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APPLICATION OF MITSCHERLICH–BRAY EQUATION FOR FERTILIZER USE ON RAYA

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Abstract
Raya (Brassica juncea L.) as an imperative oilseed crop, necessitates a judicious amount of fertilizers for its sufficient yield, however the soils in Pakistan are becoming nutrient scarce owing to extensive farming. In order to evaluate the accurate fertilizer requirement for potential raya yields, an experiment was conducted at Regional agricultural research institute, Bahawalpur, Pakistan during the years 2018-2020. Various combinations of NPK fertilizers were made and applied to Raya crop. The treatments were T1 (0-0-0 NPK kg/ha), T2 (0-60-60 NPK kg/ha) ,T3 (60-60-60 NPK kg/ha), T4 (90-60-60 NPK kg/ha), T5 (120-60-60 NPK kg/ha), T6 (90-0-60 NPK kg/ha), T7 (90-30-60 NPK kg/ha), T8 (90-90-60 NPK kg/ha), T9 (90-60-0 NPK kg/ha), T10 (90-60-30 NPK kg/ha) and T11 (90-60-90 NPK kg/ha). Subsequently, fertilizer recommendations were made on the basis of the Mitscherlich-Bray equation. Theoretical maximum yield of Raya was obtained by plotting log y (grain yield) versus 1/x (amount of nutrient applied). The results showed that Soil having 10 kg (P ha^{-1}) would need 125 kg Phosphorus oxide per hectare fertilizer to attain 90% grain yield. Moreover it was concluded that the recommended dose of fertilizer for Raya was less in comparison to that achieved through application of the Mitscherlich-Bray equation. From these results, it is crucial to assess the 90%maximum yield by implementing the formula prior to conducting of field trials in order to enhance economic outputs and to balance the nutrients in soils.
Keywords: *Brassica juncea, Increase in income, Phosphorus, Potassium*

INTRODUCTION

Pakistan soils are facing acute nitrogen deficiency because of fewer amounts of farm yard manure, organic matter and high temperature. These conditions are affecting optimum plant growth drastically (1). Hence crops without adequate fertilizers are not feasible to grow (2, 3).

Pakistan is among the third largest importer of consumable oil in the world. Pakistan depends on imported consumable oil (75%) and face economic loss (4). Rapeseed and mustards consists of 44-46% good quality oil (1). As the country depends on agro based economy for sustenance, but it, at the same time is facing shortage in consumable oil, whereby actual demand of consumable oil is far more as compared to the final produce (5). Out of the total demand, only 17% is produced in the country while the remaining 83% is imported thus causing a huge economic loss in terms of foreign exchange (6).

Mustard (*B. juncea* L.) and rapeseed (*B. napus* L.) are oil seed crops in Pakistan and stand at a position of second most import oil source (7). As Raya has wide adaptability in saline and drought affected areas, hence it is cultivated on both irrigated and non-irrigated lands in Pakistan (8). Khan *et al.* (9) has stated an improvement in yield up to 2-3 times substantial increase is attainable by utilizing the improved raya varieties that have average yield of 2500 kg per hectare. The nutritional requirement of the crop is fulfilled by adding synthetic and non-synthetic fertilizers. Fertilizers are incorporated into the soil for improving its fertility and acts as one of the cost effective input for improving crop productivity (10) .and soil sustainability

Nutrients like nitrogen phosphorus potassium are necessary required for normal plant growth and in order to receive healthy output, their recommended quantities should be applied to the soil. Nitrogen acts as an integral part of the proteins and play vital role in photosynthesis and control various biochemical, physiological and enzymatic mechanism in plants (11).

However due to unpredictable climate situations, non-adaptability of advance sowing methods and non-availability of timely inputs has caused a shortage in raya yield (12). This scenario has given rise to acute shortage of consumable oil.

However, in Pakistan the fertilizer use is highly unbalanced in comparison to other countries. Averaged utilize of nitrogen, phosphorus and potassium is 60% , 22% and 18% respectively while in Pakistan, total take wing is 72%, 27% and <1 % (13). The situation becomes worse regarding fertilizer use as our farmers have least knowledge regarding fertilizer mix and quantities.

The imbalance hike in fertilizer prices as well as decline in product prices are among all major reasons of that unstable and unbalanced use of fertilizer (14). All this situation leads to low input use efficiency, loss of soil texture, lower yield and income (15). With regard to such factors, the main aim of this study was to conduct a fertilizer response experiment on Raya crop and application of Mitscherlich–Bray Equation in order to determine the site specific and more economic yet efficient fertilizer quantities for enhancing raya yields.

