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Effect of Potassium on Growth, Yield and Quality of Mungbean under Different Irrigation Regimes

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ABSTRACT: Effect of potassium on growth, yield and quality of mungbean ((*Vigna radiata* L.) under different irrigation regimes was studied at the Research Farm, Department of Agronomy, University of Agriculture Faisalabad, Pakistan. The field experiment was carried out in May-August 2015 using randomized complete block design with split plot arrangement having three replications with net plot size of 5 m × 1.8 m. Crop variety NIAB-MUNG 2011 was used as test crop. The treatments were comprised of different irrigation regimes at different growth stages; no stress (control), skipping one irrigation at vegetative growth stage, skipping one irrigation at flowering stage, skipping one irrigation at pod formation stage and different doses of potassium viz, 0, 15, 30 and 45 kg ha^{-1} respectively. To study the economic feasibility of the treatments economic analysis was done. Results showed that number of pods per plant, number of seeds per pod (6.33), 1000-grain weight, seed yield, biological yield and harvest index (31.03), plant height at maturity, number of pod bearing branches (9.00) were statistically significant in treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})]. Protein contents, leaf area index, leaf area duration, crop growth rate, net assimilation rate and benefit cost ratio (1.80) were statistically significant in the same treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) x (one and half recommended dose of potassium (45 kg ha^{-1})]. It was concluded from experiment that better mungbean yield was harvested with more net return when potassium was applied in soil @ 45 kg ha^{-1} and when there was no water stress.
Keywords: mungbean, potassium, irrigation regimes, growth, yield, quality

INTRODUCTION

Pulses are important food crops and also a cheap source of protein. Mungbean (*Vigna radiata* L.) is an important summer pulse crop of Asia and main component of many cropping systems as well. Mungbean is an ancient crop in Asian countries for its dietary value (Shanmugasundaram, 2004). It is a subtropical drought tolerant crop with a short growing season. Pulses are an important part of profitable agriculture in Pakistan because a large section of population has to rely on this as it is low priced source of protein (Usman *et al*., 2007). Mungbean holds a vital position in grain legumes in Asia (Quddus *et al*., 2011). It is also grown traditionally in Pakistan (Abbas *et al*., 2011). Mungbean grains are cooked as vegetable and its vegetative parts are used as

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feed for livestock. Mungbean has the ability to fix atmospheric nitrogen biologically @ 63-342 kg ha^{-1} (Mahmood and Athar, 2008; Mandal *et al*., 2009; Kaisher *et al*., 2010). Unavailability of crop nutrients is the major constraint in crop production. In most of the soils deficiency of both macro and micro nutrients have been reported, which could be achieved by various nutrient management practices (Ali *et al*., 2008). Application of sulphur containing fertilizers can result in soil acidification and ultimately it may affect the nutrient uptake (Havlin *et al*., 2007).

From different soil fertility surveys it is cleared that among the essential nutrient elements like N, P, K, S, Mg etc, and our soils are deficient 100 % in N and up to 90 % in P (Anonymous, 2000). In addition to being an essential source of carbohydrates and proteins, leguminous plant also reported to a good source of minerals. The mineral content of legumes is generally high (Sandberg, 2002). Its seed contains 24.5 % protein and 59.9 % carbohydrate. It also contains 75 mg calcium, 8.5 mg iron, and 49 mg β-carotene per 100 g of split dal (Afzal *et al*., 2004). Typically the yield of mungbean is quite low in Pakistan mainly due to poor crop stand establishment, unavailability of high yielding varieties, imbalanced nutrition etc. Yield and quality of mungbean can be improved by using improved cultivars and balanced fertilizers. Nutrient deficiency is a major factor of lower yield of pulses (Quddus *et al*., 2011). The average yields of mungbean are relatively low that requires attention. Among different factors, balanced fertilizer use has primary importance. Growth of mungbean has been improved by the application of nitrogen and phosphorus. Potassium eliminates the adverse effects of drought in legumes. It also increased the shoot growth of mungbean under water stress conditions. Potassium, among macro nutrients, plays an important role in protein synthesis, activation of different enzymes, photosynthesis and resistance against pest attack and diseases (Arif *et al*., 2008). It is an important macro nutrient in plant growth and sustained crop production (Baligar, 2001) and plays role in the maintenance of cell turgor pressure necessary for cell expansion, assists in stomata regulation and osmo-regulation of plant cells (Yang *et al*., 2003) and also involves in the activation of more than 60 enzymes (Bukhsh *et al*., 2011). Among the various factors affecting the yield and quality of mungbean, deficiency of potassium is progressively increasing due to the intensive cropping system. Generally our soils contain the minerals having large capacity to provide potassium to the crops. But introduction of high yielding varieties and increased cropping intensity results in considerable use of reserved potassium.

