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Effect of different levels of NPK with combined use of FYM and sulphur on yield, quality and nutrients uptake in Indian mustard (*Brassica juncea* L.)

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Abstract
Thrice replicated field experiments were conducted in Rabi season of year 2009-10 and 2011-12 to evaluate the effect of three levels of NPK with and without FYM and sulphur on yield, quality and nutrients uptake by Indian mustard (*Brassica juncea* L.). The results revealed that treatment containing 100% RDF of NPK + FYM 5MT ha^{-1}+ Sulphur 40kg ha^{-1} recorded significantly highest mustard grain yield (17.96 q ha^{-1}), protein content (21.06%), oil yield (6.72 q ha^{-1}) and uptakes of nitrogen (60.53 kg ha^{-1}), phosphorus (7.6 kg ha^{-1}), potassium (13.47 ha^{-1}) and sulphur (21.01 ppm) by mustard seed were also significantly highest with this treatment, whereas treatment consisting 100% RDF of NPK + Sulphur 40kg appeared to be more promising to gave significantly and highest stover yield (43.7 q ha^{-1}), oil content (37.66 q ha^{-1}) and uptakes of nitrogen (47.42 kg ha^{-1}), phosphorus (8.02 kg ha^{-1}), potassium (60.09 ha^{-1}) and sulphur (15.21 ppm) by mustard stover over other treatments.

Keywords: Yield, Quality, Nutrients uptake, NPK, FYM, FYM and Indian mustard

1. Introduction
India is the fourth largest oilseed economy in the world. Rapeseed-mustard contributes 28.6 % in the total oilseeds production among the seven edible oilseeds cultivated in India and ranks second after groundnut sharing 27.8% in the India's oilseed economy. The annual production of rapeseed-mustard is about 8.17 m t covering an area of about 6.51 m ha with a total productivity of 12.57 q ha^{-1} [1]. The share of oilseeds is 14.1% out of the total cropped area in India, rapeseed-mustard accounts for 3% of it [2]. Indian mustard (*Brassica juncea* (L.) is predominantly cultivated in Rajasthan, UP, Haryana, Madhya Pradesh, and Gujarat and some non-traditional areas of South India including Karnataka, Tamil Nadu, and Andhra Pradesh. The mustard growing areas in India are experiencing the vast diversity in the agro climatic conditions and different species of rapeseed-mustard are grown in some part of the country. Under marginal resource situation, cultivation of rapeseed-mustard becomes less remunerative to the farmers. This results in a big gap between requirement and production of mustard in India. Studies found a positive effect of sulphur along with FYM on yield, quality & nutrients content and their uptake in Indian mustard by several investigators like Singh and Pal [3], Rundala *et al.* [4] and Paliwal and Singh [5]. The role of sulphur (S) in nutrition of crop is well recognized as sulphur is takes place in three essential amino acids named cysteine, cystine and methionine, which are essential for protein synthesis. Sulphur is also involved in the formation of chlorophyll, glucosides and glucosinolates and thiamine. It also takes place in activities of enzymes. Oilseed crops respond to sulphur and FYM application remarkably. Results were found similar on effect of Sulphur along with FYM on yield, quality, nutrients content and their uptake in Indian mustard by Ramesh *et al.* [6].
There is a negative balance of sulphur in our soils as its addition through various sources is much lower than the removal. Sulphur is generally medium to deficient in about 50% soils especially in light textured soils of India and needs much attention for maintenance of sulphur in soils. Bharose, *et al.* [7] reported that sulphur deficiency in recent years has been aggravated in the soil due to continuous crop- removal and use of sulphur free high analysis NPK fertilizers. Leaching and erosion losses also contribute to sulphur deficiencies, sulphur deficiency also affect adversely the growth and yield of oil seed crops, which reduce the crop yield to an extent of 10-30%.

Farm yard manure (FYM) improves the soil physico-chemical properties along with direct release of macro as well as micronutrient, and finally crop yields increase recorded by Singh and Kumar, [8]. Farm yard manure is also serves as sources of energy for the growth of soil microorganisms [9]. Integration of chemical fertilizers along with FYM and Bio-fertilizers may serve the purpose, as they are cheap, pollution free and renewable [10]. In views of these points investigation was undertaken to investigate the effect of different levels of NPK with combined use of sulphur and FYM on yield, quality and nutrients uptake in Indian mustard (*Brassica juncea* L.)

