Response of Different Potassium Application Rates on Growth, Yield, Carbohydrates and Protein Content of Mungbean (*Vignaradiata L.*)

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Abstract: ***The study was conducted at Kyungpook National University, College of Agriculture and Life Sciences experimental site, Daegu, South Korea from November 2017/2018.The research objectives were to investigate the response of different potassium applicationsrates on the growth and yield of mungbean in the greenhouse and outside and to find the best potassium application rate on mungbean for enhancing high production. The field experimental design was a randomized complete block design and each treatment had four replications. Mungbean (Vignaradiata L.) was grown under five levels of potassium K_1 (0g/pot), K_2 (0.13g/pot), K_3 (0.3g/pot), K_4 (0.5g/pot) and K_5 (0.63g/pot). The results showed that different potassium fertilizer applications have significantly affected the growth and yield of mungbean both inside and outside of the greenhouse. The application of K_4 (0.5g/pot) produced the maximum seed yield (7.81g) inside the greenhouse and (8.16g) outside. The lowest yield (3.11g) and (3.82g) were observed at K_1 (0g/pot) inside and outside of the greenhouse respectively. Total carbohydrates and total proteins content were significantly increased by increasing applications of potassium. It can be concluded that the application of K_4 (0.5g/pot) have shown the best results and can be used to get the maximum growth and yield of mungbean both inside and outside of greenhouse conditions. The potassium application outside condition gave a significantly higher growth and seed yield than inside the greenhouse.***

Keywords: potassium, growth and yield, Carbohydrate, proteins, mungbean

1. Introduction

The mungbean (*Vignaradiata* L.) is the major pulse crop and also known as green gram. It is under the family of Leguminosae and is grown as a drought tolerant cash and quick-maturing crop in most of the countries. Mungbean is a shot-season indeterminate small-seeded pulse crop. The crop is originated from India and have been widely cultivated in India since ancient times. It is the main source of high nutritive protein content and an important role for malnutrition people.It is widely grown for use as a human food and also commonly grown as fodder, the green manure and cover crop. It contains 51% carbohydrate, 25% protein, 4% mineral, 1.3% fat and 3% vitamins (Kaul,1982). It is often considered as meat substitutes especially for people who eat vegetables in lessdeveloped countries as protein supplement. Mungbean as a pulse and legume crop is a prime importance because of its excellent flavor, easy digestibility, well palatability, good market price as well as its capability for biological nitrogen fixation (Mandal et al., 2009).

As populations are increasing all over the world, one of the protein rich foods (mungbean) is needed to provide nutrient supplement crops for increasing world populations. Fertilizers play an important role to increase crop yields for demanding food. To meet demand for it, more fertilizer is required and in an improved nutrient balance. Many farmers grow mungbean without applying any fertilizers (potassium) in most of the developing countries. The pests and diseases are also very serious problems when potassium was insufficient in the plant. Being a legume crop, it requires less nitrogen but potassium is the vital nutrient to get its high yield. When farmers do not apply potassium fertilizer, mungbean productivity is quite low compared to its average production. The growth of mungbean can improve by using balanced amount of potassium.

Potassium plays a vital role as macronutrient in plant growth and sustainable crop production (Baligar *et al.*, 2001).Potassium is fundamental to many metabolics through the activation of large number of enzymes required for chemical reactions. Potassium is not only to promote the translocation of newly synthesized photosynthates but has also a beneficial effect on the mobilization of other nutrients. Potassium is the third macronutrient requires for plant growth, after nitrogen and phosphorus (Abbas et al., 2011). The application of potassium is important for efficient photosynthesis and helps to retain water use efficiently at growth period (Garg et al., 2005). Potassiumcan regulate the stomata activity to prevent water loss during the drought (Waraich et al., 2011). Potassium is also required to protect plant diseases and pests (Arif et al., 2008) and increases the yield (Ali et al., 2010). Potassium acts as an important role for nodulation, carbohydrate transport, nitrogen fixation and incorporation of combined nitrogen into protein. Potassium can improve plant immunity, root growth and enhance drought tolerance and reduces lodging. Potassium is the fundamental nutrient for crop growth to improve plant health, crop quality and yield. The proper application of potassium fertilizer increases crop yield and improves its quality. So, this research effort aimed to remove the constraints for low productivity of mungbean. Considering the above facts, the objectives of this research were to evaluate the responses of different potassium application rates on growth and yield of mungbean and to find the best potassium application on mungbean for enhancing high production.

