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Effect of different levels of potassium and sulphur on growth, yield and economics of summer cowpea (*Vigna unguiculata* (L.) Walp)

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Abstract
A field experiment was conducted on medium black calcareous soil at Junagadh (Gujarat) during summer season of 2019 to study the effect of different levels of potassium and sulphur on growth, yield and quality of summer cowpea (*Vigna unguiculata* (L.) Walp). The experiment comprising of 9 treatment combinations with three levels of potassium (0, 20 and 40 kg K_2O/ha) and three levels of sulphur (0, 10 and 20 kg S/ha) was laid out in Factorial Randomized Block Design with three replications. The results of experiment revealed that application of 40 kg K_2O/ha and 20 kg S/ha promoted growth parameters *viz*., plant height, dry matter per plant, number of branches per plant, number of root nodules per plant, yield attributes *viz*., number of pods per plant, length of pod, number of seeds per pod, 100-seed weight and ultimately gave higher seed yield and stover yield. Which remained statistically analogous to application of 20 kg K_2O/ha and 10 kg S/ha in most of cases. Combined application of potassium @ 40 kg/ha and sulphur @ 20 kg/ha resulted significantly the highest no. of pod per plant, 100-seed weight and seed yield of cowpea. On the other hand, in all the cases the minimum response was found from the control treatment. However, maximum net realization and BCR were also realized with basal application of 20 kg K_2O/ha and 10 kg S/ha along with 20 kg N/ha and 40 kg P_2O_5/ha (basal) on clayey soil having medium status of available N, P, K and S under South Saurashtra Agro-climatic Zone.

Keywords: Cowpea, *Vigna unguiculata* (L.) Walp, potassium, sulphur, growth, yield attributes and yield

Introduction

The important grain legumes grown in India are redgram, greengram, blackgram, cowpea, mothbean, horsegram, peas etc. Among the grain legumes, cowpea (*Vigna unguiculata* (L.) Walp) is one of the most ancient human food sources and has probably been used as a crop plant since Neolithic times Acharya (1998) [2]. Cowpea is commonly known by its vernacular name chowli. Due to its ability to restore soil, smothering nature, drought tolerance and adaptability, cowpea is the most versatile *Kharif* as well as summer pulse. It covers the ground and checks soil erosion and works as mulch to reduce the evaporation losses apart from being a leguminous crop it contributes to the improvement of soil fertility by the atmospheric nitrogen fixation in the soil (60-70 kg N/ha to the subsequent crop) in association with symbiotic bacteria under favourable conditions (Singh *et al*., 2006) [22].

At present India is passing through a shortage of protein where the people are predominantly vegetarian, pulses are the main source of protein. Cowpea is one of the most important pulse crops and plays an important role in Indian diet because it contains about 23.1 percent protein which is more than two times of cereals. Therefor it also called "vegetable meat" due to high amount of protein having better biological value. It is a warm weather crop well adapted to many areas of the humid tropics and Sub tropical climate with a drought tolerant nature. It is a minor pulse mostly grown in arid and semi-arid regions of Gujarat, Rajasthan, Karnataka, Kerala, Tamil Nadu, and Maharashtra. In Gujarat, area under summer pulses is 0.27 lakh hectares with a production of 0.33 lakh tones with productivity of 1221.88 kg/ha (DOA 2019) [10]. It is mainly grown in Banaskantha, Sabarkantha, Mehsana, Patan, Ahmadabad and Kheda districts of Gujarat.

The potassium is one of the major plant nutrient for the growth and development of plants. It is involved in nearly all processes needed to sustain the plant life and unique among the essential nutrients, governs the diversity of roles in plant metabolic processes and it has many vital nutritional roles. Potassium is known to help crop to perform better under water stress through the regulation of the rate at which plant stomata open and close and it is the major cation in the maintenance of cation-anion balances (Sharma *et al*., 2008) [20].

The major functions are associated with enzyme involved in photosynthesis, metabolism of carbohydrate and physiological processes, such as root growth, water uptake and utilization efficiency, synthesis of protein and amino acids, enzyme activation and yield determining process *viz*., drought, pest and disease tolerance (Singh and Kuhad, 2005) [23].

Sulphur is a secondary plant nutrient but now considered as the fourth major plant nutrient after nitrogen, phosphorus and potash. In pulse crops, sulphur contributes to the nitrogen's conversion into protein. It promotes nodule formation on roots of leguminous plants which is necessary for the efficient fixation of nitrogen by the plant (Scherer, 2009) [17]. Sulphur performs many physiological functions like synthesis of sulphur containing amino acids (cysteine, cystine and methionine) and it is also responsible for synthesis of certain vitamins (biotin and thiamin), metabolism of carbohydrates, fats and proteins (Schnug, 1991; McGrath *et al*., 1996) [14, 12]. Sulphur application increases drought and cold tolerance in plant due to process of di-sulphide linkage and helps in control in diseases and pests and fastens the decomposition of crop residue.