2. Materials and Methods

Site description

The field experiments were conducted at Rabi season of 2009-10 and 2011-12 at Agricultural research farm of Amar Singh (PG) College Lakhaoti, Bulandshahar (U.P).

The experimental site is situated at 28^0 N Latitude, 77^0E Longitude. In general, the climate was subtropical with remarkable humidity. Summers were extremely hot and dry. Month of May & June were hottest with mean maximum temperature ranging between 35 ^{0}C & 45 ^{0}C. The winters were cold & frosty. The average minimum temperature in the coldest month of January varied from 4.3 to 6.5 ^{0}C. The mean annual rainfall was 671 mm recording about 75% in monsoon season.

The physico-chemical properties of the experimental soil are given in [Table-1]. It is obvious from the preliminary analysis that soil are light textured (Sandy loam), slightly alkaline in reaction, low in available N, P, medium in K and deficient in available sulphur.

The treatment comprises 3 levels of NPK i.e. 0, 75 and 100% of RDF (100:60:40) N, P_2O_5 and K_2O kg ha^{-1}respectively, 2 levels of sulphur i.e. 0 and 40 kg ha^{-1} and two levels of FYM i.e. 0 and 5MT ha^{-1} experiment were planted on October 27, 2009 and October 28 on 2011. The crop was sown in rows 40 cm apart using 4 kg seed ha$^{-1.}$ Full doses of FYM, P_2O_5, K_2O, S & half dose of N were drilled besides seed row followed by light planking. Remaining dose of N was top dressed after first irrigation.

Data collection

Observations on grain yield, stover yield, biological yield, harvest index were recorded at harvest stage. The yield was estimated at 14% moisture at harvest by the produce obtained from net plot area, treatment wise.

Oil conent and Oil yield

Seed samples were taken randomly from grain yield after harvest and analysed for oil content (%) in seeds with the help of Soxhlet's method [11]. The oil content was expressed in per cent. Oil yield (kg/ha) was calculated by multiplying seed yield and oil content in the seeds.

Crude protein content and crude protein yield

The crude protein yield (kg/ha) was calculated by multiplying seed yield with protein content in seeds with the help of total nitrogen by Kjeldal's method [11].

Nutrients Uptake

The total nutrient uptake was computed by adding of seed and stover determined separately taking into account their respective yield and nutrient content determined by using following methods:

- Nitrogen content of mustard seed and stover was determined by modified Micro Kjeldals's method [11].
- Phosphorus content was determined by vandomolybdophosphoric yellow colour method [11].
- Potassium was estimated by flame photometry method [11].
- For Sulphur content seed and stover samples were digested in di-acid mixture and content was determined by spectronic-20 at 420 mm.

Statistical analysis

The data on yield, oil content and protein content as well as their yield were recorded as per the standard procedure. The treatment differences were tested by using "F" test and critical differences at 5% probability.

3. Results and Discussion

Crop yields

The data presented in [Table-2] revealed that the application of FYM or sulphur or both in combination with 75% and 100% RDF of NPK increased grain yield, stover yield of Indiam mustard, significantly over absolute control and other. A significant increase in grain yield 10.2 q ha^{-1} and 14.3 q ha^{-1} was recorded with the application of 75% and 100% RDF of NPK alone, while with the addition of sulphur 40kg ha^{-1} with both levels 75% and 100% RDF of NPK produces 15.01 q and 16.64q ha^{-1} grain yield those were much superior with 11.28 and 16.03 q ha^{-1} as compare to application of 75% RDF of NPK + 5MT ha^{-1} FYM and 100% RDF of NPK + 5MT ha^{-1} FYM respectively. A significantly highest grain yield 17.96 q ha^{-1} was noticed with the application of combined use of sulphur and FYM with 100% RDF of NPK over all other. In case of stover yield of mustard, a significantly and highest stover yield 43.7 q ha^{-1} was recorded with the application of 100% RDF of NPK in combination with sulphur 40 kg ha^{-1} over all other treatments followed by 40.55 q ha^{-1} with combined use of Sulphur and FYM with 100% RDF of NPK. The results are in line with the findings of Singh and Singh [13], Yadav *et al.* [14], Khambalkar *et al.* [15] and Mehdi and Singh [16].

