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Effects of phosphorus, sulphur and Irrigation on yield and NPS uptake of mustard + chickpea in intercropping system

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Abstract
To study the effect of phosphorus, sulphur and irrigation on mustard + chickpea intercropping system, a field experiment was conducted at A.S. (P.G.) College, Lakhaoti, Bulandshahr, (U.P.) during *rabi* season of 2009-2010 and 2010-2011. The experiment was carried out in split plot design with three replications. The treatments consisted of four levels (no irrigation, one irrigation at pre-flowering, one irrigation at grain filling and two irrigations one each at pre-flowering and grain filling stage of mustard) of irrigation in main plots, and three levels (0, 30 and 60 kg P_2O_5 ha^{-1}) of phosphorus and three levels (0, 20 and 40 kg S ha^{-1}) of sulphur in sub-plots. The results showed that in both the years of experimentation, application of two irrigations significantly increased number of primary and secondary branches $plant^{-1}$ over other levels of irrigation, which resulted in significantly higher grain and biological yield with two irrigations as compared to one irrigation in mustard + chickpea intercropping. Application of 60 kg P_2O_5 ha^{-1} produced more number of primary branches than control during both the years of study. Application of 40 kg S ha^{-1} produced more number of primary and secondary branches $plant^{-1}$ than control during both the years of study. Biological yield of mustard and chickpea increased significantly with the successive increase in the level of applied phosphorus and sulphur in both the years. NPS content in stover and grain of mustard and chickpea and NPS uptake increased significantly with increasing level of phosphorus, sulphur and irrigation.

Keywords: Phosphorus, sulphur, irrigation, NPS uptake, mustard and chickpea

Introduction

India is the fourth largest edible oil economy in the world and contributes about 10% to the world's oilseed production, 6-7% to the global production of vegetable oils, and nearly 7% to the protein meal. This sector also occupies an important place in the Indian agriculture. It covered an area of about 28.1 million hectares (mha), with total production of about 32.8 million tonnes (Mt) in the triennium ending 2013-14 (GOI, 2015-16) [4].

Mustard (*Brassica juncea* L.) belongs to the family cruciferae popularly known as rai is an important *rabi* season oilseed crop of north India. Mustard is second most important edible oilseed crop after groundnut, accounts nearly 30% of the total oilseeds produced in India. India is one of the largest rapeseed-mustard growing countries in the world, occupying the first rank in area and second in production next to China. India is the third largest producer of rapeseed-mustard (Piri *et al.* 2011) [10] having 5.90 million hectares area with 6.41 million tonnes production, but the average yield of rapeseed-mustard in India is only 1145 kg/ha (Economic survey 2013) [3] due to the lack of optimum use of nutrients and improper water management. Indian mustard is responsive to irrigation, and the most efficient water use by mustard depends on number as well as timing of irrigation at critical growth stages. Increase in the amount of water by increasing the number of irrigation augmented the leaf water potential, stomatal conductance, light absorption, and leaf area index which ultimately increased growth, yield attributes (Ray *et al.* 2014) [12] and quality (Majid and Simpson 1999) [6].

Pulses are rich source of protein for the vegetarian. Chickpea is the important pulse crop grown in larger area and production in the world. Chickpea ranks in first position in area (6.93 million hectare) and production (5.39 million tonnes) in India. It constitutes 32% and 40% of area and production of total pulse grown in India. Chickpea and mustard have lion's share in pulse and oilseeds, respectively. These crops are often grown in association in North and North-Western parts of India.

One of the main reason of low productivity of this system is inadequate nutrition specially phosphorus and sulphur. The phosphorus and sulphur requirement of the crops further influenced by available moisture conditions of the soil.