MATERIALS AND METHODS

EXPERIMENTAL SITE

Experiment was carried out at Regional Agricultural Research Institute Bahawalpur, Pakistan. The location experiences a semi-arid climate. The location has 29.39 latitude and 71.68 longitude with an elevation of 214 m above sea level. It experiences an avg. temperature about 16 ˚ C and 88% relative humidity.

TREATMENTS AND LAYOUT OF THE STUDY

The trial comprised of 11 fertilizer treatments in which different combinations of NPK fertilizers were made and applied to Raya crop. The treatments were T1 (0-0-0 NPK kg/ha), T2 (0-60-60 NPK kg/ha) ,T3 (60-60-60 NPK kg/ha), T4 (90-60-60 NPK kg/ha), T5 (120-60-60 NPK kg/ha), T6 (90-0-60 NPK kg/ha), T7 (90-30-60 NPK kg/ha), T8 (90-90-60 NPK kg/ha),T9 (90-60-0 NPK kg/ha), T10 (90-60-30 NPK kg/ha) and T11 (90-60-90 NPK kg/ha).

The sources for fertilizers were urea, diammonium phosphate and sulphate of potash for nitrogen, phosphorus and potassium respectively.

To conduct experiment the RCBD design was used with 3 replications and a plot of 18*30 ft size. row to row distance was 1.5 ft. Crop maintenance and crop protection practices were kept uniform during the both years.

OBSERVATIONS DURING THE EXPERIMENTAL DURATION

The experiment was conducted during the years 2018-2020 (Rabi season)on a newly emerged raya strain (BRJ-1405) The daily weather conditions were noted from a weather observatory present at the institute and details at given in Table I. Soil analysis carried out up to trial sowing and the general soil conditions are presented in Table II.

APPLICATION OF MITSCHERLICH–BRAY EQUATION

After harvesting the grain yield data was obtained which is subjected follow Mitsc-Bray equation. (Sonar *et al.*, 2002).

$$\log (A - y) = \log A - c1b - cx \quad (1)$$

A = percent theoretical max output; y = Factual output (kg ha^{-1}); b = soil test value (kg ha^{-1}); x = Nutrient& Fertilizer applied (kg ha^{-1}); c1 and c = Persistent (constants).

Table I. Climatic data collected during the study duration

Factors	Average	Range	Average	Range
	November 2017		**November 2018**	
Temp. (Max. ⁰C)	30	24-35	35	29-41
Temp. (Min. ⁰C)	21	11-28	17	09-25
Humidity (%)	75	58-92	83	75-91
Rainfall (mm)	5mm		NIL	
Cloudy Days	02		02	
	December 2017		**December 2018**	
Temp. (Max. ⁰C)	26	20-31	25	18-33
Temp. (Min. ⁰C)	10	06-14	7	01-14
Humidity (%)	78	67-89	84	77-91
Rainfall (mm)	15		Traces	
Cloudy Days	06		04	
	January 2018		**January 2019**	
Temp. (Max. ⁰C)	21	16-26	18	11-24
Temp. (Min. ⁰C)	08	05-12	03	01-05
Humidity (%)	82	75-89	83	76-90
Rainfall (mm)	Nil		09mm	
Cloudy Days	04		06	
	February 2018		**February 2019**	
Temp. (Max. ⁰C)	28	22-33	16	11-21
Temp. (Min. ⁰C)	10	05-16	03	02-04
Humidity (%)	74	56-91	82	75-89
Rainfall (mm)	03mm		53mm	
Cloudy Days	05		10	
	March 2018		**March 2019**	
Temp. (Max. ⁰C)	35	27-43	21	12-30
Temp. (Min. ⁰C)	20	15-25	11	04-17
Humidity (%)	74	56-92	83	75-91
Rainfall (mm)	01mm		41mm	
Cloudy Days	05		07	
	April 2018		**April 2019**	
Temp. (Max. ⁰C)	39	34-47	31	26-37
Temp. (Min. ⁰C)	22	16-27	17	14-20
Humidity (%)	72	52-91	87	82-91
Rainfall (mm)	07mm		40mm	
Cloudy Days	02		05	
	May 2018		**May 2019**	
Temp. (Max. 0C)	42	36-48	40	32-48
Temp. (Min. 0C)	27	22-32	28	25-31
Humidity (%)	76	60-91	78	64-92
Rainfall (mm)	15		22	
Cloudy Days	03		02	
	June 2018		**June 2019**	
Temp. (Max. ⁰C)	44	39-49	45	41-50
Temp. (Min. ⁰C)	27	22-33	27	20-34
Humidity (%)	74	56-93	81	76-93
Rainfall (mm)	17		26	
Cloudy Days	08		06	