2. Materials and Methods

The study was conducted at Kyungpook National University, College of Agriculture and Life Sciences experimental site, Daegu, South Korea from November2017/2018

Experimental site

The experimental field was located at between 35˚ 53' 41.3" N and 128˚36 ' 45.9" E. The experimental soil texture was clay loam with pH 5.8. The area of climate was humid subtropical climate. There were four seasons in Daegu such as spring, summer, fall and winter. The temperature range was −16 °C and 40°C.

Treatments application and Experimental design

The experiment had five treatments in the greenhouse and outside conditions and each treatment had four replications by using Randomized Complete Block Design. Mungbean (*Vignaradiata L.*) was grown under five levels of potassium K_1 (0g/pot), K_2 (0.13g/pot), K_3 (0.3g/pot), K_4 (0.5g/pot) and K_5 (0.6g /pot) as K_2O.

Total 20 pots inside the greenhouse and 20 pots outside the greenhouse (30cm) diameter were filled with 10kg of clay loam soil for growing mungbean. Nitrogen and Phosphorous were applied as a urea and P_2O_5, and K_2O was used as potassium fertilizer source. The fixed recommended rates of nitrogen (0.54 g/pot) and phosphorous (0.3 g/pot) and each of potassium treatments (0g, 0.13g, 0.3g, 0.5g and 0.6g/pot) were applied to each pot before one day of sowing. Mungbean seeds were soaked in water a few minutes and put the petridish for 5-6 hours before sowing. The pots were prepared randomly according to the planned layout. The three seeds were sown in one pot at the depth of (1.5cm) on 24th November,2017 inside the greenhouse and 1st May, 2018 outside the greenhouse. All the required cultural and other management practices were the same inside the greenhouse and outside conditions. Thinning was done at 10 days after germination and only one plant was left in each pot. The water was applied to all pots uniformly every 3 days to keep adequate soil moisture. Plant protection managements were given to keep themungbean free from diseases and insects. Weeds were removed by hand throughout the growing season. Mungbean was harvested at fully maturity when the colour of pods were turned to dark brown. The crop was picked within 80-90days after sowing.

Data Analysis

All data recorded was entered into Microsoft Excel and Analysis of variance (ANOVA) was used to test treatment effects and where treatment effects were significant at $p<0.05$, means were separated using ± standard error of the difference.

3. Results and Discussions

The experiment in the pots was carried out to determine the responses of the different potassium application rates on crop growth and yield of mungbean and the best potassium application on mungbean for enhancing maximum production. Different potassium application rates significantly affected the plant height, number of branches per plant, number of pods per plant, pod length, number of seeds per pod, seed weight, seed yield and nutrient content of mungbean as presented below.

Effect on the plant height

The plant height of mungbean was significantly affected due to different potassium application rates inside the greenhouse and outside. (Fig.1) showed the results of the plant height for each potassium treatments. In the greenhouse, the highest plant height (20.75cm) was observed at K_4 (0.5g/pot) and followed by (19.13cm, 17.80cm and 16.70cm) in K_5, K_3 and K_2while the lowest plant height (15.38cm) was observed in K_1 treatment where potassium was not applied. Outside conditions, the highest plant height (21.88cm) was observed at K_4 (0.5g/pot) and followed by (20.75cm, 19.13cm, 18.63cm) in K_5, K_3 and K_2. The lowest plant height (16.88cm) was observed in K_1 treatment (0g/pot). This study showed that the plant height increased with increasing potassium levels up to K_4 (0.5g/pot) and then decreased gradually. The results were in agreements that the plant height was significant affected by different potash levels that could enhance the strength of the height and potassium fertilizer improved the height of plant,branches, pods, seed yield and seed weight (Fatima *et al.*, 2001; Kumar *et al.*, 2014; Jamil *et al.*, 2018). In both conditions, the plant height in outside condition produced taller than in the greenhouse.