Materials and Methods

A field experiment was carried out during summer season of the year 2019 at Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh (Gujarat). Junagadh is situated in South Saurashtra Agro-climatic zone of Gujarat state and enjoys a typically subtropical climate characterized by fairly cold and dry winter, hot and dry summer and warm and moderately humid monsoon. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction with pH 7.9 and EC 0.33 dS/m. which was free from any kind of salinity or sodicity hazards.The soil was medium in available nitrogen (277 kg/ha), available phosphorus (28.82 kg/ha), available potash (249.55 kg/ha) and available sulphur (17.01 mg/kg).

The experiment comprisig of nine treatment combinations consisting of three levels of potassium *viz*., no potassium application (K_1), 20 kg K_2O/ha (K_2), 40 kg K_2O/ha (K_3) and three levels of sulphur *viz*., no sulphur application (S_1), 10 kg sulphur/ha (S_2) and 20 kg sulphur/ha (S_3) were framed in Factorial Randomized Block Design (FRBD) with three replications. The calculated quantities of fertilizers (on the basis of gross plot size) were applied to the respective plots. These mixtures were applied in furrows which were ready for sowing. A uniform basal dose of 20 kg N + 40 kg P_2O_5/ha in all treatments through Urea and DAP fertilizers, respectively. Potassium and sulphur were applied as basal as per treatments through MOP and Cosavet, respectively. Cowpea variety Gujarat Cowpea-6 was used for sowing with seed rate of 25 kg/ha. The growth and yield attributes were recorded from the five marked plants in each plot. Seed and stover yield were recorded from the net plot area and converted into kilogram per hectare base.

The costs associated with all cultivation operations from preliminary tillage to harvesting, including the cost of inputs like seeds, fertilizer, manures, irrigation, etc. applied to each treatment was calculated on the basis of prevailing local charges. The gross realization in terms of rupees per hectare was worked out taking into consideration the seed and stover yields from each treatment and local market prices. Net return of each treatment was calculated by subtracting the total cost of cultivation from the gross returns. The benefit: cost ratio (B:C) was calibrated by dividing gross return with cost of cultivation. Statistical analysis of the individual data of various characters studied in the experiment was carried out using standard statistical procedures as described by Panse and Sukhatme (1985) [15]. Standard error of mean, critical difference (C.D.) at 5 percent level of probability and coefficient of variance were worked out for the interpretation of the results.

Results and Discussion

Effect of potassium

Effect on growth parameters

The data presented in Table 1 revealed that growth attributes *viz.*, plant height at 40 DAS (28.59 cm) and 60 DAS (46.13 cm), dry matter per plant at 40 DAS (13.29 g) and at harvest (24.12 g), number of branches per plant (4.43), number of root nodules per plant (24.38) recorded significantly higher value with the application of 40 kg K_2O/ha (K_3). But it was found statistically analogous with application 20 kg K_2O/ha (K_2) and which was significantly higher over control (0 kg K_2O/ha).

The increase in growth attributes of plant might be due to the potassium increase in plant height could partly be attributed due to increasing of K might also be due to adequate nutrients which are turns help in vigorous vegetative growth of plants and subsequently increase the plant height through cell elongation, cell division, photosynthesis assimilation and turgidity of plant cell. These results are in close conformity with those of Abayomi *et al.* (2008) [1] and Thesiya *et al.* (2013) [24]. Potassium increases leaf area and leaf chlorophyll content, delays leaf senescence and therefore contributes to a greater canopy photosynthesis and crop growth. The availability of nutrient in adequate amount resulted in sufficient formation of photosynthates, which promote the metabolic activities, accelerated cell division and formation of meristematic tissues, ultimately enhanced the number of branches. This increase in plant height and number of branches might be attributed to better nutritional environment for plant growth at active vegetative stage. These results are in similarity with the findings of Shubhashree *et al.* (2011) [21] and Anuradha *et al.* (2017) [4]. Maximum number of root nodules with the higher doses of potassium may be due to the involvement of potassium in various plant activities. Potassium is required by adenosine S- triphosphate phosphohydrolase (ATP ase) for the movement of sugars from the apoplast between the cells of the phloem. The study by on composition of the effects of K and N_2 fixation and photosynthesis in a legume found that potassium was found to have large effect on nodulation and N_2 fixation. Highest number of nodules was observed by Chattopadhyay and Dutta (2003) [6], Kabir *et al.* (2007) [11] and Anjaly and Isaac (2018) [3].