Table II. Pre-sowing soil analysis

Depth (Inches)	EC	pH	OM%	Available p	Available k	Saturation %	Texture
0-6	3.1	8.2	0.58	6.3	120	38	Loam
6-12	3.1	8.1	0.53	6.1	116	37	Loam
0-6	3.2	8.3	0.59	6.2	115	36	Loam
6-12	3.1	8.2	0.55	5.08	110	36	Loam

EC=Electrical conductivity, pH=Potential of hydrogen, OM=Organic matter, P=Phosphorus, K=Potassium

STATISTICAL ANALYSIS

From the Raya yield acquired from field experiment conducted at RARI, Bahawalpur, values of, c_1/c, 1/x, c, c1, and y ratios were deliberate for different K and P (Table. II). Maximum output for k and P was 1075 and 1175 kg ha^{-1} respectively (Fig. 1 and Fig. 2) similarly C_1 values for K and P were 0.00252 and 0.0349 (Table III). The C_1 values were higher for P than K.

Table III. Efficiency & pod yield coefficient related to fertilizer & soil

T	Yield (kg ha^{-1})	Log (Y)	(1/X)	C1	c	C1/C
P_2O_5 (Applied)						
0	744.2			0.0349		
30	837.2	2.92	0.0333		0.0035	
60	1003.3	3.00	0.0167		0.0066	
90	1043.2	3.02	0.0111		0.0057	
Mean	907.0				0.0053	6.63
Theoretical maximum yield	1175					
K_2O applied						
0	823.9			0.00252		
30	950.1	2.98	0.0333		0.0100	
60	1003.3	3.00	0.0167		0.0090	
90	1036.5	3.02	0.0111		0.0090	
Mean	953.5				0.0093	0.27
Theoretical maximum yield	1075					

A=Percent theoretical max output; Y=Factual output (kg Ha^{-1}); B=Soil test value (kg ha^{-1}); X=Nutrient& fertilizer applied (kg ha^{-1}); C1 and C=Persistent (constants).

RESULTS

The C1/C proportion found lower for Potassium tests as contrast to Phophorus tests, showing high retaliation of K fertilizer. All such outcomes were concurrence with past results of Sonar *et al.* (2002), who conducted trial at various Indian areas utilizing wheat (*T. aestivum*) as check and Afzal *et al.* (2014) conducted tests at different sites in Northern Rainfed areas Punjab Pakistan, utilizing groundnut (*Arachis hypogaea*) as trial crop (15, 22). It detailed lesser C1/C qualities for K as compared to P showing high and maximum reaction to applied Potassium. Using mean C1 and C values, fertilizer recommendation of K and P for various scale of soil testing values ranges from 2.5 to 25 (kg ha^{-1}) for Phosphorus and also 200 to 400 (kg ha^{-1}) for Potassium were determined in support of Raya crop (Table IV).

Table IV. F Recommended for Raya based on Mits-Bray theory

Soil available nutrient (kg ha^{-1})	% theoretical max. pod yield				
P	50	75	80	85	90
2.5	40	97	115	138	172
5	24	81	99	122	156
7.5	7	64	82	106	139
10	0	48	66	90	123
12.5	0	31	50	73	106
15	0	15	33	57	90
17.5	0	0	17	40	73
20	0	0	0	24	57
22.5	0	0	0	7	40

25	0	0	0	0	24
Potassium					
200	0	10	21	34	53
250	0	0	7	21	40
300	0	0	0	7	26
350	0	0	0	0	13
400	0	0	0	0	0

Recommendations of Fertilizer give a possibility for application of F kept in consideration of target outcomes & basic level of soil fertility. Soil have 10 kg (P ha^{-1}) would need 125 kg Phophorus oxide per hac Ftoattain 90%.