Effect on number of branches per plant

Different potassium application rates showed no significant variation in number of branches per plant inside the greenhouse and outside. (Fig.1) shows that the highest number of branches (6.25) was observed at K_4 (0.5g/pot), which was similar branches (6.25) at K_5compared with K_1 where no potash was applied. K_1 (0g/pot) obtained the lowest number of branches (5.50) in the greenhouse. At outside conditions, the results showed that the highest number of branches per plant (6.50) was also at K_4 (0.5g/pot). K_1 (0g/pot) produced the lowest number of branches (5.75). But there were no statistical differences in number of branches among the treatments. This similar result also found by Asghar Ali *et al.*, 2006.

Effect on number of pods per plant

The effect of different potassium application rates showed significant effect on the number of pods per plant of mungbean inside and outside of the greenhouse (Fig 2). Results showed that the highest pods per plant (20) was produced in K_4 treatment which was statistically similar with K_5 (19.50) and followed by K_3 (17.75) and K_2 (13.00). The lowest number of pods per plant (11.25) was produced at K_1 (0g/pot) treatment using no potassium inside the greenhouse. In the outside case, the results showed that the highest pods per plant (21.00) was produced in K_4treatment which was statistically similar to K_5 (20.50) and followed by K_3 (18.50) and K_2 (15.75) respectively. The lowest pods per plant (12.75) was produced in K_1 treatment. The same result was reported that potassium application of 90kg/ha gave the maximum number of pods per plant on mungbean (Hussain*et al.*, 2011). This result contradicted the findings of Asghar Ali *et al.*, (2006) reported that potassium applications had non-significant differences in no. of pods/plant. In both conditions, this study showed that the number of pods in outside condition produced higher pods than in the greenhouse.

Effect on pod length (cm)

The data presented in (Fig.2) indicated that significant variation was observed on pod length inside the greenhouse and outside conditions. The longest pod length (7.08cm) was obtained in K_4 (0.5g/pot) treatment, which was similar with K_5 (6.98cm) and followed by K_3 (6.03cm) and K_2 (5.30 cm) respectively. The shortest pod length (5.05cm) was obtained at K_1 (0g/pot) treatment inside the greenhouse. Outside conditions, the results showed that the longest pod length (7.28cm) was obtained in K_4 (0.5g/pot) treatment and followed by K_5 (7.10cm) and K_3 (6.30cm) and K_2 (5.58cm) respectively. The shortest pod length (5.18cm) was obtained at K_1 (0g/pot) treatment where no potassium was applied. Among the treatments, K_4 (0.5g/pot) treatment produced the longest pod length in the greenhouse and outside. The same result found that the application of 25kg K/ha significantly observed the longest pod length (Mazed*et al.*,2015). In both conditions, the pod length in outside condition was taller than inside the greenhouse.

Effect on number of seeds per pod

The data on the number of seeds per pod as influenced by different potassium applications was presented in (Fig.3). The number of seeds per pod was the important parameter used to calculate mungbean yield. Results showed that K_4 (0.5g/pot) treatment got the highest seeds per pod (8.10) which was statistically similar with K_5 (0.6g/pot) (7.95) but different with other treatments. K_1 (0g/pot) showed the lowest seeds per pod (5.69) where no potash was applied in the greenhouse. The outside case showed the highest seeds per pod (8.32) in K_4 (0.5g/pot) treatment, which was statistically similar with K_5 (0.6g/pot) (8.24) but different with other treatments. The lowest seeds per pod (5.89) was observed in K_1 (0g/pot) treatment. The proper potassium fertilizer rate increased the pods setting and leads to the highest seeds per pod. Among the treatments, K_4 (0.5g/pot) treatment produced the highest seeds per pod in the greenhouse and outside. In both conditions, the number of seeds per pod in the outside condition was higher than inside the greenhouse. These results also confirm that the number of seeds/pod was significantly increased due to potassium applications (Hussain *et al.*, 2011; Kumar *et al.*, 2014;Jamil *et al*., 2018). Potassium served as not only transporter of the other nutrients but also enhanced the photosynthesis rate to increase seed filling inside the pod of mungbean.