Water stress being the main limiting factor for crop production in low rainfall areas influences almost all the crop growth stages. The plant response to stress depends upon the intensity rate and duration of stress and the growth stage of crop at which stress occurs. It is necessary to understand the drought sensitive growth stages of crop and also the crop water requirements of the crop to achieve maximum yields and maintaining appropriate soil moisture conditions during moisture sensitive growth stages, so irrigation water may be reserved if soil water could be depleted, without affecting crop yield, during different growth stages. Drought is the major environmental factor limiting the growth and yield of different crops (Sangakkara *et al*., 2001). Drought affects almost all growth and developmental stages of mungbean. Mungbean under drought conditions resulted in poor seed yield. In order to obtain higher grain yields the adequate amounts of water should be applied at proper time especially on critical growth stages.

Keeping in view the above mentioned facts, this experiment was conducted to evaluate the effect of different doses of potassium on growth, yield and quality of mungbean under different irrigation regimes.

MATERIALS AND METHODS

The research studies were conducted for summer season (2015) at the Agronomic Research Area, University of Agriculture Faisalabad, Pakistan. The experimental area is located at 73º East longitude, 31º North latitude and at an altitude of 135 m above sea level. The experiment was laid out in Randomized Complete Block Design (RCBD) in split plot arrangement with three replications. The treatments were comprised of different irrigation regimes at different growth stages no stress (control), skipping one irrigation at vegetative growth stage, skipping one irrigation at flowering stage, skipping one irrigation at pod formation stage and different doses of potassium viz, 0, 15, 30 and 45 kg ha^{-1} respectively. Soil of the experimental area was quite uniform, so a composite and representative soil samples were collected with a soil auger to a depth of 30 cm immediately before sowing of crop. Soil samples were analyzed in the laboratory of Soil Sciences, University of Agriculture Faisalabad for various physico-chemical properties.

Mungbean (NIAB-MUNG 2011) was sown as a test crop in a well prepared soil in summer (27 May, 2015) with the help of single-row hand drill at 75 cm spaced rows with seed rate of 30 kg ha^{-1}. Soil samples were taken before sowing and after harvesting of the crop for its physico-chemical analysis. The seed bed was prepared by pulverizing the soil with cultivator followed by planking. Recommended dose of fertilizer were applied @ 23: 58 kg ha^{-1} N: P using urea and DAP as the sources. Potassium was applied as per treatment. Thinning of crop and necessary plant protection measures were adopted to keep crop free of weeds, insects and diseases. Crop was harvested (25 August, 2015) when about 90 percent pods were ripened. Agronomic parameters, growth parameters (LAI, LAD, CGR and NAR), water related parameters (Leaf water potential, Leaf osmotic potential and Turgor potential) and quality parameters (Seed protein content) were study in this experiment. Data recorded for the experiment were statistically analyzed by using the Fisher's analysis of variance technique and LSD test at 5% probability was used to compare the differences among treatments' means (Steel *et al.*, 1997).

