Effect of Foliar Application of Potassium on Yield, Drought Tolerance and Rain Water Use Efficiency of Toria under Rainfed Upland Situation of Assam

P.K. Sarma, M. Hazarika, D. Sarma, P. Saikia, P. Neog, R. Rajbongshi, N. Kakati, M. Bhattacharjee and Ch. Srinivasa Rao[1]

All India Coordinated Research Project for Dryland Agriculture, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali, Sonitpur-784 176, Assam
[1]Central Research Institute for Dryland Agriculture, Hyderabad-500 059, Telangana

Email: sarmahpk@gmail.com

ABSTRACT: A field experiment was conducted during rabi seasons of 2011-12 and 2012-13 at the research farm of All India Coordinated Research Project for Dryland Agriculture at Biswanath College of Agriculture, Assam Agricultural University to study the effect of foliar application of potassium on yield, drought tolerance and rain water use efficiency of toria under rainfed upland situation of Assam. The experiment was conducted with 8 treatments (T_1: Control, T_2: 100% NPK (RDF), T_3: 100% N & P + 75% K as basal, T_4: 100% N & P + 50% K as basal, T_5: T_3 + 2% KCl spray before flowering, T_6: T_4 + 2% KCl spray before flowering, T_7: T_5 + 2% KCl spray at siliqua formation, T_8: T_6 + 2% KCl spray at siliqua formation) in a Randomized Block Design with three replications. Foliar application of potassium on growth and yield of toria revealed that application of 100% N&P + 75% K as basal + 2% KCl spray before flowering + 2% KCl spray at siliqua formation (T_7) resulted in highest grain yield (5.66 q/ha), straw yield (10.82 q/ha), Rain Water Use Efficiency (16.23 kg/ha mm^{-1}), net return (₹ 9341 ha^{-1}) and B:C ratio (2.15).

Key words: Toria, foliar application, rain water use efficiency, B:C ratio, drought tolerance, Assam

Toria (*Brassica campestris*) is the most important rabi oilseed crop grown by the farmers of Assam having oil content of 37-45%. The oil is utilized for human consumption throughout northern India in cooking and frying purposes. The seed is also used extensively as condiment in preparation of pickles and for flavoring curries and vegetables. The oil cake is used as a cattle feed and manure. The leaves of young plants are used as green vegetables as they supply enough sulphur and minerals in the diet. Among the seven edible oilseed crops cultivated in India, rapeseed-mustard *(Brassica spp.)* contributes 28.6% in the total production of oilseeds. In India, it is the second most important edible oilseed after groundnut sharing 27.8% of India's oilseed economy. In terms of acreage, oilseeds occupy 14.1% and rapeseed-mustard alone occupies 3% of the total cropped area in the country. The global production of rapeseed-mustard and its oil is around 38-42 million tonne and 12-14 million tonne, respectively. India produces around 6.70 million tonne of rapeseed-mustard next to China (11-12 m.t) and EU (10-13 m.t) with significant contribution in world rapeseed mustard industry (Shekhawat *et al.,* 2012). In Assam, rapeseed-mustard is cultivated in 2.43 lakh ha with a total production of 1.42 lakh MT, average productivity being 5.85 q/ha (2011-12), which is 48.77% lower than the national average (11.42 q/ha).

The crop growth and yield performance of toria is influenced by a number of factors like soil, climate, manures and fertilizers, irrigation, control of pests, diseases, weeds etc., of which the application of fertilizers under intensive system of cultivation is identified as the single most important factor controlling the yield optimization. Since farmyard manure or compost alone cannot supply the entire nutrient requirement of the crop to maintain adequate growth performance throughout the life cycle, the plants often suffer from hidden hunger due to deficiency of major plant nutrients like nitrogen (N), phosphorus (P) and potash (K). Among all the major plant nutrients K plays an important role under rainfed, moisture stress, upland condition. It is one of the most important element in plant nutrition and attributed to the role of K in biochemical pathways in plants. K increases the photosynthetic rates of crop leaves, CO_2 assimilation and facilitates carbon movement having favourable effects on metabolism of nucleic acids, proteins, vitamins and growth substances. These are manifested in metabolites formed in plant tissues and directly influence the growth and development processes. Furthermore, K has significant role in translocation of photosynthates from sources to sinks (Sawan *et al.,* 2006). K also plays a major role in regulation of water in plant (osmo-regulation). Foliar application of K significantly increased the crop yield (Patel *et al.,* 1987). Uptake of water through the stomata is affected by K. Potassium is also known to improve drought resistance. Method of fertilizer application is a non-monetary input which influences growth and consequently the crop yields. Foliar nutrition is recognized as an important method of fertilization, since foliar nutrients usually penetrate the leaf cuticle or stomata and enter the cells facilitating easy and rapid utilization of nutrients by the crop (Latha and Nadanassababady, 2003).