Effect on (100) seed weight

There was significant variation on (100) seed weight when different rates of potassium fertilizers were applied on mungbean shown in (Fig.3). Among the different potassium applications, the application of K_4 (0.5g/pot) produced the highest seed weight (5.67g), which was statistically similar with K_5 (5.48g) and followed by K_3 (4.96g) and K_2 (4.94g). The application of K_1 (0g/pot) treatment produced the lowest seed weight (4.30 g) in the greenhouse. The same results in outside condition recorded that the application of K_4 (0.5g/pot) produced the highest seed weight (5.92g) which was statistically similar with K_5 (5.64g) and followed by K_3 (5.28g) and K_2 (5.26g). The application of K_1 (0g/pot) treatment produced the lowest seed weight (4.99g). Among all treatments, K_4 (0.5g/pot) treatment produced the heavier seed weight than other treatments. The same result also found by Hussain *et al.*, (2011) who reported that 1000 seed weight of mungbean was increased at 90kg K_2O/ha compared with other treatments. Potassium helped to increase grain filling and 100 seed weight on mungbean. In both conditions, the heavier seed weight was observed from the outside condition as compared to the greenhouse for each potassium treatment.

Effect on the seed yield

Different levels of potassium significantly influenced on the seed yield of mungbean (Fig.4). Seed yield was increased significantly with increased application ratesof potassium K_4 (0.5g/pot). The maximum seed yield (7.81g) was produced in the application of K_4 (0.5g/pot) followed by K_5 (0.6g/pot) (7.35g), K_3 (0.3g/pot) (6.23g) and K_2 (0.13g/pot) (4.57g). The minimum seed yield (3.11g) was produced in K_1 (0g/pot) where no potassium was applied in the greenhouse. Outside showed that the maximum seed yield (8.16g) was produced atK_4 (0.5g/pot) which was statistically similar with K_5 (0.6g/pot) (7.89g) and followed by K_3 (0.3g/pot) (6.58g) and K_2 (0.13g/pot) (5.46g) when the minimum seed yield (3.82g) was produced in K_1 (0g/pot) where no potassium was applied. Among all treatments, K_4 (0.5g/pot) treatment produced more seed yield than other treatments. Seed yield in outside condition was produced higher yield than inside the greenhouse. Chaudhry and Mahmood (1999) also found that the application of 50kg K_2O/ha observed the maximum yield (832 kg/ha) in mungbean. Mali*et al.*, (2001); Hussain *et al.*, (2011); Buriro. M. *et al.*, (2015)also agreed that the potassium applications increased significantly the seed yield of mungbean. Increasing seed yield obtained by increasing seed weight. Potassium helped for increasing number of pods, number of seeds/pod, seed weight that lead to increase seed yield.

Effect on Harvest Index (%)

Data in (Fig.4) showed that there was significant variation in the harvest index of mungbean when different potassium application rates were applied inside the greenhouse and outside conditions. K_1 (0g/pot) treatment showed the highest harvest index (52.69%) and K_5 (0.6g/pot) treatment showed the lowest harvest index (50.91%) inside the greenhouse. In outside condition, K_1 (0g/pot) treatment observed the highest harvest index (53.85%) among all treatments while K_5 treatment (0.6g/pot) treatment showed the lowest harvest index (51.88%). The same result found that potassium applications increased the harvest index of mungbean (Buriro. M. *et al.*, 2015). Potassium increased the leaf area index and also increased the plant dry matter accumulation. Not only the seed yield but also the plant dry weight was high so the harvest index of mungbean had significant differences due to different potassium applications in this study. In both conditions, the harvest index in the outside condition was observed higher than in the greenhouse.

Effect on total carbohydrate content

Different potassium applications had a significant influence on total carbohydrate content of mungbean shown in (Fig 10). The highest total carbohydrate content (31.04) was observed in K_5 (0.6g/pot) treatment and followed by K_4 (30.33), K_3 (28.28) and K_2 (27.37). The lowest total carbohydrate (26.04) was observed in K_1 (0g/pot) treatment in the greenhouse. In case of carbohydrate content, the order of the treatments was K_5, K_4, K_3, K_2 and K_1.