Table.1. Physico-chemical Analysis of Soil

	Determination	Unit	Value
a.	**Physical Analysis**		
	Sand	%	46
	Silt	%	39
	Clay	%	15
	Texture class	Loamy soil	
b.	**Chemical Analysis**		
	Saturation	%	32
	Ph		7.69
	ECe	dSm^{-1}	2.09
	Organic matter	%	0.57

Nitrogen	%	0.042
Phosphorus	ppm	6.68
Potassium	ppm	182.9

RESULTS AND DISCUSSION

Yield contributing attributes are the most important factors that have direct contribution toward economic yield. In present study high temperature stress reduced the growth and yield of controlled plants in both the hybrids. Though foliar application of growth promoting substances increased grain yield and its attributes in each hybrid but maximum improvement was observed in PS525 where foliar spray of TRIA and MLE was applied. This was might be the impact of its genetic character and more response to growth promoting substances under heat stress conditions in late sown crop. The experimental units of spring maize hybrid PS525 exhibited improved performance almost in all attributes. Maximum number of grain rows per cob, number of grains per cob, number of grains per row, thousand grain weight, biological and grain yields were observed by foliar application of TRIA followed by MLE. Similar trend was observed in plants sprayed with MLE regarding thousand-grain weight and number of grain rows per cob.

The results of current study are in line with many other researchers who reported that TRIA application increased yield and production of many crops for example 16% increase in the production of rice was achieved (Kawashima *et al*., 1987), 12% in winter wheat and 20% in maize (Ries, 1985). This increase in yield might be due to the improved crop growth and development as a result of foliar spray of TRIA and MLE. Shahbaz *et al*. (2013) reported that TRIA is a potential plant growth regulator which has been reported to significantly affect plant growth and development ,exogenously applied TRIA has been shown to enhance growth of many crops including wheat, maize, rice (Naeem *et al*., 2009; Perveen *et al*., 2010; 2011). All the foliar spray with growth promoting substances significantly improves crop growth attributes such as leaf area index of both hybrids under late sown condition. A periodic increase was examined in maize growth and development by the exogenous application of growth enhancers in the farm of improved leaf area index of both hybrids (Fig 1). TRIA (0.1 mg L^{-1}) and 3% MLE sprays significantly improved growth and development in both hybrids even under temperature stress condition due to late sown crop and this increase might be due to higher accumulation of assimilates in the grain (Foidle *et al*., 2001; Basra *et al*., 2011). Improved physiological parameters by foliar spray of growth promoters in both hybrids might be the result of enhanced tolerance toward heat stress that result in reduced cell membrane permeability, higher relative water contents and chlorophyll contents as compared to control. Maintenance of higher RWC has been considered to be drought resistance rather than drought escape mechanism and it is consequence of adaptive characteristics such as osmotic adjustment (Grashoff and Ververke, 1991).

a). AGRONOMIC PARAMETERS

Statistically maximum number of plants (22) was produced by treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})]. The treatment I_3K_1 [(skipped one irrigation at pod formation stage) × (half dose of recommended potassium (15 kg ha^{-1})] Produced minimum number of plants (19.67). These results are in conformity with those of Thalooth *et al*., (2006) who concluded that potassium and irrigation had significant impact on number of plants (m^{-2}) of mungbean. Significantly the tallest plant (81 cm) was produced by the treatment I_3K_3 [(skipped one irrigation at pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})] and the smallest plant (51 cm) was produced by the treatment I_1K_0 [(skipped one irrigation at vegetative growth stage) × (no potassium (0 kg ha^{-1})]. Highest plant height with higher doses of potassium might be obtained due to the fact that potassium is involved in enhancing plant vigor and supports stalks. These results are in conformity with those of (Hussain *et al*., 2011) and (Thalooth *et al*., 2006) who concluded that potassium had significant impact on plant height.