Harvest index

Data (Table-2) shows that with the application of FYM or sulphur or both in combination with 75% or 100% RDF of NPK improved the harvest index (HI) over absolute control. A significantly highest HI 30.7 % was calculated with the application of 100% RDF of NPK + FYM 5MT ha^{-1} + sulphur 40 kg ha^{-1} followed by 29.02% with 75% NPK + sulphur 40 kg ha^{-1}, whereas a minimum harvest index was found with treatment absolute control. The results are in agreement with those reported by Yeshpal *et al.* [17], Jain *et al.* [18] and Singh *et al.* [19].

Protein content

Protein content of mustard grain increased from 17.19 to 21.06% with the application of 100% RDF of NPK + FYM 5MT ha^{-1} + sulphur 40 kg ha^{-1} followed by 20.88% with treatment 100% RDF of NPK + Sulphur 40kg ha^{-1} over control. Harvest index 19.78 and 20.88% with combined use of sulphur with both levels 75% and 100% RDF of NPK respectively were much superior as compared to 19 and 19.75% with the application of FYM 5MT ha^{-1} combined with 75% and 100% RDF of NPK respectively shows in [Table-2]. The similar results were also reported by Mir *et al.* [20] and Parmar and Parmar [21].

Oil content and oil yield

Oil content and oil yield were significantly increased [Table-2] with both levels of NPK combined with FYM or sulphur or both. A significantly and highest oil content 37.66% was calculated with the application of 100% RDF of NPK + sulphur 40 kg ha^{-1} followed by 37.43% with treatment comprising 100% RDF of NPK + FYM 5MT ha^{-1} + sulphur 40 kg ha^{-1}, whereas a minimum 30.63% oil content was found with absolute control.

Oil yield was increased from 2.46 to 6.72Q ha^{-1} with the application of 100% RDF of NPK + FYM 5MT ha^{-1} + sulphur 40 kg ha^{-1} over absolute control treatment. Oil yield 5.32Q ha^{-1} and 6.27Q ha^{-1} with both levels 75% and 100% RDF of NPK in combination with 40 kg ha^{-1} sulphur, respectively were found superior as compared to 3.60Q and 5.56Q ha^{-1} with the application of 75% and 100% RDF of NPK with FYM 5MT ha^{-1} respectively. Similar findings were reported by Jain *et al*. [22] and Paliwal and Singh [23].

Nutrients uptake

Nitrogen: Significant and higher N uptake 47.51 kg and 55.58 kg ha^{-1} were recorded [Table-3] from both levels of NPK 75 and 100% RDF combined with sulphur 40 kg ha^{-1} were much superior with 34.29 and 50.65 kg ha^{-1} with the application of both levels of NPK 75 and 100% RDF combined with FYM 5MT ha^{-1} by mustard grain. A significantly highest 60.53 kg ha^{-1} N-uptake in mustard grain was found with treatment consisting 100% RDF of NPK + FYM 5MT ha^{-1} + sulphur 40 kg ha^{-1} followed by 55.58 kg ha^{-1} with treatment consisting 100% RDF of NPK + sulphur 40 kg ha^{-1}. A significantly highest 47.42 kg ha^{-1} N uptake by stover was recorded with the treatment comprising 100% RDF of NPK + Sulphur 40kg ha^{-1} followed by 44.61 kg ha^{-1} N uptake with the application of 100% RDF of NPK + sulphur 40 kg+ FYM 5MT ha^{-1} as compare to 12.05 kg ha^{-1} uptake of N with absolute control. Similar findings were reported by Ramesh *et al*. [24] and Kumawat *et al*. [25].