Outside condition, the highest total carbohydrate (31.53) was observed in K_5 (0.6g/pot) treatment and followed by K_4 (30.68), K_3 (29.11) and K_2 (28.58). The lowest total carbohydrate (27.19) was observed in K_1 (0g/pot) treatment. In case of carbohydrate content, the order of the treatments was K_5, K_4, K_3, K_2 and K_1 respectively. In both conditions, the outside experiment obtained higher total carbohydrate content than in the greenhouse.

Effect on total protein content

The results of the protein content of mungbean as affected by different potassium application rates were shown in (Fig5). K_5 (0.6g/pot) treatment obtained the highest total protein content (25.35%) which was statistically similar with K_4 (25.26%) and followed by K_3 (24.51%) and K_2 (24.33%) while K_1 (0g/pot) obtained the lowest total protein content (23.81%) in the greenhouse.

Potassium also affected protein and carbohydrate synthesis in plants. The results in the outside condition found that K_5 (0.6g/pot) treatment obtained the highest total protein content (26.09%) which was statistically similar with K_4 (26.07%) and followed by K_3 (25.06%) and K_2 (24.77%). K_1 (0g/pot) treatment obtained the lowest total protein content (24.03%). In both conditions, total protein content in the outside condition gave higher amount than in the greenhouse.

Potassium could activate a large number of enzymes to induce the synthesis of protein and carbohydrates. Potassium helped to improve the uptake of available nitrogen from the soil and changed nitrogen to protein content in grain. Potassium helped to maintain a normal balance between carbohydrates and proteins. The different potassium applications significantly influenced on carbohydrate and protein content of mungbean. Similar results were recorded by Asghar Ali *et al.*, (2006), Hussain *et al.*, (2011), Biswash *et al.*, (2014), Kumar *et al.*, (2014) andRanpariya*et al.*, (2017) who reported that protein content of mungbean increased significantly with increasing levels of potassium.

4. Conclusions

The maximum growth and yield of mungbean produced with the increase application of potassium K_4 (0.5g /pot) in the greenhouse and outside. Total carbohydrate and total protein content were also significantly increased with increasing applications of potassium. Therefore, the application of potassium at K_4 (0.5g /pot) can perform as the best application rate of potassium for enhancing growth and seed yield of mungbean in both conditions. The potassium application in outside condition gave a significantly higher growth and seed yield than inside the greenhouse.

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Response of different potassium applications on growth and yield of mungbean (Vignaradiata L.)