Among the three major plant nutrients, phosphorus stands next only to nitrogen and has a vital role in crop production. It is directly involved in energy transfer and protein metabolism in plants. An adequate supply of phosphorus to plants is important in laying down the primordia for its reproductive parts. Phosphorus is required for uniform maturity of crops and is essential for root development and seed formation. Hence, adequate supply of phosphorus is indispensable for profitable agriculture. Rapeseed shows a high efficiency in the phosphorus uptake because of a high influx-rate through the root hairs (Dell and Huang, 1977) [2]. Phosphorus fertilization is of prime importance for normal growth and development of plants due to its vital role in chlorophyll synthesis and involvement in various physiological and metabolic processes of the plant (Mehta *et al.*, 2005) [7]. Phosphorus has an important role in the process of photosynthesis of plants (Arnon, 1953) [1]. Phosphorus is one of the most important nutrient for plant and chickpea (*Cicer arietinum* L.) also responds significantly to phosphorus application. Phosphorus contributes directly to both the yield and quality of chickpea. It has often been called the "Master key of Agriculture". Phosphorus plays an important role in physiological functions of plant. It is a constituent of adenosine di-phosphate (ADP), sugar phosphate and nucleic acid, proteins and several co-enzymes, which are of the great importance in energy transformation and metabolic process of the plants. The nitrogen fixation is much accelerated when optimum quantity of phosphorus is available in the soil (Nawange, *et al.* 2011) [8].

Sulphur performs many important functions in the plant. It is best known for its role in the synthesis of proteins, oils and vitamins. It is a constituent of three essential amino acids *viz.*, methionine, cysteine and cystine. Sulphur is also a constituent of S glycosides (mustard oils), coenzyme A, vitamins, biotine and thiamine and ferrodoxins. Sulphur is also known to promote nodulation in legumes thereby promoting nitrogen fixation. Sulphur is associated with production of crops of high nutritional quality and market value. Sulphur plays an important role in the chemical composition of mustard tissue. Sulphur is the fourth major nutrient in crop production. The nitrogen and sulphur requirements of crops are closely related because both nutrients are required for protein synthesis. Sulphur is involved in the synthesis of chlorophyll. Sulphur is one of the 16 elements essential to crop production. Much research has done for studying effect of sulphur fertilizers on mustard and other crops.

Sulphur deficiencies in India are widespread and scattered. Deficiency of sulphur in Indian soils is on increase due to intensification of agriculture with high yielding varieties and multiple cropping coupled with the use of high analysis sulphur free fertilizers along with the restricted or no use of organic manures have accrued in depletion of the soil sulphur reserve. Crops generally absorb sulphur and phosphorus in similar amounts. Soils, which are deficient in sulphur, cannot on their own provide adequate sulphur to meet crop demand resulting in sulphur deficient crops and sub-optimal yields (Chattopaddhyay and Ghosh, 2012) [25]. Yield improvement with sulphur applications has been attributed to enhanced nitrogen use efficiency (Ghosh *et al.*, 1999) [26], possibly by increasing nitrate reductase activity.

Sulphur is now recognized as major plant nutrient, along with nitrogen (N), phosphorus (P), and potassium (K). It is essential for the growth and development of all crops, without exception. Most of the plants requirement of Sulphur is absorbed through the roots in the form of sulphate (SO_4^{-2}). Sulphur deficiency is becoming more critical with each passing year which is severely restricting crop yield, produce quality, nutrient use efficiency and economic returns on millions of farms. Like any essential nutrient, sulphur also has certain specific functions to perform in the plant. Thus, sulphur deficiencies can only be corrected by the application of sulphur fertilizer (Tandon and Messick, 2007) [24].

Major constraint limiting the productivity of oilseeds is that these are predominantly raised on under energy-starved conditions. Since the growth and productivity of any crop species are governed to a great extent by its surrounding environments, hence, type and amount of fertilisers applied exert a considerable influence on the growth and mineral composition of the crop plants (Singh *et al*., 2010; Singh and Thenua, 2016) [16, 17]. Consequently, the present study was based on the hypothesis that increasing irrigation, phosphorus and sulphur levels may enhance the yield and NPS uptake of mustard and chickpea in intercropping system.