Significantly, the maximum number of nodules (12.67) were produced by treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})] and minimum number of nodules (1.33) were produced by treatment I_0K_0 [(irrigation at vegetative, flowering and pod formation stage) × (no application of potassium (0 kg ha^{-1})]. Treatment I_3K_3 [(skipped one irrigation at pod formation stage) × (one and half dose of recommended potassium (45 kg ha^{-1})] produced maximum number of pod bearing branches (9.00). The treatment I_2K_0 [(skipped one irrigation at flowering stage) × (No potassium (0 kg ha^{-1})] produced minimum number of pod bearing branches (3.33). Maximum pod bearing branches might be due to the direct effect of water stress in initiation of branches in mungbean. These results are in line with those of (Fooladivanda *et al*., 2014) who concluded that potassium application and water stress had significant effect on pod bearing branches of mungbean.

The treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})] produced maximum number of pods per plant (25). Minimum number of pods (21) was produced by treatment I_3K_0 [(skipped one irrigation at pod formation stage) × (no potassium (0 kg ha^{-1})]. Maximum number of pods might be obtained due to maximum radiation use efficiency and maximum availability of reproductive sinks. These results are in conformity with those of (Omid 2008) who concluded that irrigation has significant impact on number of pods per plant of mungbean. Maximum number of pods per plant (6.33) was produced by treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})]. Maximum number of seeds might be obtained due to higher potassium application because potassium enhanced the protein synthesis which is the main reason of production of maximum number of seeds per pod. These results are in accordance with those of (Thalooth *et al*., 2006) who concluded that the interactive effect of potassium application and irrigation had significant effect on number of seeds per pod of mungbean.

The treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})] produced significantly the heaviest 1000-grain weight (43.00 g) and lightest 1000-grain weight (37.67 g) was produced by treatment I_3K_0 [(skipped one irrigation at pod formation stage) × (no potassium (0 kg ha^{-1})]. Highest 1000-grain weight might be produced due to higher potassium application because potassium increased photosynthates translocation from source to sinks and also enhanced availability of other nutrients. The results of present study regarding 1000-grain weight are in accordance with those of Fooladivanda, (2014) and Sara, (2015) who concluded that 1000-grain weight was strongly affected by severe water stress and was significantly reduced with increasing irrigation intervals and less potassium consumption as it is involved in assimilate translocation.

The Treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})] produced significantly highest seed yield (1467.90 kg ha^{-1}), biological yield (4729.63 kg ha^{-1}) and maximum harvest index. Minimum seed yield, biological yield and harvest index might be obtained due to the water stress at flowering stage which reduced number of pods per plant and number of seeds per pod and ultimately the seed yield. The results of present study regarding seed yield (kg ha^{-1}) and biological yield (kg ha^{-1}) are in conformity with those of Ibrahim *et al*. (2012), Moradi *et al*. (2008) and Fooladivanda (2014) who concluded that seed and biological yield was strongly affected by the application of potassium and water stress.

b). QUALITY PARAMETERS

PROTEIN CONTENT (%)

Significantly the highest seed protein contents (24.30 %) were received from the treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})]. Statistically the lowest seed protein contents (18.53 %) were received from treatment I_3K_0 [(skipped one irrigation at pod formation stage) × (no potassium (0 kg ha^{-1})]. The results of present study regarding seed protein content (%) are in accordance with those of Hussain *et al*. (2011) and Thallooth *et al*. (2006) who concluded that potassium and water stress had significant effect on crude protein content of mungbean.