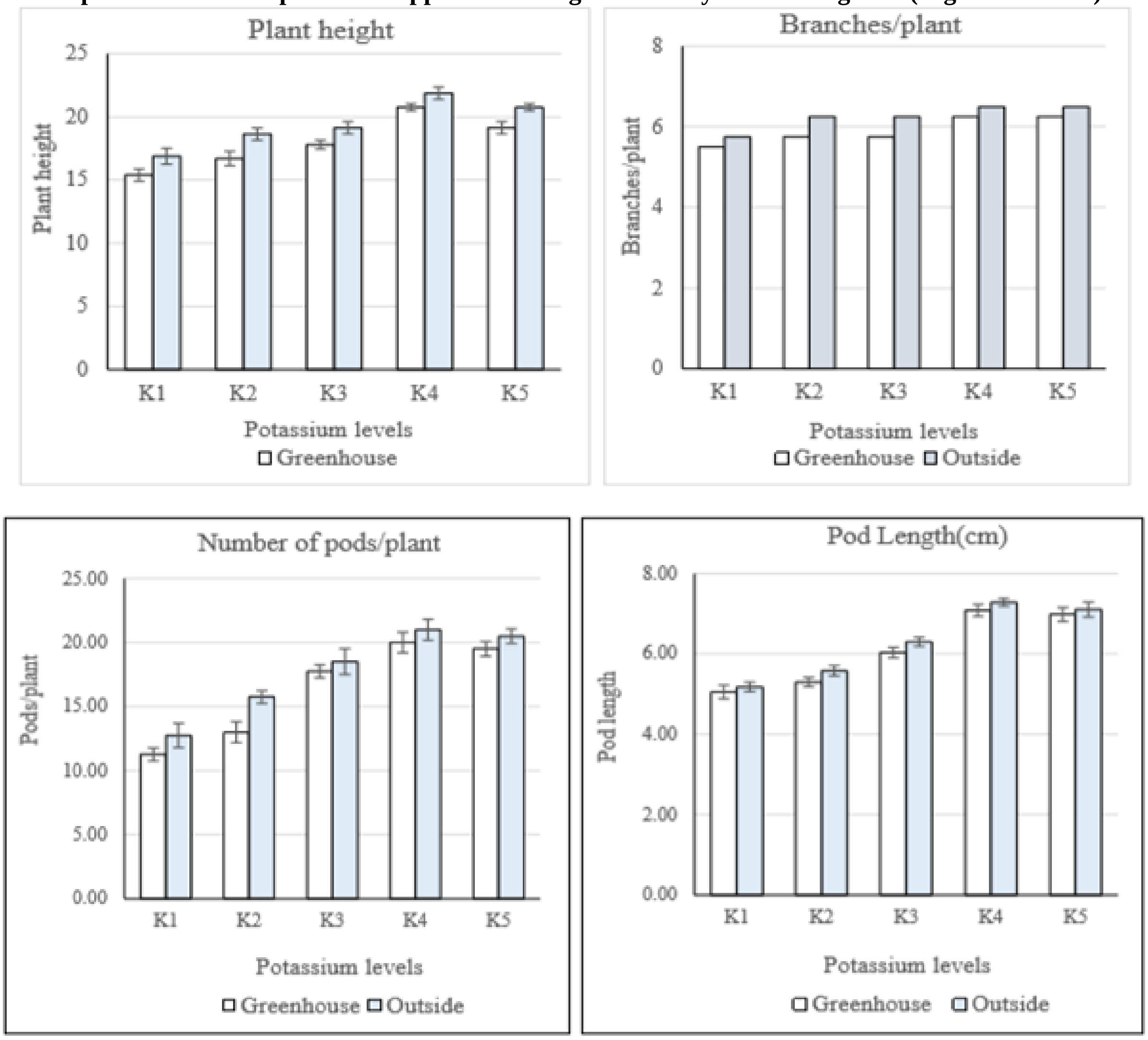

Fig 2. Comparison of the number of pods per plant and pod length on mungbean at different potassium applications in the greenhouse and outside

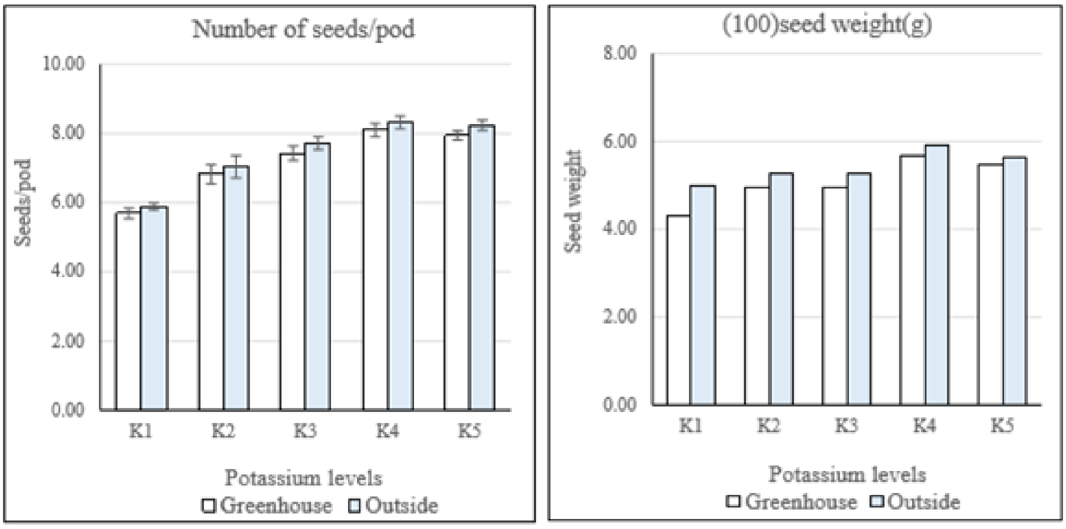

Fig 3. Comparison of the number of seeds per pod and (100) seed weight on mungbean at different potassium applications in the greenhouse and outside