Therefore, keeping these in view an investigation was carried out to study the effect of foliar application of potassium on yield and rain water use efficiency of toria under rainfed upland situation.

Materials and Methods

Field experiment was conducted at the experimental field of All India Coordinated Research Project for Dryland Agriculture at Biswanath College of Agriculture, Biswanath Chariali, Assam (Latitude: 26°84' N Longitude: 93°13' E Altitude: 86.7 m) during the rabi seasons of 2011-12 and 2012-13. The soil of the experimental site was sandy loam in texture with acidic in reaction (pH 5.05). The initial fertility status of soil was medium in available N (385.73 kg/ha), medium in available P (12.33 kg/ha) and medium in available K (148.05 kg/ha). The experiment was comprised of 8 treatment combinations T_1: Control, T_2: 100% NPK (RDF), T_3: 100% N & P + 75% K as basal, T_4: 100% N & P + 50% K as basal, T_5: T_3 + 2% KCl spray before flowering, T_6: T_4 + 2% KCl spray before flowering, T_7: T_5 + 2% KCl spray at siliqua formation, T_8: T_6 + 2% KCl spray at siliqua formation. The experiment was laid out in a Randomized Block Design and replicated 3 times. Toria variety 'TS-36' was grown during rabi season along with recommended fertilizer dose of 40:35:15 kg/ha N: P_2O_5: K_2O. The fertilizers were applied as per treatment combination. The cultural operations were carried out as and when required as per State's Package of practices. Observations on growth and yield attributes (plant height, number of siliqua plant^{-1}, number of seeds siliqua^{-1} and 100 seeds weight), grain yield and straw yield were recorded and analyzed statistically. The Rain Water Use Efficiency (RWUE) was calculated by dividing the grain yield (kg/ha) to cumulative rainfall (mm) from sowing to harvest. RWUE (kg/ha mm^{-1}) indicates yield attained by a treatment per millimeter of rain water received during the cropping period. Since there is no irrigation to the crop other than rain water, RWUE would indicate the water productivity or water use efficiency of a treatment under rainfed condition. The soil available nutrient status viz. N, P, K, organic carbon and pH were analyzed using standard laboratory procedures.

Results and Discussion

Growth and yield attributes as influenced by various treatments

The various growth and yield attributing characters of toria were significantly influenced by treatments. The treatment, T_7 was found superior to other treatments i.e control, sprayed and unsprayed treatments (Table 1). Spraying of 2% KCl spray before flowering + 2% KCl spray at siliqua formation along with 100 % N & P + 75% K as basal (T_7) appreciably improved growth and yield attributing parameters like plant height, number of siliqua per plant and number of seeds per siliqua. However, 100 seeds weight did not show significant variation. Spraying of KCl at flowering and siliqua formation stage influenced the vigour of the plant through effective absorption of nutrients at critical stages, resulting in enhanced physiological activity and increased dry matter production. Increase in growth and yield attributing characters due to foliar application of KCl at critical stages could be ascribed to the overall improvement in plant growth, vigour and production of photosynthates owing to increased availability, absorption and translocation of nutrient in plants. Sarkar *et al.* (1999) and Lin and Danfeng (2003) also reported that improvement of growth and yield attributing characters were associated with enhancement of potassium level in plant due to foliar application of K.