Phosphorus: Significantly highest 7.6 kg ha^{-1} phosphorus uptake in mustard grain was noticed in treatment comprising 100% RDF of NPK + FYM 5MT ha^{-1} + sulphur 40 kg ha^{-1} followed by 7.01 kg ha^{-1} with the application of 100% RDF of NPK + Sulphur 40kg ha^{-1} over all other treatments and 2.3 kg ha^{-1} by absolute control. In mustard stover, A highest 8.02 kg ha^{-1} P uptake was noticed with the treatment comprising 100% RDF of NPK + Sulphur 40kg ha^{-1} followed by 7.44 kg ha^{-1} with treatment consisting 100% RDF of NPK + FYM 5MT ha^{-1} + sulphur 40 kg ha^{-1} over 3.76 kg ha^{-1} P uptake in mustard stover with the control treatment. The results are closed with the findings of Singh and Pal [26] and Rundala *et al*. [27].

Potassium: Data presented in [Table-3] revealed that both levels of NPK 75% and 100% RDF combined with FYM 5MT ha^{-1} and sulphur 40 kg ha^{-1} noticed 9.23 kg ha^{-1} and highest 13.47 kg ha^{-1} potassium uptake by mustard grain respectively were higher over other treatments comprising 75% and 100% RDF of NPK alone or in combination with FYM or sulphur respectively. While a minimum potassium uptake in mustard grain was calculated by 3.05 kg ha^{-1} with absolute control treatment.

A highest 60.09 kg ha^{-1} potassium uptake in mustard stover was noticed with the treatment comprising 100% RDF of NPK + Sulphur 40kg ha^{-1} followed by 56.16 kg ha^{-1} with treatment consisting 100% RDF of NPK + FYM 5MT ha^{-1} + sulphur 40 kg ha^{-1} over 15.42 kg ha^{-1} potassium uptake in mustard stover by the control treatment was recorded. The results are in close conformity with the finding of Yadav *et al*. [28].

Sulphur: A significantly highest 21.01 kg ha^{-1} sulphur uptake by mustard grain recorded with treatment comprising 100% RDF of NPK + FYM 5MT + sulphur 40 kg ha^{-1} followed by 18.05 and 17.89 kg ha^{-1} with the treatments consisting 100% RDF of NPK + sulphur 40 kg ha^{-1} and 75% RDF of NPK + FYM 5MT +sulphur 40kg ha^{-1} respectively whereas a minimum 3.78 kg ha^{-1} potassium uptake was recorded with the absolute control.

A highest 15.21 kg ha^{-1} potassium uptake was noticed with the treatment 100% RDF of NPK + sulphur 40 kg ha^{-1} followed by 14.34 kg ha^{-1} with the treatment comprising 100% RDF of NPK + FYM 5MT + sulphur 40 kg ha^{-1}, whereas a minimum 4.96 kg ha^{-1} potassium uptake in mustard stover was recorded with the absolute control. These results are in line with the findings of Brajendra *et al*. [29].

Table 1: Physico-chemical properties of experimental field (Rabi 2009-10 & 2011-12)

Properties	Values/Qty	
	2009-10	2011-12
pH (1:2.5)	7.6	7.8
E.Ce (d Sm^{-1} at 25^0 C)	0.30	0.32
Organic Carbon (g kg^{-1} soil)	0.24	0.26
Bulk Density (Mg m^3)	1.36	1.34
Water holding capacity (%)	42.10	42.80
Available N (Kg ha^{-1})	196.0	198.0
Available P (Kg ha^{-1})	9.0	9.2
Available K (Kg ha^{-1})	110	112
Available S (ppm)	8.00	8.20
Textural Class	Sandy loam	Sandy loam

Table 2: Grain yield, stover, harvest Index, Protein content, Oil content and Oil yield affected by different levels of NPK with combined use of FYM and sulphur (Data pooled over two year)

