Irrigation Regime

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ABSTRACT

BACKGROUND: Vermicompost in sustainable agriculture is very useful for improving soil porosity and thereby providing more nutrients to crop.

OBJECTIVES: Current research was conducted to evaluate effect of biofertilizer (vermicompost) under different level of irrigation on crop production and protein yield.

METHODS: This study was carried out via split plot experiment based on randomized complete blocks design with four replications along 2018 year. The main factor included different interval of irrigation (I_1= 70mm, I_2= 90mm, I_3= 110mm and I_4= 130mm evaporation of Pan) and four level of vermicompost (V_1= control, V_2= 4 $t.ha^{-1}$ and V_3= 8 $t.ha^{-1}$).

RESULT: According result of analysis of variance effect of different interval of irrigation and vermicompost on all measured traits was significant, also interaction effect of treatments on seed yield, number of pod per m^2 and 100-seed weight was significant. Result of mean comparison of different interval of irrigation revealed maximum amount of number of seed per pod (7.87) and protein yield (44.1 $gr.m^{-2}$) was for 70 (mm) evaporation of pan treatment but highest amount of protein percentage (24.43%) belonged to 130 (mm) evaporation of pan. Also the maximum amount of mentioned traits was for use 8 $t.ha^{-1}$ vermocompost and minimum of those were for control. Mean comparison result of interaction effect of treatments revealed the highest amount of seed yield (250.14 $gr.m^{-2}$), number of pod per m^2 (304) and 100-seed weight (11.01 gr) were obtain for 70 (mm) evaporation of pan with use 8 $t.ha^{-1}$ vermocompost and lowest ones were for 130 (mm) evaporation of pan with nonuse of vermocompost.

CONCLUSION: The present study revealed that the use of vermicompost is useful for improve growth of mung bean under water stress situation. In order to achieve maxi-mum quantitative and qualitative yield the treatment of irrigation intervals with 90 (mm) evaporation of pan (it doesn't had significant difference with 70mm evaporation of pan) with application 8 $t.ha^{-1}$ vermicompost under water stress condition can be advised to the producers.