Grain and straw yields as influenced by various treatments

The grain and straw yields were significantly influenced by different treatments in both the years and also when pooled (Table 2). The highest grain yield was recorded by T_7 during individual years 2011-12, 2012-13 and in pooled (5.56, 5.75 and 5.66 q/ha, respectively) followed by T_2 (4.94, 5.13 and 5.04 q/ha, respectively), which was statistically superior over T_4 and T_1. The straw yield was also significantly influenced by various treatments during 2011-12, 2012-13 and in pooled and showed the similar trends as grain yields. However, treatment T_7 showed better performance in terms of grain yield, straw yield, RWUE and B:C ratio as compared to T_2. Further monthly rainfall distribution pattern during both the crop season (2011-12 and 2012-13) showed that comparatively higher rainfall was received during October commenturating sowing of seed, however very limited rainfall was received during flowering and siliqua formation stage. This indicates that higher values of grain yield, straw yield, RWUE and B:C ratio in T_7 is due to foliar application of K which contributed significantly in increasing the grain yield and other yield related parameters of the crop under moisture stress condition during critical growth stages (Figure 1) under normal range of temperature for the growth of toria (Figure 2). Foliar application of potassium produced variations in biomass and grain yield. Potassium Chloride (2%) when sprayed during flowering and siliqua formation stage along with 100% N & P and 75% K as basal (T_7) also gave significantly higher siliqua yield than control and unsprayed treatment in both the years and also in pooled data (Table 1). This treatment produced 81.15 number of siliqua per plant but control and unsprayed treatments produced 66.87 to 76.06 number of siliqua per plant respectively, on pooled basis. This was followed by the treatment T_8. It appears that nutrient salt i.e potassium supplied through foliar application of KCl at critical stages are effectively absorbed as cation by the plants, assimilated and translocated more efficiently to the developing pods for proper filling which reflected in higher values of yield attributes and resulted in higher siliqua yield. Foliar spray K during flowering also enhances photosynthetic activity in effective leaves and in turn supplied the developing siliqua with current photosynthates and resulted higher yield. Highest straw yield of 10.82 q/ha was also recorded by he treatment T_7. Cakmak *et al.* (1994) found that potassium nutrition had pronounced effects on carbohydrate partitioning by affecting either phloem export of photosynthates (sucrose) or growth rate of sink and/or source organ. The result is in conformity

with the findings of Prasad and Shukla (1993), Tiwari *et al.* (2012) and Zhang *et al.* (2002), Marschner (1986) and Sarrwy *et al.* (2010).

Rain Water Use Efficiency (RWUE)

The RWUE was significantly higher in T_7 where KCl was applied at flowering and siliqua formation stage with 100% N & P and 75% K as basal as compared to control treatment (Table 2) during both the year i.e 2011-12 and 2012-2013 and when pooled. The pooled data recorded the highest RWUE of 16.23 kg/ha mm^{-1} in T_7 which was 50% higher over the control treatment. This indicated the better use of rain water under this treatment as compared with rest of the treatments.

Economics

On the basis of benefit:cost ratio, highest monetary returns was observed under the treatment T_7. Least monetary returns was observed under control treatment (T_1). The pooled data for two years recorded highest net return (₹ 9,341) in T_7 followed by T_8 (₹ 8,668). Lower net return were observed under control treatment as well as under unsprayed treatments. The results revealed that spray of KCl at different critical stages of the crop growth can improve and sustain the the productivity of toria during rabi season.

Table 1 : Growth and yield attributing characters as affected by various treatments (two years pooled data)

Treatment	Number of siliqua/plant	Number of seeds/siliqua	100 Seed weight (g)	Plant height (cm)
T_1: Control	66.87	9.38	1.87	70.35
T_2: 100% NPK (RDF)	76.58	11.22	2.01	81.46
T_3: 100% N & P + 75% K as basal	78.16	11.40	2.04	85.05
T_4: 100% N & P + 50% K as basal	76.06	11.01	2.00	81.87
T_5: T_3 + 2% KCl spray before flowering	79.16	12.20	2.12	87.19
T_6: T_4 + 2% KCl spray before flowering	78.23	11.16	2.10	86.21
T_7: T_5 + 2% KCl spray at siliqua formation	81.15	12.32	2.13	88.27
T_8: T_6 + 2% KCl spray at siliqua formation	80.19	12.22	2.12	87.79
CD (P=0.05)	2.43	0.18	NS	2.45

Table 2 : Grain yield, straw yield and RWUE of *toria* as affected by various treatments (2 years pooled data)