Material and Methods

Field experiments were conducted at the research farm of A.S. (P.G.) College, Lakhaoti, Bulandshahr (U.P.) during the *Rabi* season 2009-10 and 2010-11. The design applied for statistical analysis was carried out with split plot design, with four levels of Irrigation (I_0- Control, I_1- one irrigation at pre-flowering stage of mustard, I_2- one irrigation at grain filling stage of mustard, I_3- two irrigations one each at pre-flowering and grain filling stages of mustard) in main plots, three levels of Phosphorus (0, 30, and 60 kg ha^{-1}) and three levels of Sulphur (0, 20, and 40 kg ha^{-1}) in sub plots, respectively. Thus, 36 treatment combinations were tested and replicated thrice. Both crops were sown in lines, and lines were drawn with the help of rope manually maintaining row to row distance of 45 cm. Mustard was grown with chickpea in 1: 1 row ratio intercropping. The chickpea was grown to replace of mustard crop in alternate row. 60 kg N ha^{-1} was applied through Urea, in two equal splits (1/2) basal and other half 30 days after sowing of the crop while the full doses of P and S were applied as basal dose as per treatments. The soil of farm is well levelled, sandy loam in texture and slightly alkaline in reaction. It analyzed low both in organic carbon and total nitrogen. It was medium in available phosphorus and potash. The farm is situated at 28.4˚ N latitude, 77.10˚ E longitude and altitude of 207.3 meters above the mean sea level.

Nutrient content in both intercrops were determined separately as per standard procedures (Johnson and Ulrich 1959; Tabatabai and Bremner, 1970) [5, 22]. Their uptake (kg ha^{-1}) was calculated by the following formula.

$$\text{Nutrient uptake (kg/ha)} = \frac{Stover\ yield\ (kg/ha) \times Nutrient\ content\ (\%)}{100} + \frac{Seed\ yield \times Nutrient\ content}{100}$$

Result and Discussion

A. Mustard

Effect of irrigation

The grain and biological yield (q ha^{-1}) was increased with the application of two irrigations (one each at pre-flowering and grain filling of mustard) (Table-1). It is increased due to the number of primary and secondary branches increased with the application of two irrigations. The biological yield was attributed due to the more plant height, more numbers of primary and secondary branches plant^{-1}. The seed yield (q ha^{-1}) was significantly increased due to the more number of siliquae plant^{-1}, more number of seeds siliquae^{-1} and higher 1000- grain weight. This may be due to more uptake of nutrients and photosynthesis due to more availability of moisture with application of irrigation. The same findings also reported by Singh, *et al.* (2017) [18].

The nitrogen, phosphorus and sulphur uptake by mustard grain, stover and total N, P and S uptake by mustard plant was significantly increased due to the application of two irrigations in mustard + chickpea 1: 1 row ratio intercropping (Table- 2, 3 and 4). It is attributed due to the increased seed yield (q ha^{-1}) and stover yield (q ha^{-1}). Availability of more moisture might have helped in better absorption and translocation of nutrients by plant of mustard. Similar results have been reported by Raut *et al.* (2000) [11]. The higher yield of any crop more uptakes of nitrogen, phosphorus and sulphur. The same findings also reported by Singh, *et al.* (2017) [18].

Effect of Phosphorus

The grain yield and biological yield (q ha^{-1}) was significantly increased with the application of 60 kg ha^{-1} phosphorus (Table-1). It is increased due to the plant height of mustard, number of primary and secondary branches plant^{-1}, number of siliquae plant^{-1}, number of seeds siliquae^{-1} and 1000-seed weight significantly increased with the application of 60 kg ha^{-1} phosphorus in mustard + chickpea 1: 1 row ratio. It is increased due to the more availability of P_2O_5 to mustard plant. The same results also reported by Singh and Thenua (2016) [17] and Singh, *et al.* (2017) [18].