KEYWORDS: *Biofertilizer, Protein, Seed weight, Water stress, Yield.*

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1. BACKGROUND

The increasing need of society to food and irregular growth of the population and reduction of food sources is one of the most important issues that have attracted politicians, thinkers and researchers' attention. Iran will need food approximately 2 times more than the current figure until another 20 years with current consumption level. The population growth and economic and social development of the country in the past two decades has led to a dramatic increase in the consumption of protein, especially red meat. Accordingly, the increased production of protein substances, especially plant proteins which are more valuable sources in nutrition, is inevitable. Legumes, by having approximately 20% of protein and sometimes more, play an important role in providing the protein needed by human beings, especially in countries with low animal and agricultural products. Legumes in human nutrition can be considered as a good dietary supplement for cereals (Mahmoudi *et al*., 2016). Mung bean is one of the most important pulse crops for protein supplement in subtropical zones of the world. It is widely grown in Indian subcontinent as a short duration catch crop between two principal crops. Mung bean contains 51% carbohydrate, 24–26% protein, 4% mineral, and 3% vitamins (Afzal *et al*., 2008). Mung bean plays an important role in human feeding of developing country. The importance of this legume is related to desirable characteristics such as high protein content, broad adaptation, low need for agricultural inputs and high ability to increase the soil fertility (Makeen, 2007). Also Non-conventional sources of amending organic matter status of soil are acquiring much attention because of their easy availability, prompt response and feasibility in using over large area in less time. Excessive use of inorganic fertilizers creates environment related problems, and situation can be improved through the use of bio-fertilizers (Saadatnia and Riahi, 2009). The use of organic fertilizers like vermicompost, while maintaining the environmental health, enhances product quality, soil moisture and improves the soil structure (Sharma, 2003). Vermicomposts are finely-divided mature peat-like materials with a high porosity, aeration, drainage and water-holding capacity and microbial activity which are stabilized by interactions between earthworms and microorganisms in a non-thermophilic process (Edwards and Burrows, 1988). Vermicompost has many characteristics such as high porosity, ventilation and proper drainage, high moisture absorption and maintenance power, high uptake level for water and food stuffs, and its use in sustainable agriculture is very useful to improve soil porosity and thus more availability of nutrient elements required by plants. In fact, the superiority of vermicompost compared to other organic fertilizers is that its structure has changed well and the number of plant pathogenic microorganisms in it has strongly decreased (Claudio *et al*., 2009). The yield increase is probably due to high amount of available nitrogen which is essential for the production of structural proteins. In addition to nutritional elements and organic materials, vermicompost contains a large quantity of humic substances that these materials enhance plant growth and yield through improving bioavailability of certain nutritional elements, especially iron and zinc (Chen *et al*., 2004). The use of vermicompost has positive effects on crop yield. The favorable effect of vermicompost is probably due to the relatively higher amounts of nutritional elements and hence the increase in availability of macro and micro nutritional elements (Jat and Ahlawat, 2008). The most valuable feature of vermicompost is in the performance of enzymes, microorganisms and different hormones in it. Vermicompost has enzymes such as protease, amylase, lipase, cellulase and Pectinase that have an effective role in decomposition of organic matter in the soil and thus making available the nutrients required by plants and enhance the performance by providing a suitable growth medium (Jat and Ahlawat, 2006). Suhane *et al*. (2008) reported that the use of only 2.5 $t.ha^{-1}$ vermicompost wheat farm has a better result compared to use chemical fertilizers. Vermicompost could also reduce plant's water requirement by about 30 to 40%. The use of vermicompost increases protein yield, probably this increase is due to the relatively higher amounts of nutrients and increased grain yield (Jat and Ahlawat, 2008). The use of vermicompost has positive effects on the amount of protein and nutrient uptake by the plant. The favorable effect of vermicompost is probably due to relatively higher amounts of nutritional elements and hence increase in availability of macro and micro nutrients which leads to increased protein percentage (Jat and Ahlawat, 2008). The addition of vermicompost to soil increased availability of the nutrients, and also improves the physical and vital processes of the soil, and provides optimum environment for root growth to increase biological yield. Some researchers reported that the use of vermicompost (due to the presence of fungi, bacteria, yeast, and actinomycetes that have microbial activity) improves the nutritional elements through hormones such as auxin, gibberellin, cytokinin and ethylene, have a positive effect on growth and yield, so the use of 10 $t.ha^{-1}$ vermicompost increased the biological yield (Singh, 2000). Water is about to become increasingly limited for crop production (Martineau *et al*., 2017). In arid and semi-arid areas of the world, water is the principal limiting factor of agricultural production primarily due to low and/or uneven distributions of annual rainfall (Keshavarz Afshar *et al*., 2014). Water deficit stress causes an increase in solute concentration in the soil and root zone environment leading to an osmotic flow of water out of plant cells. This in turn causes the solute concentration inside plant cells to increase, thus lowering water potential and disrupting membranes along with essential processes like photosynthesis. This drought stressed the plants consequently exhibit poor growth and yield (Moser *et al*., 2006). Drought is one of the factors which threaten agriculture products in most parts of the world (Abolhasani and Saeidi, 2004). It causes stress in plants and is not only caused by the reduction of rainfalls and great heat, but in the cases where there is moisture in the soil, this moisture cannot be used for plants for some reasons such as excessive soil salinity or soil frost, and plants will be stressed (Baydar and Erbas, 2005). Drought and water shortage are considered an objective reality. In the past, water crisis was not as significant as today, since the population was less, but with the population increase by about six times and the need for more food during the last 100 years, the incidence of this crisis has become more evident than the past (Chimenti *et al*., 2002). Water deficit stress is one of the main obstacles in the production of horticultural and field crop in many parts of the world, especially in arid and semi-arid areas like Iran (Sadeghipour, 2009). Zabet and Hosseinzade (2011) reported that the reduction in plant height and number of nodes per stalk cause drought stress decreases cellular proliferation and vegetative growth of the plant and thereby reduction of plant's biological yield. The drought stress and reduction of leaf area through reducing cell divisions, turgor, enlargement and impact on whole plant growth, reduction of plant height and leaf loss, as well as decrease in stomatal conductance for avoiding waste of water and thus attracting less carbon dioxide and effect of stress on chlorophyll decrease Photosynthesis. The researchers concluded that the lack of water after flowering stage severely affect the growth and development of reproductive organs and reduce the seed yield (Gholinejad *et al*., 2009). The yield of crops under drought stress conditions is due to the achieved improvement in physical and chemical properties of soil as a result of the use of vermicompost biofertilizers (Rahbarian *et al*., 2010). Increasing the yield requires the use of proper agricultural management in each region and the knowledge of physiological relationships of plant with the agricultural systems (Hassani *et al*., 2015). Arsalan *et al*. (2016) investigated effect of different level of vermicompost (control and 2 $t.ha^{-1}$) on growth and nutrient uptake in mung bean and reported maximum seed yield, number of pod per plant and number of seed per pod and plant height was obtained from use 2 $t.ha^{-1}$ vermicompost treatment and the least of these traits were obtained from control.