c). GROWTH PARAMETERS

Statistically the maximum value of leaf area index (0.42) was noted in treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})]. The minimum value of leaf area index (0.16) was noted in treatment I_0K_0 [(irrigation at vegetative, flowering and pod formation stage) × (no application potassium (0 kg ha^{-1})]. These results are in line with those of Nisha *et al*. (2014) who concluded that interactive effect of potassium and water stress had significant effect on leaf area. Significantly maximum value of leaf area duration (4.63) was recorded in treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})]. However, the least leaf area duration (2.85) was recorded in treatment I_3K_0 [(skipped one irrigation at pod formation stage) × (no potassium (0 kg ha^{-1})]. Highest improvement in CGR (12.32 g m^{-2} day^{-1}) was observed in treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})]. While statistically lowest improvement in CGR (9.40 g m^{-2} day^{-1}) was found in treatment I_3K_0 [(skipped one irrigation at pod formation stage) x (no potassium (0 kg ha^{-1})] and I_2K_1 [(skipped one irrigation at flowering stage) × (half dose of recommended potassium (15 kg ha^{-1})]. The highest improvement in NAR (95.98 g m^{-2} day^{-1}) was observed in treatment I_0K_1 [(irrigation at vegetative, flowering and pod formation stage) × (half recommended dose of potassium (15 kg ha^{-1})] and the lowest improvement in

Table.2. Effect of Potassium on Yield and yield Components of Mungbean Under Different Irrigation Regimes.

Treatments	No. of Plants	Plant Height (cm)	Nodules Count	Pod bearing branches	No. of Pods per plant	No. of Seeds per pod	1000-grain wt. (g)	Seed yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
I_0K_0	21.33 **abc**	61.00 **k**	1.33 **i**	4.00 **g**	24.67 **ab**	6.00 **a**	42.67 **a**	1268.88 **b**	4659.27 **abc**	27.23 **c**
I_0K_1	21.67 **ab**	65.33 **hi**	2.67 **h**	5.33 **e**	24.67 **ab**	6.33 **a**	43.00 **a**	1464.61 **a**	4714.82 **ab**	29.65 **b**
I_0K_2	20.00 **d**	72.33 **e**	7.67 **cd**	7.67 **c**	21.67 **ghi**	4.33 **d**	38.33 **ef**	788.18 **hi**	4000.01 **g**	19.73 **j**
I_0K_3	22.00 **a**	76.67 **c**	12.67 **a**	8.33 **b**	25.00 **a**	6.33 **a**	43.00 **a**	1467.90 **a**	4729.63 **a**	31.03 **a**
I_1K_0	20.67 **bcd**	51.00 **n**	2.67 **hi**	3.00 **h**	24.00 **abcd**	5.67 **abc**	41.33 **b**	1182.97 **cd**	4577.78 **cd**	26.85 **c**
I_1K_1	20.67 **bcd**	56.00 **m**	3.33 **gh**	4.00 **g**	24.00 **abcd**	5.33 **abcd**	41.00 **b**	1125.69 **d**	4496.34 **d**	25.04 **d**
I_1K_2	21.33 **abc**	61.15 **k**	5.67 **ef**	4.67 **f**	24.33 **abc**	6.00 **a**	41.67 **b**	1238.29 **bc**	4611.11 **bc**	21.07 **ghi**
I_1K_3	20.00 **d**	65.00 **i**	11.67 **ab**	5.33 **e**	21.67 **ghi**	4.33 **d**	38.33 **def**	780.12 **hi**	3874.05 **h**	20.14 **ij**
I_2K_0	20.33 **cd**	57.67 **l**	3.33 **gh**	3.33 **h**	23.67 **bcde**	5.33 **abcd**	39.67 **c**	1020.81 **e**	4340.08 **e**	21.14 **ghi**
I_2K_1	20.00 **d**	62.67 **j**	2.33 **hi**	4.33 **fg**	21.33 **hi**	4.33 **d**	38.00 **ef**	772.86 **i**	3670.37 **i**	21.38 **gh**
I_2K_2	20.33 **cd**	71.33 **f**	7.00 d**e**	5.33 **e**	23.33 **cdef**	5.00 **bcd**	39.33 **cd**	969.53 **ef**	4303.70 **e**	23.52 **e**
I_2K_3	20.33 **cd**	79.33 **b**	10.67 **b**	6.67 **d**	23.33 **cdef**	4.67 **cd**	39.00 **cde**	917.24 **fg**	4292.59 **e**	22.53 **f**
I_3K_0	20.00 **d**	65.67 **h**	2.00 **hi**	4.67 **f**	21.00 **i**	4.33 **d**	37.67 **f**	772.36 **i**	3655.55 **i**	20.28 **hij**
I3K_1	19.67 **d**	69.33 **g**	4.33 **fg**	5.33 **e**	22.33 **fgh**	4.33 **d**	37.67 **f**	825.53 **hi**	4070.37 **fg**	21.09 **ghi**
I_3K_2	20.00 **d**	74.00 **d**	9.00 **c**	6.33 **d**	22.67 **efg**	4.33 **d**	38.67 **def**	863.20 **gh**	4096.30 **fg**	21.71 **fg**
I_3K_3	20.33 **d**	81.00 **a**	11.67 **ab**	9.00 **a**	23.00 **def**	4.67 **cd**	39.00 **cde**	788.18 **hi**	4155.56 **f**	19.73 **j**