The nitrogen, phosphorus and sulphur uptake by grain, stover and total N, P and S uptake by mustard plant was observed significantly increased with the application of 60 kg P_2O_5 ha^{-1} (Table- 2, 3 and 4). The nitrogen, phosphorus and sulphur uptake appreciable increased in grain and stover yield of mustard with chickpea intercropping. It is attributed due to the seed and stover yield significantly increased in intercropping with chickpea. The same findings also reported by Singh and Thenua (2016) [17].

Table 1: Grain and Biological yield (q ha^{-1}) of mustard in both the years as influenced by Irrigation, Phosphorus and Sulphur levels in mustard + chickpea intercropping.

Treatments	Grain yield (q ha^{-1}) of mustard			Biological yield (q ha^{-1}) of mustard		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Irrigation						
I_0	7.41	7.55	7.48	26.74	27.52	27.13
I_1	9.04	9.22	9.13	32.89	33.10	33.00
I_2	10.50	10.75	10.36	38.22	39.11	38.67
I_3	11.64	11.94	11.79	42.43	43.45	42.94
SE (d)	0.16	0.18	0.12	0.38	0.42	0.28
CD (P=0.05)	0.39	0.45	0.26	0.93	1.03	0.62
Phosphorus Levels						
P_0	8.83	9.03	8.93	32.11	33.01	32.56
P_{30}	9.72	9.94	9.83	35.30	35.65	35.48
P_{60}	10.40	10.63	10.52	37.80	38.64	38.22
SE (d)	0.19	0.21	0.13	0.44	0.48	0.31
CD (P=0.05)	0.38	0.42	0.26	0.87	0.96	0.61
Sulphur Levels						
S_0	8.90	9.11	9.01	32.37	33.24	32.81
S_{20}	9.85	10.06	9.96	35.80	36.66	36.23
S_{40}	10.18	10.43	10.31	37.04	37.40	37.22
SE (d)	0.19	0.21	0.13	0.44	0.48	0.31
CD (P=0.05)	0.38	0.42	0.26	0.87	0.96	0.61

Effect of Sulphur

The grain and biological yield (q ha^{-1}) of mustard + chickpea intercropping in 1: 1 row ratio was significantly increased with the application of 40 kg S ha^{-1} (Table-1). It is attributed due to the application of 40 kg S ha^{-1} was significantly increased the plant height, number of various types of branches plant^{-1}, number of siliquae plant^{-1}, number of seeds siliquae^{-1} and 1000-grain weight increased significantly with the application of 40 kg S ha^{-1}. Ultemately the grain and biological yield (q ha^{-1}) of mustard was increased. It may be due to enhanced photosynthesis, as sulphur is moved in the formation of chlorophyll and activation of enzymes. The above findings also reported by Singh and Thenua (2016) [17], Singh, *et al.* (2017) [18] and Singh, *et al.* (2018) [20].

The nitrogen, phosphorus and sulphur uptake by the grain, stover and total N, P and S uptake by mustard plant was observed significantly higher in the application of 40 kg S ha^{-1} (Table-2, 3 and 4). It is attributed due to the significantly highest yield of biomass and grain yield of mustard. It is attributed due to the application of 40 kg S ha^{-1} was significantly increased the biomass yield (q ha^{-1}), grain yield (q ha^{-1}) ultimately the nitrogen, phosphorus and sulphur uptake increased with the application of 40 kg S ha^{-1}. The same findings also reported by Singh and Thenua (2016) [17].

Table 2: N- uptake by mustard grain, stover and total N- uptake (kg ha^{-1}) in both the years as influenced by Irrigation, Phosphorus and Sulphur levels in mustard + chickpea intercropping