2. OBJECTIVES

Current research was conducted to evaluate effect of biofertilizer (vermicompost) under different level of irrigation on crop production and protein yield.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This study was carried out to evaluate effect of different irrigation regime and biologic fertilizer on quantitative and qualitative traits of Mung bean via split plot experiment based on randomized complete blocks design with four replications along 2018 year. Place of research was located in Hamydieh region at longitude 48°10'E and latitude 31°33'N in Khuzestan province (Southwest of Iran). The main factor included different interval of irrigation (I_1= 70mm, I_2= 90mm, I_3= 110mm and I_4=

130mm evaporation of Pan) and four level of vermicompost (V_1= control, V_2= 4 $t.ha^{-1}$ and V_3= 8 $t.ha^{-1}$). This experiment had 36 plots. Each plot consisted of 6 lines with a distance of 50 cm and 5 meters length. The distance between the bushes on every row was 15 cm.

3.2. Farm Management

Base fertilizers (50 $kg.ha^{-1}$ Nitrogen from urea, 80 $kg.ha^{-1}$ phosphorus from ammonium phosphate and 80 $kg.ha^{-1}$ potassium from potassium sulfate) were added to the soil based on soil tests and the recommendations of the Iranian Soil and Water Research Institute at the planting stage. All vermicompost fertilizer was applied in the above treatments before sowing at a depth of 15 to 20 cm. After fertilization, the soil was mixed with soil by disk. The first irrigation was done one day after planting. After the four-leaf stage, subsequent irrigation was carried out according to the irrigation treatments based on the plot map. Weed weeding was done manually after seed germination and plant stem elongation. Physical and chemical properties of the studied field and vermicompost were mentioned in table 1 and 2, respectively.

Table 1. Physical and chemical properties of studied field

Depth of soil (cm)	Soil texture	Organic carbon	EC ($ds.m^{-1}$)	pH	N (ppm)	P ($mg.kg^{-1}$)	K ($mg.kg^{-1}$)
0-30	Clay loam	0.32	4.21	7	5.52	8.8	198

Table 2. Physical and chemical properties of vermicompost

Moisture (%)	EC ($ds.m^{-1}$)	pH	Mn ($mg.kg^{-1}$)	Zn ($mg.kg^{-1}$)	Fe ($mg.kg^{-1}$)	N (٪)	K (٪)	P (٪)
25	2.9	6.9	21	33	44	4.96	3.19	0.61