Effect on yield attributes and yield

A close perusal of data (Table 2) divulged that when the crop fertilized with 40 kg K_2O/ha (K_3) showed significantly improved yield attributing characters like; number of pods per plant (22.13), length of pod (12.61 cm), number of seeds per pod (12.50), 100-seed weight (10.95 g), seed yield (1126 kg) and stover yield (2196 kg) of cowpea, which was found statistically at par with application 20 kg K_2O/ha (K_2).

The better development of yield attributes with potassium fertilization might be due yield attributes of crop are function of vegetative build-up of a crop and partitioning of photosynthesis between basic section of plant and yield attributes. Therefore, bio-physico-chemical portion of soil-plant system will influence to build up of yield attributes and yield. The positive effect of potassium on yields might be due to the pronounced role of potassium in carbohydrates synthesis from which fat is formed (Asgar *et al*. 1994) [5]. High K levels facilitate the efficient transportation of starch from sites of production to storage organs. Potassium favours balanced utilization of nitrogen involved in reproductive organs and also its role in increasing NUE which further increase the metabolites and nutrient to develop reproductive structure which seems to have positive effect in higher number of seeds per pods. Higher 100-seed weight may be the result of enhanced photosynthetic activity, followed by efficient transfer of metabolites and subsequent accumulation of these metabolites in the seed with the resultant increase in the size and weight of individual seed. Similar result also observed by Chavan and Khafi (2013) [7] and Muoneke *et al*. (2015) [14].

Effect of sulphur

Effect on growth parameters: The present study further revealed that (Table 1) the growth attributes *viz.*, plant height at 40 DAS (28.82 cm) and 60 DAS (46.30 cm), dry matter per plant at 40 DAS (13.28 g) and at harvest (24.01 g), number of branches per plant (4.38), number of root nodules per plant (24.00) recorded significantly higher value with the application of 20 kg S/ha (S_3). But it was found statistically analogous with application 10 kg S/ha (S_2) and which was significantly higher over control (0 kg S/ha).

This increase in growth attributes may be due to being an essential constituent of several biologically active compounds like amino acids (Cystine, cysteine and methionine), vitamins (Thiamine and biotin), lipoic acid, acetyl Co-A, ferrodoxin and glutathione, sulphur play multiple roles in the plant metabolism. One of the essential functions of sulphur in plant life is its indirect role in chlorophyll formation being the constituent of succynyl Co-A and by creating balanced nutritional environment in the plant system by keeping the micronutrients in physically active state. It may be attributed to sulphur's essential role for plant growth through its effect on biochemical functioning related to enzyme activation. It resembles N in its capacity to enhance cell division, cell elongation and tissue differentiation. Thus S fertilization has improved all the growth parameters reported by Dhanushkodi *et al*. (2009) [9].

Effect on yield attributes and yield: A glimpse of data (Table 2) indicated that application of 20 kg S/ha (S_3) showed significantly improved yield attributing characters *viz*., number of pods per plant (21.03), length of pod (12.64 cm), number of seeds per pod (12.24), 100-seed weight (10.79 g), seed yield (1124 kg) and stover yield (2163 kg) of cowpea, which remained statistically alike with the application of 10 kg S/ha (S_2). Contrarily, the control (S_1) recorded significantly the lowest value in all of the cases.

The marked improvement in above stated yield attributes by the application of sulphur might be due to overall improvement in vigour and crop growth. This could also be on account of its profound influence in enhancing adequate supply of metabolites and nutrients matching to demands of reproductive structures. Sulphur involves in various physiological and biological processes along with N-fixation process, which may enhance the dry matter accumulation playing key role in higher photosynthetic rate resulting in increased yield attributes and finally yield in leguminous crops. These finding are in accordance with those of Chettri and Mandai (2004) [8]. Sulphur is involved in the synthesis of cystine, cysteine and methionine, the important s-containing amino acids required for protein synthesis. It is also involved in chlorophyll synthesis which has direct bearing on the production potential of the plant. Above findings are in accordance with those reported by Serawat *et al.* 2018 [19]. Patel *et al*. 2018[16] reported that significant improvement in the number of branches per plant, number of pods per plant, number of seeds per pod and test weight of seeds consequently resulted into higher yield. All these factors discussed above collectively boosting the yields under the influence of various sulphur levels. These finding are corroborating with the result of Moniruzzaman *et al*. (2008) [13].