Treatments	N- Uptake by mustard grain (kg ha^{-1})			N- Uptake by mustard stover (kg ha^{-1})			Total N- Uptake by mustard (kg ha^{-1})		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Irrigation									
I_0	18.25	18.63	18.44	9.93	10.27	10.10	28.14	28.90	28.52
I_1	22.27	22.74	22.51	12.11	12.51	12.31	34.28	35.24	34.81
I_2	25.87	26.54	26.21	14.07	14.41	14.24	40.00	40.95	40.48
I_3	28.70	29.43	29.07	15.60	15.99	15.80	44.29	45.45	44.87
SE (d)	0.25	0.34	0.20	0.17	0.29	0.13	0.41	0.50	0.33
CD(P=0.05)	0.61	0.68	0.43	0.42	0.50	0.29	1.02	1.23	0.71
Phosphorus Levels									
P_0	21.75	22.26	22.01	11.82	12.21	12.02	33.58	34.47	34.03
P_{30}	23.94	24.54	24.24	13.02	13.43	13.23	36.96	37.97	37.47
P_{60}	25.63	26.20	25.92	13.93	14.24	14.09	39.60	40.46	40.03
SE (d)	0.29	0.34	0.21	0.19	0.22	0.14	0.50	0.58	0.36
CD(P=0.05)	0.57	0.68	0.41	0.38	0.44	0.27	0.99	1.16	0.71
Sulphur Levels									
S_0	21.94	22.47	22.21	11.93	12.21	12.07	33.87	34.68	34.28
S_{20}	24.28	24.81	24.55	13.20	13.48	13.34	37.52	38.29	37.91
S_{40}	25.10	25.72	25.41	13.65	14.20	13.93	38.74	39.93	39.34
SE (d)	0.29	0.34	0.21	0.19	0.22	0.14	0.50	0.58	0.36
CD(P=0.05)	0.57	0.68	0.41	0.38	0.44	0.27	0.99	1.16	0.71

Table 3: P-uptake by mustard grain, stover and total P- uptake (kg ha^{-1}) in both the years as influenced by Irrigation, Phosphorus and Sulphur levels in mustard + chickpea intercropping

Treatments	P- Uptake by mustard grain (kg ha^{-1})			P- Uptake by mustard Stover (kg ha^{-1})			Total P- Uptake by mustard (kg ha^{-1})		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Irrigation									
I_0	4.51	4.67	4.59	3.11	3.17	3.14	7.62	7.84	7.73
I_1	4.58	5.75	5.66	3.79	3.87	3.83	9.37	9.62	9.50
I_2	6.48	6.60	6.54	4.44	4.52	4.48	10.89	11.15	11.02
I_3	7.20	7.34	7.27	4.89	4.99	4.94	12.09	12.35	12.22
SE (d)	0.11	0.12	0.08	0.07	0.09	0.06	0.18	0.19	0.13
CD(P=0.05)	0.28	0.30	0.18	0.18	0.21	0.13	0.43	0.47	0.28
Phosphorus Levels									
P_0	5.44	5.62	5.53	3.73	3.79	3.76	9.15	9.41	9.28
P_{30}	5.98	6.12	6.05	4.08	4.18	4.13	10.06	10.30	10.18
P_{60}	6.41	6.53	6.47	4.36	4.45	4.41	10.77	11.01	10.89
SE (d)	0.41	0.15	0.10	0.08	0.10	0.05	0.19	0.21	0.14
CD(P=0.05)	0.28	0.30	0.19	0.17	0.20	0.12	0.38	0.41	0.27
Sulphur Levels									
S_0	5.48	5.62	5.55	3.74	3.83	3.78	9.22	9.47	9.35
S_{20}	6.07	6.22	6.15	4.16	4.22	4.19	10.20	10.45	10.33
S_{40}	6.28	6.42	6.35	4.28	4.36	4.32	10.56	10.80	10.68
SE (d)	0.14	0.15	0.10	0.08	0.10	0.05	0.19	0.21	0.14
CD(P=0.05)	0.28	0.30	0.19	0.17	0.20	0.12	0.38	0.41	0.27

Table 4: S-uptake by mustard grain, stover and total S- uptake (kg ha^{-1}) in both the years as influenced by Irrigation, Phosphorus and Sulphur levels in mustard + chickpea intercropping