3.3. Measured Traits

In order to determine seed yield and its components, two edge lines and half meter the top and bottom all lines were removed as marginal effects. So final harvest took place on November 20, 2018 in an area of one and a half square meters in every plot. To obtain the number of seed per pod, 20 pods selected and after counting all seeds, from divided number of seeds on number of pods, number of seed per pod calculated. After physiological ripening number of pods per m^2, number seed per pod, 100-seed weight, seed yield, protein percentage and protein yield was determined. In order to measure 100-grain weight, five samples were randomly separated from each sample and after weighing by digital scales with an accuracy of one-hundredths, the average of samples were considered as 100-grain weight. Nitrogen content of the seeds was measured with the Kjeldahl method (included nitrogen digestion, distillation and titration). So, to calculate the protein percentage the following formula was used (Bremner *et al.*, 1983):

Equ. 1. Protein percentage= Nitrogen percentage × 5.8.

Protein yield was achieved by multiplying protein content by seed yield (Linn and Martin, 1999).

3.4. Statistical Analysis

Data were analyzed with SAS (Ver.8) statistical software. After analysis of variance, means were compared by using the Duncan test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Seed yield

According result of analysis of variance effect of irrigation intervals, vermicompost and interaction effect of treatments on seed yield was significant at 1% probability level (Table 3). Evaluation mean comparison result of interaction effect of treatments indicated maximum seed yield (250.14 $gr.m^{-2}$) was noted for 70 mm evaporation of pan with 8 $t.ha^{-1}$ vermicompost and lowest one (73.16 $gr.m^{-2}$) belonged to 130 mm evaporation of pan with nonuse of vermicompost treatment (Table 4). In the present study, water deficit stress at flowering stage and pod formation led to reduce flower and pod. Also, seed weight is reduced due to lack of sufficient moisture in grain filling period. Overall, reduction of these traits resulted in a decrease in seed yield. In other words, by using vermicompost fertilizer can improve soil water retention, uptake nutrition, permeability and microbial activity in the root zone. So that matter increase the tolerance of the mung bean plant to cutting water. Application of vermicompost fertilizer in addition to supplying a large portion of plant nutrients was also moderating the negative effects of water deficit stress. By reducing these negative effects it can be able to produce the product and maintain the performance to an acceptable level, which was consistent with the results of this study. Mentioned results of current research were consistent with another researcher such as Biswash *et al*. (2014) and Rahimi and Hashemi *et al*. (2016). Dhakal *et al*. (2015) reported application of 2.5 $t.ha^{-1}$ vermicompost significantly increased chlorophyll index, dry matter, seed yield and harvest index in mung bean.

Table 3. Result analysis of variance of measured traits

S.O.V	df	Seed yield	No. pod per m^2	No. seed per Pod	100-seed weight	Protein percentage	Protein yield
Replication	3	1015.2^{ns}	401.31^{ns}	0.032^{ns}	1.18^{ns}	2.47^{ns}	58.39^{ns}
Irrigation intervals (I)	3	26993.7**	9368.4**	9.01*	12.24*	18.55*	657.1**
Error I	9	401.35	468.37	2.57	3.66	5.06	42.11
Vermicompost (V)	2	15848.62**	4801.75**	5.80*	9.15*	20.04*	721.3**
I×V	6	3704.51**	3640.19**	0.04^{ns}	6.1*	1.62^{ns}	9.66$^{n.s}$
Error II	24	157.66	325.94	1.26	1.15	3.77	15.51
CV (%)	-	8.03	8.2	11.22	13.4	8.87	11.35

$^{ns, * and **}$: Non–significant and significant at 5% and 1% probability levels, respectively.

4.2. Number of pods per m²

Result of analysis of variance revealed effect of irrigation intervals, vermicompost and interaction effect of treatments on number of pods per m^2 was significant at 1% probability level (Table 3). According mean comparison result of interaction effect of treatments maximum of number of pods per m^2 (304) was obtained for 70 mm evaporation of pan with 8 $t.ha^{-1}$ vermicompost and minimum of that (10.09 cm) was for 130 mm evaporation of pan with nonuse of vermicompost treatment (Table 4). Hosseinzadeh *et al*. (2017) reported that the application of vermicompost in non-stress conditions led to a significant increase in the number of pods per plant trait. Results of current research were consistent with of another researcher such as Mojaddam *et al*. (2014) and Najarian *et al*. (2016).