Economics

A valuation of data clearly indicated that (Table 3) the highest net returns of Rs. 39661/ha with BCR of 2.11 were accrued with application of 20 kg K_2O/ha + 10 kg S/ha (K_2S_2). This is closely followed by application of 40 kg K_2O/ha + 10 kg S/ha (K_3S_2) with net returns of Rs. 39300/ha and BCR of 2.08. The higher net returns and BCR ratio under these treatments are obviously due to higher seed and stover yield recorded with these combinations along with comparatively less cost than additional income. The present findings are within the close vicinity of those reported by Shubhashree *et al.* (2011) [21].

Table 1: Growth attributes of summer cowpea as influenced by different levels of potassium and sulphur

Treatments	Plant height (cm)		Dry matter per plant (g)		Number of branches per plant	Number of root nodules per plant
	At 40 DAS	At 60 DAS	At 40 DAS	At harvest		
Levels of Potassium (kg K_2O/ha)						
K_1 - Control	22.77	38.32	11.56	20.28	3.16	21.27
K_2 - 20	27.06	44.67	12.84	23.61	4.17	23.66
K_3 - 40	28.59	46.13	13.29	24.12	4.43	24.38
S.Em.±	0.95	1.37	0.33	0.67	0.15	0.56
C.D. at 5%	2.84	4.10	1.00	2.00	0.44	1.67
Levels of Sulphur (kg S/ha)						
S_1 - Control	23.45	39.11	11.94	21.45	3.38	21.93
S_2 - 10	26.14	43.71	12.47	22.55	4.00	23.37
S_3 - 20	28.82	46.30	13.28	24.01	4.38	24.00
S.Em.±	0.95	1.37	0.33	0.67	0.15	0.56
C.D. at 5%	2.84	4.10	1.00	2.00	0.44	1.67
Interaction (K x S)						
S.Em.±	1.64	2.37	0.58	1.16	0.25	0.96
C.D. at 5%	NS	NS	NS	NS	NS	NS
C.V.%	10.86	9.54	7.96	8.84	11.22	7.22

Note: A uniform basal dose of 20 kg N + 40 kg P_2O_5/ha in all treatments.

Table 2: Yield attributes and yield of summer cowpea as influenced by different levels of potassium and sulphur

Treatments	Number of pods per plant	Length of pod (cm)	Number of seeds per pod	100-seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
Levels of Potassium (kg K_2O/ha)						
K_1 - Control	15.77	10.05	9.53	8.42	914	1772
K_2 - 20	19.55	12.16	11.88	10.55	1117	2159
K_3 - 40	22.13	12.61	12.50	10.95	1126	2196
S.Em.±	0.58	0.43	0.42	0.22	28	53
C.D. at 5%	1.73	1.28	1.27	0.65	83	158
Levels of Sulphur (kg S/ha)						
S_1 - Control	16.64	10.61	10.32	8.96	925	1872
S_2 - 10	19.78	11.56	11.35	10.17	1108	2091
S_3 - 20	21.03	12.64	12.24	10.79	1124	2163
S.Em.±	0.58	0.43	0.42	0.22	28	53
C.D. at 5%	1.73	1.28	1.27	0.65	83	158
Interaction (K x S)						
S.Em.±	1.00	0.74	0.73	0.37	48	91
C.D. at 5%	3.00	NS	NS	1.12	144	NS
C.V.%	9.05	11.01	11.22	6.50	7.91	7.76

Note: A uniform basal dose of 20 kg N + 40 kg P_2O_5/ha in all treatments.

Table 3: Effect of different levels of potassium and sulphur on economics of cowpea

Treatments	Gross return (Rs./ha)	Total expenditure (Rs./ha)	Net return (Rs./ha)	Benefit: cost ratio
Levels of Potassium (kg K_2O/ha)				
K_1 - Control	57472	32868	24603	1.75
K_2 - 20	70284	33548	36736	2.10
K_3 - 40	70837	34228	36609	2.07
Levels of Sulphur (kg S/ha)				
S_1 - Control	58304	32868	25436	1.77
S_2 - 10	69599	35134	34465	1.98
S_3 - 20	70689	37400	33289	1.89

Conclusion

On the basis of one year field experimentation, it seems quite logical to concluded that higher production and net returns from cowpea (GC-6) can be secured by application of 20 kg K2O/ha and 10 kg S/ha at the time of sowing besides with recommended dose of N and P_2O_5 on medium black calcareous clayey soil having medium status of available N, P, K and S under South Saurashtra Agro-climatic Zone.

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