Treatments	Grain Yield (Q ha^{-1})	Stover Yield (Q ha^{-1})	HI (%)	Protein content (%)	Oil content (%)	Oil Yield(Q ha^{-1})
T_1 – Control	8.04	24.09	25.02	17.19	30.63	2.46
T_2 - 75% N P K	10.20	28.57	26.31	18.44	32.07	3.27
T_3 - 75% N P K + FYM	11.28	30.17	27.22	19.00	31.9	3.60
T_4 - 75 % N P K + Sulphur	15.01	36.72	29.02	19.78	35.43	5.32
T_5 -75% N P K + FYM + Sulphur	15.76	38.87	28.85	20.13	35.41	5.58
T_6 - 100% N P K	14.30	38.93	26.86	19.38	34.99	5.00
T_7 - 100% N P K + FYM	16.03	39.48	28.88	19.75	34.68	5.56
T_8 - 100 % N P K + Sulphur	16.64	43.70	27.58	20.88	37.66	6.27
T_9 -100% N P K + FYM + Sulphur	17.96	40.55	30.70	21.06	37.43	6.72
C.D (0.05)	0.66	4.00	0.44	0.46	1.02	0.28

Table 3: Nutrients uptake affected by different levels of NPK with combined use of FYM and sulphur (Data pooled over two year)

Treatments	Nitrogen uptake (kg ha^{-1}) by Mustard			Phosphorus uptake (kg ha^{-1}) by Mustard			Potassium uptake (kg ha^{-1}) by Mustard			Sulphur uptake (ppm.) by Mustard		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
T_1 – Control	22.11	12.05	34.16	2.30	3.76	6.06	3.05	15.42	18.47	3.78	4.96	8.74
T_2 - 75% N P K	30.1	15.72	45.81	3.53	4.83	8.36	5.3	29.58	34.88	5.15	6.32	11.47
T_3 - 75% N P K + FYM	34.29	18.25	52.54	4.00	5.07	9.07	6.43	33.48	39.92	5.64	6.85	12.49
T_4 - 75 % N P K + Sulphur	47.51	23.5	71.01	5.40	6.21	11.6	8.41	40.39	48.8	13.96	11.99	25.95
T_5 -75% N P K + FYM + Sulphur	50.75	28.76	79.51	5.80	6.59	12.39	9.23	43.72	52.95	17.89	12.75	30.64
T_6 - 100% N P K	44.32	40.29	84.61	5.96	6.95	12.9	10.22	53.52	63.74	7.51	8.78	16.28
T_7 - 100% N P K + FYM	50.65	40.87	91.52	6.75	7.03	13.78	11.86	54.88	66.74	8.58	9.12	17.7
T_8 - 100 % N P K + Sulphur	55.58	47.42	102.99	7.01	8.02	15.03	12.23	60.09	72.32	18.05	15.21	33.26
T_9 -100% N P K + FYM + Sulphur	60.53	44.61	105.14	7.60	7.44	15.04	13.47	56.16	69.63	21.01	14.34	35.35
C.D (0.05)	2.7	N.S.	6.36	1.10	N.S.	2.06	3.1	N.S.	5.24	2.17	N.S.	4.06

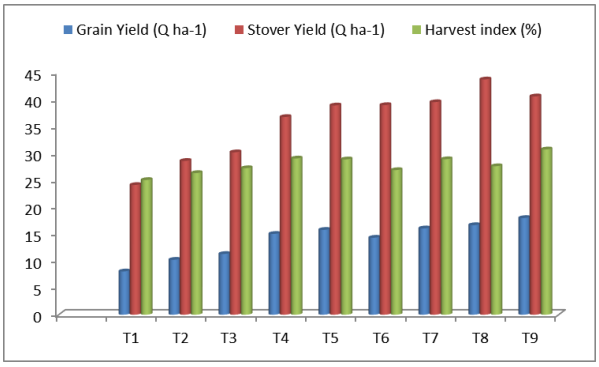

Fig 1: Grain, stover and harvest Index affected by different levels of NPK with combined use of FYM and sulphur (Data pooled over two year)

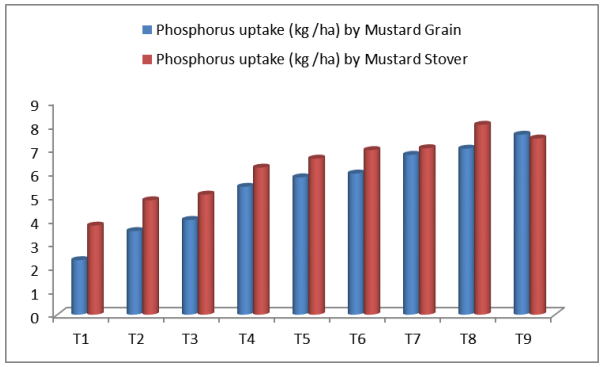

Fig 4: Effect of different levels of NPK with combined use of FYM and sulphur on Phosphorus uptake in mustard (Data pooled over two year)