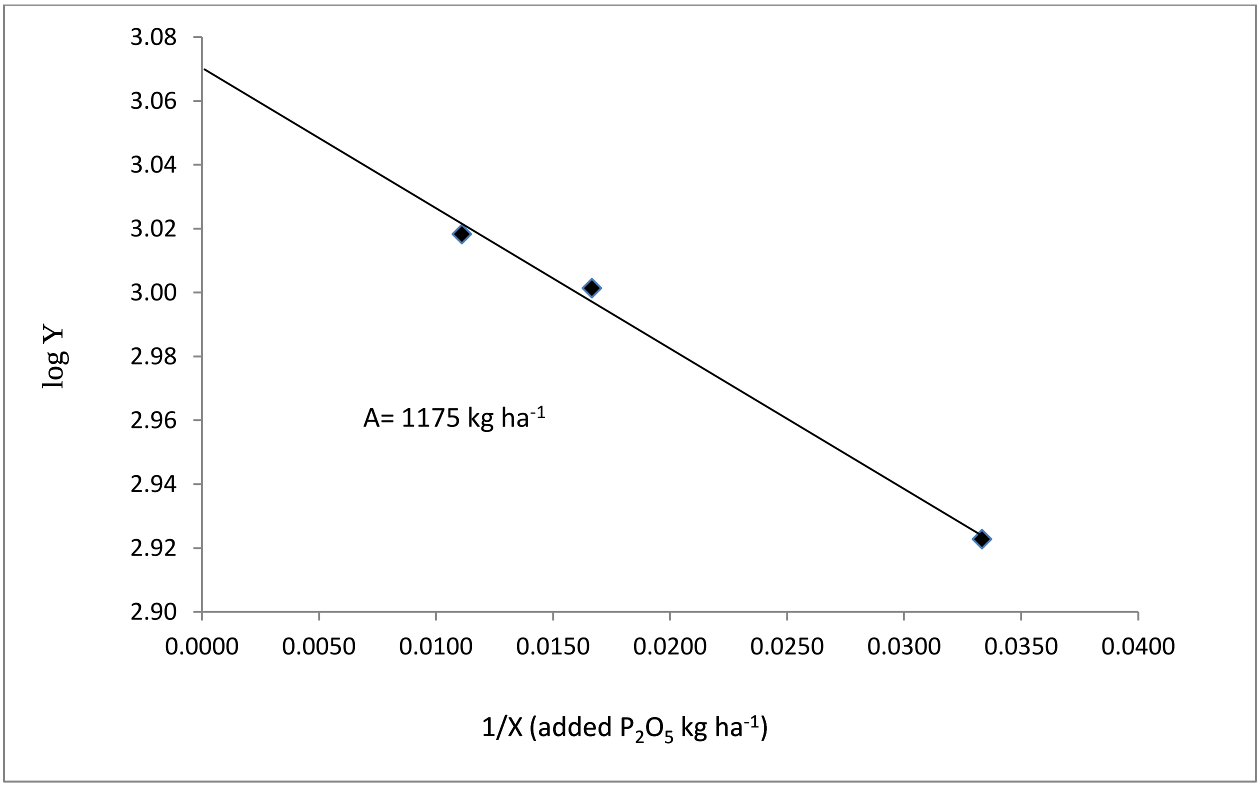

Fig. 1. Maximum output for P_2O_5 after plotting Log Y and 1/X

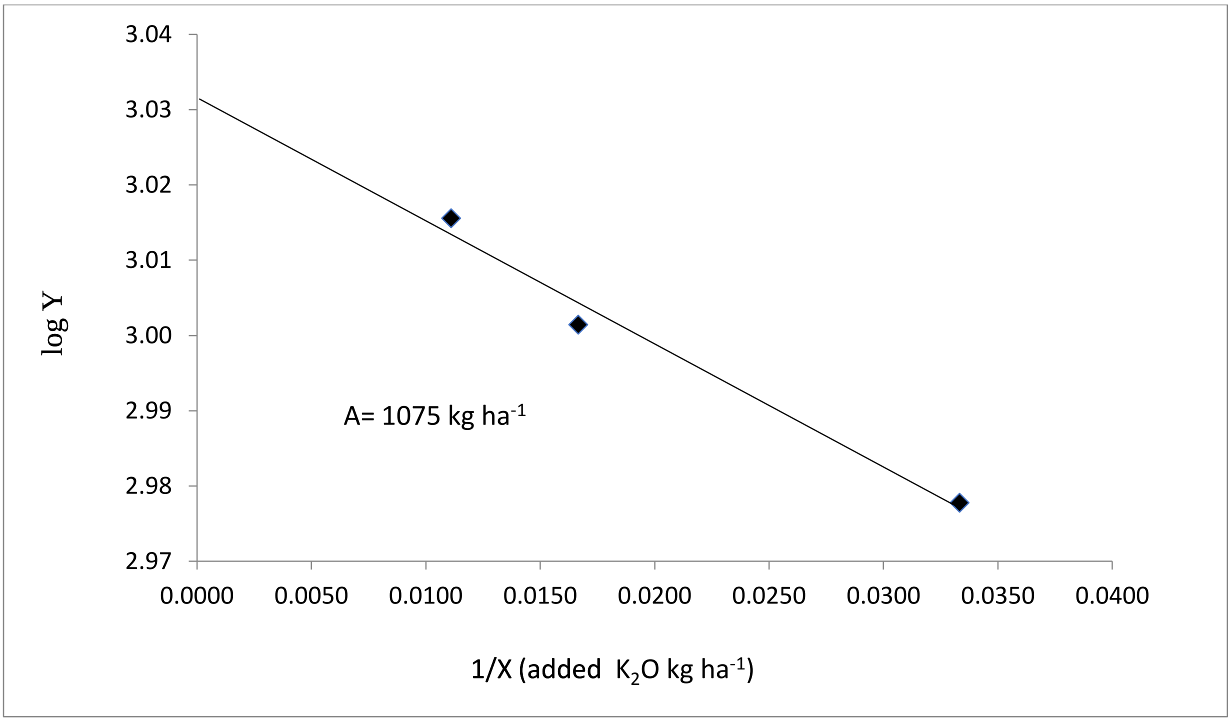

Fig. 2. Maximum output for K_2O after plotting Log Y and 1/X

Table V. Surplus of F on Raya with different T

Treatments	F (kg/ha)			Pod-outcome (kg/ ha)	% increase / control	Increase outcome	F price	VCR	Agronomic Efficiency
	N	P_2O_5	K_2O						
Control	0	0	0	445.2	0	0	0	0	0
Recommended dose	90	30	60	1003.3	125	62786.25	25505	2.46	3.10
75% of maximum yield	90	30	0	823.9	85.06	42603.75	13172	3.23	3.16
90 % of maximum yield	120	106	40	1029.9	131.33	65778.75	39903	1.65	2.20

DISCUSSION

Maximum yield as demonstrated by initial trial. Observation was also revealed that by following Mits–Bray equations level of Frequire to fulfill 90% higher output was low as contrast to overall recommendation of 90 kg phosphorus oxide/ha and 60 kg potassium oxide/ha (Table III). Opposite to concluded results from experiment carried in Bretain-Colombia in mid-sixty, it's also presumed the fertilizer recommendation by following Mits–Bray equation exaggerate F need (16). However, like our findings, Harrel (2005) observed that to accomplish ninety percent outcomes of corn, inceptive phosphorus about 15 kg/ha needed usage about 81 kg phosphorus oxide/hac which is very low as compared to requirement of Louisiana type soil (17). That variance in outlook may be because of variance in extract ants utilized for Phosphorus inspection, its reveal that in calcareous soil, the Bray II test over states accessible phosphorus also when soil phosphorus has value of 700 mg/kg its demonstrate the application of phosphorus at even (18). Trial data show that higher output about 1003 kg/hac was obtained by using approved dose of phosphorus about 90 kg phosphorus oxide per hac & potassium 60 kg potassium oxide per hac (Table IV). Apart from that their VCR value was low, this value was increased when treatment got 75% & 90% hypothetical output dose of fertilizer according to the Mitsc-Bray equation. Different parameters included RII, net return, incremental return higher for 90% of maximum output treated (Table V). According to Rashid *et al.