Treatments	S- Uptake by mustard grain (kg ha^{-1})			S- Uptake by mustard stover (kg ha^{-1})			Total S- Uptake by mustard (kg ha^{-1})		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Irrigation									
I_0	8.42	8.70	8.56	4.23	4.31	4.27	12.64	13.01	12.82
I_1	10.40	10.70	10.55	5.16	5.27	5.22	15.56	15.97	15.77
I_2	12.13	12.36	12.25	6.00	6.14	6.07	18.08	18.50	18.29
I_3	13.42	13.69	13.56	6.45	6.82	6.64	20.07	20.50	20.29
SE (d)	0.26	0.27	0.19	0.13	0.14	0.10	0.22	0.24	0.16
CD(P=0.05)	0.63	0.66	0.41	0.32	0.35	0.21	0.53	0.59	0.35
Phosphorus Levels									
P_0	10.14	10.46	10.30	5.04	5.16	5.10	15.19	15.61	15.40
P_{30}	11.15	11.42	11.29	5.55	5.68	5.62	16.70	17.10	16.90
P_{60}	11.98	12.21	12.10	5.94	6.07	6.01	17.88	18.28	18.08
SE (d)	0.30	0.32	0.21	0.15	0.16	0.11	0.26	0.29	0.18
CD(P=0.05)	0.60	0.64	0.41	0.30	0.33	0.22	0.51	0.58	0.36
Sulphur Levels									
S_0	10.26	10.52	10.39	5.08	5.20	5.14	15.31	15.72	15.51

S_{20}	11.31	11.60	11.46	5.63	5.74	5.69	16.93	17.24	17.41
S_{40}	11.71	11.97	11.84	5.82	5.96	5.89	17.52	17.93	17.73
SE (d)	0.30	0.32	0.21	0.15	0.16	0.11	0.26	0.29	0.18
CD(P=0.05)	0.60	0.64	0.41	0.30	0.33	0.22	0.51	0.58	0.36

B. Chickpea

Effect of Irrigation

Grain and biological yield (q ha^{-1}) of chickpea was significantly increased with two irrigations (one each at pre-flowering and grain filling stage of mustard) in mustard + chickpea intercropping system in 1: 1 row ratio (Table- 5). It is attributed due to the maximum number of primary and secondary branches $plant^{-1}$, higher number of pods $plant^{-1}$, more number of seeds pod^{-1} and higher 1000-seed weight were recorded ultimately the biological and grain yield (q ha^{-1}) was increased. The same findings also reported by Thenua, *et al.* (2010) [23], Singh (2017) [18] and Singh, *et al.* (2018) [21].

Nitrogen, phosphorus and sulphur uptake by the chickpea grain, stover and total N, P, S uptake was significantly increased with the application of two irrigations (Table- 6). It is attributed due to increase the grain and straw yield (q ha^{-1}) and ultimately the N, P and S uptake was increased.

Effect of Phosphorus

The grain and biological yield (q ha^{-1}) of chickpea intercropped with mustard was significantly increased with the application of 60 kg P_2O_5 ha^{-1} over control (Table- 5). It is attributed due to the increase in the number of primary and secondary branches $plant^{-1}$, increased number of pods $plant^{-1}$, number of seeds pod^{-1} and 1000-seed weight, the grain and biological yield ultimately increased of chickpea. The same findings also reported by Thenua, *et al.* (2010) [23], Singh (2017) [19] and Singh, *et al.* (2018) [20].

The nitrogen, phosphorus and sulphur uptake by chickpea grain, straw and total N, P and S uptake was significantly increased with the application of 60 kg P_2O_5 ha^{-1} (Table- 6, 7 and 8). It is increased due to the grain and straw yield significantly increased in this treatment. The same findings also reported by Singh, *et al.* (1997) and Thenua, *et al.* (2010) [23].