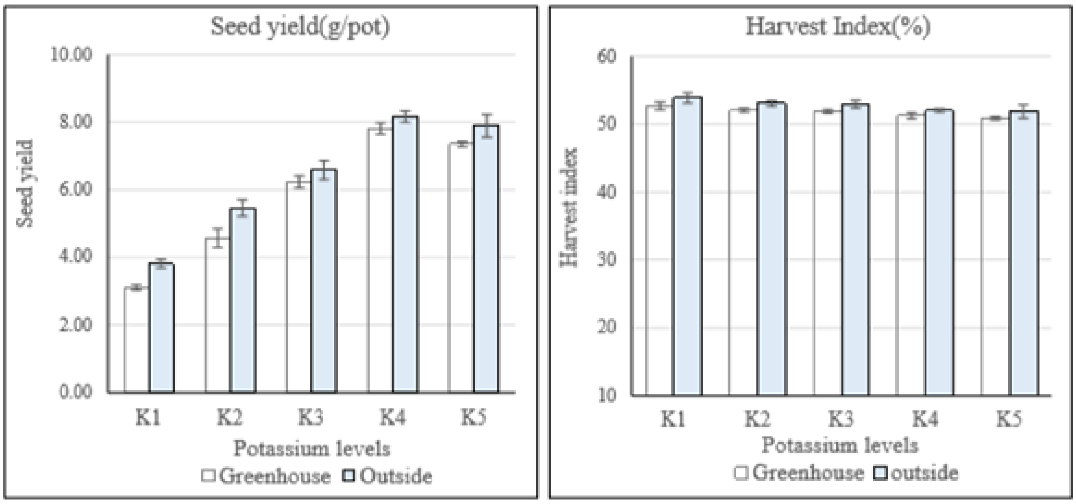

Fig 4. Comparison of seed yield and harvest index (%) on mungbean at different potassium applications in the greenhouse and outside

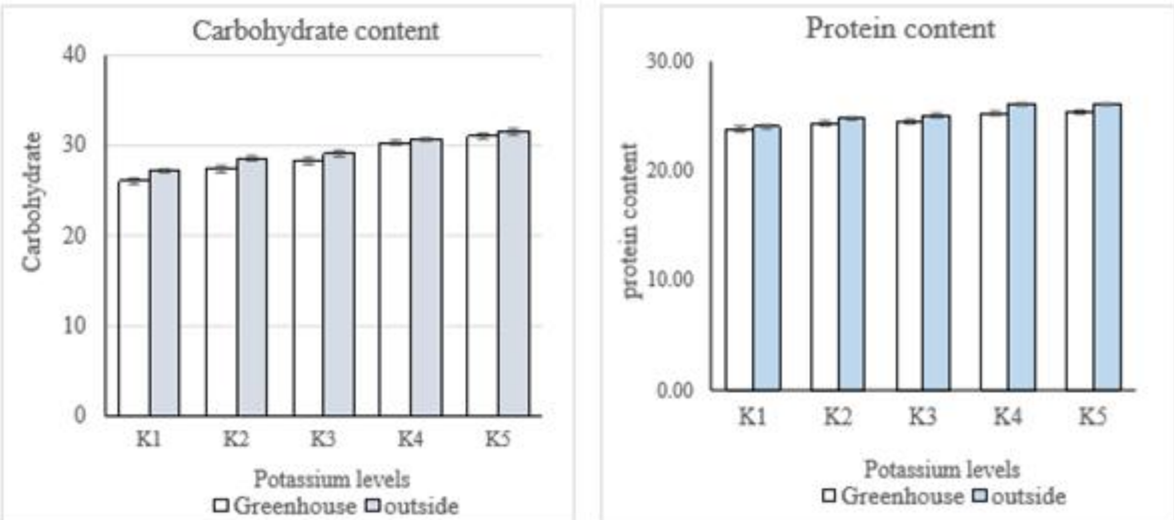

Fig 5. Comparison of total carbohydrate and total protein content on mungbean at different potassium applications in the greenhouse and outside