4.3. Number of seed per pod

According result of analysis of variance effect of irrigation intervals and vermicompost on number of seed per pod was significant at 5% probability level but interaction effect of treatments was not significant (Table 3). Mean comparison result of different level of irrigation intervals indicated that maximum number of seed per pod (11.53) was noted for 70 mm evaporation of pan and minimum of that (7.87) belonged to 130 mm evaporation of pan (Table 5). It seems crop affected drought stress during flowering stages due to the short flowering period and sterility of some of their flowers due to pollen germination and lack of proper fertilization led to reduce the number of pods and seeds compared to normal conditions (Najarian *et al*., 2016).

Table 4. Mean comparison interaction effect of treatments on seed yield, number of pod per square meter and 100-seed weight

Irrigation intervals	Vermicompost	Seed yield ($gr.m^{-2}$)	No. pod per m^2	100-seed weight (gr)
70 mm evaporation from the pan	Control	185.8^{c}	210^{*d}	8.41^{c}
	4 $t.ha^{-1}$	202.32^{b}	264^{b}	9.45^{b}
	8 $t.ha^{-1}$	250.14^{a}	304^{a}	11.01^{a}
90 mm evaporation from the pan	Control	158.03^{d}	200^{d}	7.53^{de}
	4 $t.ha^{-1}$	191.11^{bc}	232^{c}	9.14^{b}
	8 $t.ha^{-1}$	242.31^{ab}	298^{ab}	10.92^{ab}
110 mm evaporation from the pan	Control	105.05^{f}	180^{ef}	6.02^{f}
	4 $t.ha^{-1}$	120.1^{e}	200^{d}	7.32^{e}
	8 $t.ha^{-1}$	152.12^{d}	228^{c}	7.71^{d}
130 mm evaporation from the pan	Control	73.16^{h}	158^{g}	5.19^{g}
	4 $t.ha^{-1}$	87.22^{g}	179^{f}	6.11^{f}
	8 $t.ha^{-1}$	111.12^{ef}	190^{e}	7.28^{e}

*Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level.

On the other hand, appropriate moisture conditions caused the plant to grow longer and to increase the pod filling period. So this condition led to improve filling of the pods more favorable, so the number of seed per pod increased. Sadeghipour and Aghaei (2014) reported an increase in number of seeds per pods under non-stress conditions than to stress situation was 25.64%. That matter was related to more photosynthesis and greater transfer of photosynthetic material to the seeds. As for Duncan classification made with respect to different level of vermicompost maximum and minimum amount of number of seed per pod belonged to 8 $t.ha^{-1}$ (10.57) and control (9.41) (Table 5). In this study, it seems that the use of vermicompost fertilizer by increase the amount of carbon and nitrogen in the soil led to increase the population and activity of beneficial soil microorganisms and provides plant access to nutrients, phosphorus and potassium. So these factors improve the overall vegetative and reproductive growth of plants. In this regard, Jahangiri Nia *et al*. (2016) reported that the application of vermicompost fertilizer in addition to supplying a large portion of plant nutrients was also involved in moderating the negative effects of water stress and by reducing these negative effects led to improve number of seeds per pod in stress situation.

4.4. 100-seed weight

Result of analysis of variance revealed effect of irrigation intervals, vermicompost and interaction effect of treatments on 100-seed weight was significant at 5% probability level (Table 3). Evaluation mean comparison result of interaction effect of treatments indicated maximum seed yield (11.01 gr) was noted for 70 mm evaporation of pan with 8 $t.ha^{-1}$ vermicompost and lowest one (5.19 gr) belonged to 130 mm evaporation of pan with nonuse of vermicompost treatment (Table 4). It seems vermicompost fertilizer with pith-like materials and with high aeration and water holding capacity, high nutrient absorption levels increased plant growth and consequently 100-seed weight. Also, using vermicompost fertilizer under moisture stress conditions can reduce the adverse effect of water interruption on the crop. Another researcher such as Biswash *et al*. (2014), Ahmad *et al*. (2015) and Abdoul Karim *et al*. (2018) report same result.