Factor A. (Irrigation Regimes)

I_0: Unstressed (Control: Three irrigations)
I_1: Skipping one irrigation at vegetative growth stage
I_2: Skipping one irrigation at flowering stage
I_3: Skipping one irrigation at pod formation stage

Factor B. Potassium application (kg ha^{-1})

K_0: 0 (Control)
K_1: 15 (Half recommended dose of potassium)
K_2: 30 (Full recommended dose of potassium)
K_3: 45 (One and half recommended dose of potassium)

NAR (59.50 g m^{-2} day^{-1}) was observed in the treatment I_2K_2 [(skipped one irrigation at flowering stage) × (full dose of recommended potassium (30 kg ha^{-1})].

d.) WATER RELATION PARAMETERS

Statistically the highest values of water potential (0.73 MPa) were observed in treatment I_0K_3 [(irrigation at vegetative, flowering and pod formation stage) × (one and half recommended dose of potassium (45 kg ha^{-1})] and the lowest values of water potential (0.56 MPa) were observed in treatment I_2K_0 [(skipped one irrigation at flowering stage) × (no potassium (0 kg ha^{-1})]. The results of present study are in accordance with those of Nisha *et al*. (2014) who concluded that potassium application and water stress had significant effects on leaf water potential of mungbean. Statistically highest values of leaf osmotic potential (1.59 MPa) were noted in the Treatment I_2K_3 [(skipped one irrigation at flowering stage) × (one and half dose of recommended potassium (45 kg ha^{-1})]. While the lowest value of leaf osmotic potential (0.54 MPa) was observed in the treatment I_0K_0 [(irrigation at vegetative, flowering and pod formation stage) × (no application potassium (0 kg ha^{-1})]. The results of present study regarding leaf osmotic potential are in line with those of Nisha *et al*. (2014) who concluded that osmotic potential decreased due to water stress and with potassium application it increased. Significantly the highest value of turgor potential (0.12 MPa) was observed in treatment I_0K_2 [(irrigation at vegetative, flowering and pod formation stage) × (full recommended dose of potassium (30 kg ha^{-1})], however, the lowest values for turgor potential (-0.92 MPa) were observed in treatment I_2K_2 [(skipped one irrigation at flowering stage) × (full dose of recommended potassium (30 kg ha^{-1})].