Treatments	Grain yield (q/ha)			Straw yield (q/ha)			Harvest Index (%)	RWUE (kg/ha mm^{-1})
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled		
T_1 : Control	2.11	2.31	2.21	4.27	4.68	4.48	33.03	8.48
T_2 : 100% NPK (RDF)	4.94	5.13	5.04	9.08	10.07	9.58	34.47	14.86
T_3 : 100% N & P + 75% K as basal	5.05	5.26	5.16	9.32	10.43	9.87	34.33	14.56
T_4 : 100% N & P + 50% K as basal	4.28	4.50	4.39	8.01	9.48	8.75	33.41	12.77
T_5 : T_3 + 2% KCl spray before flowering	5.35	5.54	5.45	9.79	10.67	10.23	34.75	15.63
T_6 : T_4 + 2% KCl spray before flowering	5.12	5.51	5.32	9.33	10.53	9.93	34.88	15.01
T_7 : T_5 + 2% KCl spray at siliqua formation	5.56	5.75	5.66	10.27	11.36	10.82	34.34	16.23
T_8 : T_6 + 2% KCl spray at siliqua formation	5.37	5.72	5.55	9.84	11.31	10.58	34.41	15.93
CD (P=0.05)	1.06	1.12	1.09	1.84	1.13	1.49	-	-

*RWUE=Rain Water Use Efficiency

Table 3 : Economics of foliar application of potassium on toria

Treatment	Cost of production (₹/ha)	Gross return (₹/ha)			Net return (₹/ha)			Return per rupee investment		
		2011-12	2012-13	Mean	2011-12	2012-13	Mean	2011-12	2012-13	Mean
T_1 : Control	6399	6430	6536	6483	0031	0137	0084	1.00	1.02	1.01
T_2 : 100% NPK (RDF)	7965	15120	15224	15172	7155	7259	7207	1.89	1.91	1.90
T_3 : 100% N & P + 75% K as basal	8117	15750	15863	15807	7633	7746	7689	1.94	1.95	1.95
T_4 : 100% N & P + 50% K as basal	7834	13140	13241	13191	5306	5407	5357	1.68	1.69	1.69
T_5 : T_3 + 2% KCl spray before flowering	8397	16750	16877	16814	8353	8480	8417	1.99	2.01	2.00
T_6 : T_4 + 2% KCl spray before flowering	8545	16060	16267	16164	7515	7722	7619	1.88	1.90	1.89
T_7 : T_5 + 2% KCl spray at siliqua formation	8139	17380	17579	17480	9241	9440	9341	2.14	2.16	2.15
T_8 : T_6 + 2% KCl spray at siliqua formation	8232	16810	16990	16900	8578	8758	8668	2.04	2.06	2.05

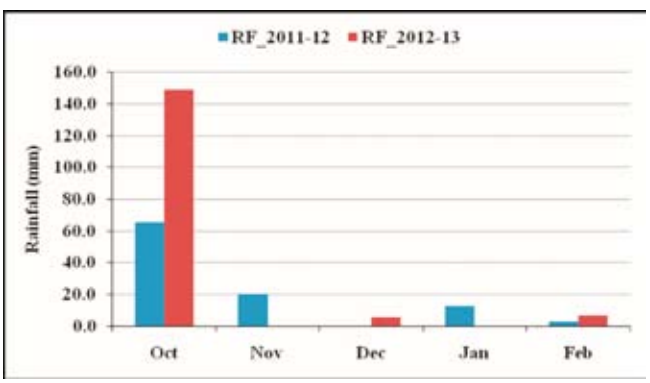

Fig. 1 : Monthly rainfall (mm) during the crop season (Oct-Feb) of 2011-12 & 2012-13

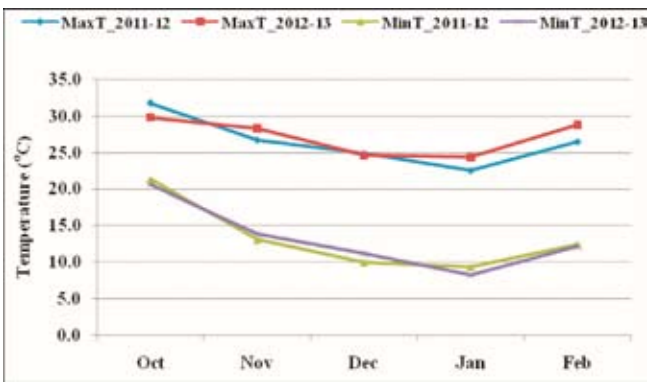

Fig. 2 : Monthly maximum and Minimum temperature (°C) during the crop season (Oct-Feb) of 2011-12 & 2012-13