* (2010), under same climate & soil conditions lesser application of nutrient was economical as compared to higher (19). The efficiency of fertilizer use is lesser in rain fed areas (20, 21) with outcomes of Sinar *et al.* (2002) who observed that fertilizer use on basis of theoretical higher outcomes is best endorsed phosphorus values in soil set on after harvesting showed similar pattern. As compared to controlling 75% theoretical output, the adjusted dose of treatment with fertilizer dose of 90% theoretical outputs gave higher phosphorus value. These outcomes are oblige the result of past report which is carried out in comparable environment & soil condition utilizing chickpea as indicator crop where use of 40 & 80 kg phosphorus oxide per hac increase phosphorus level in soil (23). In contrast potassium application in soil with various treatments give not satisfied outcomes. Mineralogical investigation reveals that minerals which are the main source of potassium such as K-Feldspar, Muscovite & Biotite obtained from their origin material (24). Exhaustion of potassium from soil is released through potassium liberation during the weathering process of those alloys.

CONCLUSION

According to the results from the study, we direly need a site specific nutrients management system that must be adopted other than the general recommendations, for the sake of more accurate and justified use of fertilizers that becomes economical also. It will not only enhance the efficiency of fertilizer use but also economically less burdened input. The decades long use of over fertilizers rates is unprofitable as the prices of fertilizers are very high hence uneconomical always.

Conflict of Interest:

Authors declared no conflict of interest.

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