Table. 3. Effect of Potassium on Growth, Quality and Water relation parameters of Mungbean under Different Irrigation Regimes

Treatments	LAI	LAD	CGR (g/m2/day)	NAR (g/m2/day)	Leaf water potential (-Mpa)	Leaf osmotic potential (-Mpa)	Leaf turgor potential(-Mpa)	Protein content (%)
I_0K_0	0.16 **h**	4.41 **abc**	12.17 **a**	84.68 **b**	0.61 **g**	0.54 **p**	0.07 **c**	19.80 **ij**
I_0K_1	0.34 **cde**	4.49 **ab**	12.24 **a**	95.98 **a**	0.66 **d**	0.55 **o**	0.10 **b**	23.27 **bc**
I_0K_2	0.39 **abc**	3.45 **gh**	10.37 **def**	63.51 **ef**	0.71 **b**	0.58 **n**	0.12 **a**	23.83 **ab**
I_0K_3	0.42 **a**	4.63 **a**	12.32 **a**	61.93 **fg**	0.73 **a**	0.63 **m**	0.09 **b**	24.30 **a**
I_1K_0	0.23 **g**	4.21 **bcd**	11.92 **ab**	61.45 **fg**	0.57 **h**	0.74 **l**	-0.17 **e**	19.67 **ij**
I_1K_1	0.26 **fg**	4.17 **bcd**	11.72 **abc**	83.53 **bc**	0.63 **f**	0.79 **k**	-0.16 **d**	22.20 **de**
I_1K_2	0.31 **def**	4.14 **bcde**	11.89 **ab**	66.34 **de**	0.66 **d**	0.82 **i**	-0.16 **d**	22.60 **cd**
I_1K_3	0.35 **bcd**	3.33 **hi**	10.05 **ef**	80.61 **c**	0.71 **b**	0.86 **g**	-0.16 **d**	21.93 **def**
I_2K_0	0.32 **def**	4.08 **cde**	11.34 **abcd**	63.74 **ef**	0.56 **i**	1.22 **d**	-0.66 **i**	18.80 **jk**
I_2K_1	0.34 **cde**	2.99 **ij**	9.50 **f**	67.25 **d**	0.60 **g**	1.47 **c**	-0.87 **j**	21.20 **efgh**
I_2K_2	0.36 **bcd**	3.99 **def**	11.27 **abcde**	59.50 **g**	0.63 **f**	1.55 **b**	-0.92 **l**	21.50 **efg**
I_2K_3	0.42 **a**	3.97 **def**	11.20 **abcde**	67.82 **d**	0.70 **c**	1.59 **a**	-0.89 **k**	21.90 **def**
I_3K_0	0.28 **efg**	2.82 **j**	9.40 **f**	66.18 **de**	0.53 **j**	0.81 **j**	-0.28 **h**	18.53 **k**
I_3K_1	0.32 **def**	3.62 **fgh**	10.63 **cdef**	63.51 **ef**	0.61 **g**	0.85 **h**	-0.24 **f**	20.20 **hi**
I_3K_2	0.37 **abcd**	3.75 **efg**	10.75 **bcde**	84.68 **b**	0.61 **g**	0.88 **f**	-0.27 **g**	20.67 **ghi**
I_3K_3	0.41**ab**	3.91 **def**	10.89 **bcde**	95.98 **a**	0.65 **e**	0.91 **e**	-0.26 **g**	21.00 **fgh**

Factor A. (Irrigation Regimes)	**Factor B. Potassium application (kg ha^{-1})**
I_0: Unstressed (Control: Three irrigations)	K_0: 0 (Control)

I_1: Skipping one irrigation at vegetative growth stage	K_1: 15 (Half recommended dose of potassium)
I_2: Skipping one irrigation at flowering stage	K_2: 30 (Full recommended dose of potassium)
I_3: Skipping one irrigation at pod formation stage	K_3: 45 (One and half recommended dose of potassium)

CONCLUSION

It was concluded from this study that potassium application under different irrigation regimes has potential to mitigate the adverse effects of water stress and to fully utilize the existing environmental conditions and express higher growth, yield and quality attributes as compared to water stressed conditions where no potassium was applied. Higher dose of potassium (45 kg ha^{-1}) under unstressed conditions gave the maximum crop yield. Thus, application of potassium under different irrigation regimes is necessary to obtain optimum growth and yield of mungbean and to reduce the deleterious effects of water stress.

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