Conclusion

Our results indicate that 100% N & P + 75% K as basal + 2% KCl spray before flowering + 2% KCl spray at siliqua formation for toria would be beneficial for the farmers to get high productivity and net return in sandy loam soil of North Bank Plain Zone of Assam under moisture stress situation during rabi season.

Acknowledgement

The authors are highly grateful to Indian Council of Agricultural Research, New Delhi and All India Coordinated Research for Dryland Agriculture, CRIDA, Hyderabad for providing financial support for conducting the present study. Authors also thankful to the honourable Vice Chancellor, AAU, Jorhat; Director of Research (Agri), AAU, Jorhat

and Dr. T.C.Baruah, Dean, BN College of Agriculture, Biswanath Chariali, Sonitpur for providing facilities to carry out the present research study.

References

Cakmak I, Hengeler C and Marschner H. 1994. Partitioning of shoot and root dry matter and carbohydrates in bean plants suffering from phosphorus, potassium and magnesium deficiency. Journal of Experimental Botany, 45: 1245-1250.

Latha MR and Nadanassababady T. 2003. Foliar nutrition in crops-A Review. Agricultural Reviews, 24 (3): 229-234.

Lin Duo and Danfeng H. 2003. Effect of potassium levels on photosynthesis and fruit quality of muskmelon in culture media. Acta Horticulturae Sinica, 30 (2): 221-223.

Marschner H. 1986. The Mineral Nutrition of Higher Plants. 1st Ed. Academic Press, New York

Patel MS, Patel JC, Shobhana HK, Yadav BS and Patel KP. 1987. Crop yield, nutrient uptake and nutrients use efficiency as influenced by varying fertility levels with and without potassium. A paper presented in National seminar of minerology of potassium in relation to crop response held TNAU, Madurai during November 11-12, 1987.

Prasad S and Shukla DN. 1993. Effect of interaction of Nitrogen, Potassium and Cycocel on Growth Characters in relation to Grain Yield of Mustard (Brassica Juncea L). Indian Journal of Agricultural Research, 27 (1): 13-20.

Sarrwy SMA, Enas A, Hassan HSA. 2010. Effect of foliar spray with Potassium Nitrate and mono-potassium phosphate on leaf mineral contents, fruit set, yield and quality of Picual Olive trees grown under sandy soil conditions, American-Eurasian Journal of Agricultural and Environmental Sciences, 8 (4): 420-430.

Sarkar RK, Chakraborty A and Saha A. 1999. Effect of foliar application of potassium nitrate and calcium nitrate on groundnut (Arachis hypogaea). Indian Journal of Agronomy, 44 (4): 809-812.

Sawan ZM, Hafez SA, Basyony AE and Alkassas AEE. 2006. Cotton seed, Protein, Oil Yields and Oil properties as affected by Nitrogen Fertilization and Foliar Application of Potassium and Plant Growth Retardant. World Journal of Agricultural Sciences, 2(1): 56-65.

Shekhawat K, Rathore SS, Premi OP, Kandpal BK and Chauhan JS. 2012. Advances in agronomic management of Indian Mustard (Brassica juncea (L.) Czernj. Cosson). International Journal of Agronomy, 2012: 14.

Tiwari DD, Pandy SB and Dubey MK. 2012. Effect of potassium application on Yield and Quality Characteristics of Pigeon Pea (Cajanus cajan) and mustard (Brassica juncea L. Czern) crops in Central Plain Zone of Uttar Pradesh. e-ifc No. 31, June 2012.

Zhang A, Huang Dan F, Hou Z. (2002). Effect of potassium nitrate on development and photosynthesis of melon plant. Journal of Shanghai Agricultural College, 20 (1): 13-17.

Received: November 2014; Accepted: February 2015