4.5. Protein percentage

According result of analysis of variance effect of irrigation intervals and vermicompost on protein percentage was significant at 5% probability level but interaction effect of treatments was not significant (Table 3). Compare different level of irrigation intervals showed that the maximum and the minimum amount of protein percentage belonged to 130 mm evaporation of pan (24.43%) and 70 mm evaporation of pan (20.04%) treatments (Table 5). In the present study, drought stress increased seed protein percentage. Under drought stress, due to the shortening of grain filling period, the photosynthetic material transfer to the seed is reduced and starch content storage decreases, so that matter led to decreases the seed size and increases the percentage of protein. Also in stress conditions, the crop by increases the amount of soluble proteins by producing stress-tolerant proteins (De-Mejia *et al*., 2003). Between different levels of vermicompost the maximum protein percentage (23.34%) was observed in 8 $t.ha^{-1}$ and the lowest one (20.08%) was found in control treatment (Table 5). Daniel and Triboi (2008) reported drought stress led to increased seed protein percentage than to normal conditions. Because of the decrease in photosynthetic material transport led to reduce the ratio of starch endosperm volume to total seed volume. In this study, it seems that increasing seed protein percentage in use vermicompost treatment may be due to mineralization process of nitrogen and release of nitrogen in soil and appropriate moisture.

Table 5. Mean comparison effect of treatments on number of seed per pod, protein percentage and protein yield

Treatments	No. seed per pod	Protein percentage	Protein yield ($gr.m^{-2}$)
Irrigation intervals			
70 (mm) evaporation of pan	11.53[*a]	20.04[c]	44.1[a]
90 (mm) evaporation of pan	11.03[a]	20.25[c]	34.28[b]
110 (mm) evaporation of pan	9.58[b]	22.78[b]	30.32[c]
130 (mm) evaporation of pan	7.87[c]	24.43[a]	25.01[d]
Vermicompost			
Control	9.41[b]	20.08[b]	22.15[c]
4 $t.ha^{-1}$	10.11[ab]	22.21[ab]	34.69[b]
8 $t.ha^{-1}$	10.57[a]	23.34[a]	47.17[a]

*Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level.

4.6. Protein yield

Result of analysis of variance indicated effect of irrigation intervals and vermicompost on protein yield was significant at 1% probability level but interaction effect of treatments was not significant (Table 3). Mean comparison result of different level of irrigation intervals indicated that maximum protein yield (44.1 $gr.m^{-2}$) was noted for 70 mm evaporation of pan and minimum of that (25.01 $gr.m^{-2}$) belonged to 130 mm evaporation of pan (Table 5). Compare different level of vermicompost maximum and minimum amount of protein yield belonged to 8 $t.ha^{-1}$ (47.17 $gr.m^{-2}$) and control (22.15 $gr.m^{-2}$) (Table 5). Shadab Niazi *et al*. (2017) by evaluate effect of different level of vermicompost (0, 2.5 and 5 $t.ha^{-1}$) on mung bean, reported highest protein yield and seed yield were obtained from 5 $t.ha^{-1}$ vermicompost and the least of these traits were due to non-use of vermicompost.

5. CONCLUSION

The present study revealed that the use of vermicompost is useful for improve growth of mung bean under water stress situation. In order to achieve maximum quantitative and qualitative yield the treatment of irrigation intervals with 90 (mm) evaporation of pan (it doesn’t had significant difference with 70mm evaporation of pan) with application 8 $t.ha^{-1}$ vermicompost under water stress condition can be advised to the producers.

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FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

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