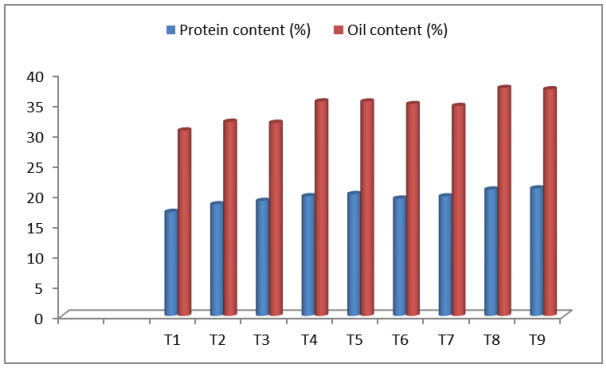

Fig 2: Protein content and Oil content affected by different levels of NPK with combined use of FYM and sulphur (Data pooled over two year)

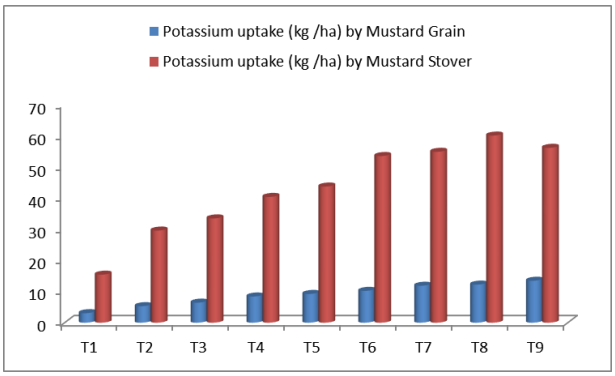

Fig 5: Effect of different levels of NPK with combined use of FYM and sulphur on Potassium uptake in mustard (Data pooled over two year)

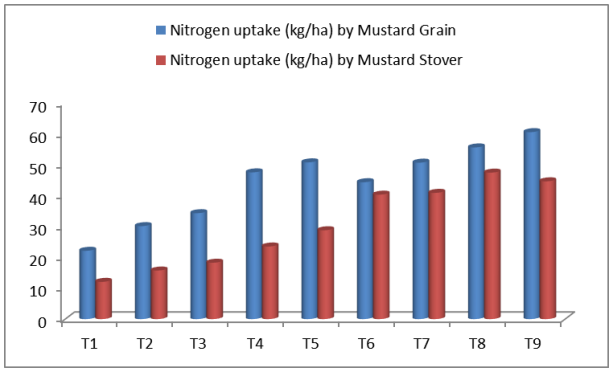

Fig 3: Effect of different levels of NPK with combined use of FYM and sulphur on Nitrogen uptake in mustard (Data pooled over two year)

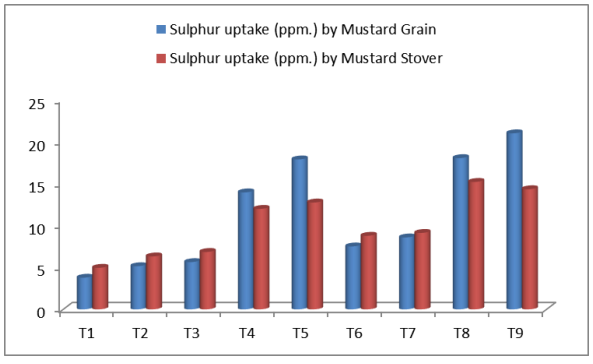

Fig 6: Effect of different levels of NPK with combined use of FYM and sulphur on Sulphur uptake in mustard (Data pooled over two year)

4. Conclusion

It may concluded that the yield of grain and stover in Indian mustard were increased with the application of increasing levels of NPK combined with sulphur and FYM either alone or in combination. An improvement was recorded in harvest index, oil content and oil yield with the application combined use of FYM and sulphur.

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