Effect of Sulphur

The grain and biological yield (q ha^{-1}) of chickpea in mustard + chickpea intercropping was significantly increased with the application of 40 kg S ha^{-1} (Table- 5). It is attributed due to the number of primary and secondary branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1} and 1000-seed weight increased significantly with the application of 40 kg S ha^{-1} and ultimately the seed yield (q ha^{-1}) and biological yield (q ha^{-1}) increased significantly. The same findings also reported by Thenua, *et al.* (2010) [23], Singh (2017) [19] and Singh, *et al.* (2018) [21].

The nitrogen, phosphorus and sulphur uptake by chickpea grain, stover and total N, P and S uptake was significantly increased with the application of 40 kg S ha^{-1} (Table- 6, 7 and 8). It is increased due to the application of 40 kg S ha^{-1} significantly increased the chickpea grain and straw yield ultimately the N, P and S uptake increased.

Phosphorus and sulphur status in soil after harvesting of both crops

Effect of Irrigation

Irrigation schedules were failed to touch the level of significance for phosphorus and sulphur status in both the years (Table-9).

Effect of Phosphorus

Phosphorus levels were significantly increased in phosphorus status in soil after harvesting of both crops in both the years. The maximum phosphorus was found with the application of 60 kg P_2O_5 ha^{-1} (Table-9) while, Sulphur status in soil after harvesting of both crops in both the years did not influenced with phosphorus levels (Table-9).

Effect of Sulphur

Phosphorus status in soil after the harvesting of both crops in both the years did not influenced with the sulphur levels while, sulphur status in soil after harvesting of both crops in both the years was significantly increased with the increasing levels of sulphur. The maximum sulphur was found with the application of 40 kg S ha^{-1}.

Table 5: Grain and Biological yield (q ha^{-1}) of chickpea in both the years as influenced by Irrigation, Phosphorus and Sulphur levels in mustard + chickpea intercropping

Treatments	Grain yield (q ha^{-1}) of chickpea			Biological yield (q ha^{-1}) of chickpea		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Irrigation						
I_0	4.47	4.78	4.63	9.03	9.71	9.37
I_1	8.83	8.68	8.50	17.27	18.11	17.69
I_2	9.12	9.57	9.35	19.13	20.19	19.66
I_3	9.22	9.70	9.46	19.41	20.63	20.02
SE (d)	0.21	0.23	0.16	0.28	0.33	0.21
CD (P=0.05)	0.52	0.57	0.34	0.68	0.80	0.47
Phosphorus Levels						
P_0	7.18	7.58	7.38	14.99	15.94	15.46
P_{30}	7.72	8.11	7.92	15.95	16.88	16.42
P_{60}	8.45	8.85	8.65	17.69	18.67	18.18
SE (d)	0.22	0.24	0.16	0.30	0.35	0.23
CD (P=0.05)	0.43	0.48	0.34	0.60	0.71	0.46
Sulphur Levels						
S_0	7.17	7.54	7.36	14.83	15.70	15.26
S_{20}	7.93	8.32	8.13	16.51	17.45	16.98
S_{40}	8.25	8.68	8.47	17.29	18.33	17.81

SE (d)	0.22	0.24	0.16	0.30	0.35	0.23
CD (P=0.05)	0.43	0.48	0.34	0.60	0.71	0.46

Table 6: N- uptake by chickpea grain, stover and total N- uptake (kg ha^{-1}) in both the years as influenced by Irrigation, Phosphorus and Sulphur levels in mustard + chickpea intercropping.

Treatments	N- Uptake by chickpea grain (kg ha^{-1})			N- Uptake by chickpea stover (kg ha^{-1})			Total N- Uptake by chickpea (kg ha^{-1})		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Irrigation									
I_0	13.51	14.45	13.98	5.62	6.07	5.84	19.13	20.52	19.83
I_1	25.17	26.25	25.71	11.01	11.61	11.31	36.18	37.86	37.02
I_2	27.49	28.94	28.22	12.32	13.07	12.70	39.92	42.01	40.97
I_3	27.89	29.34	28.62	12.68	13.46	13.07	40.57	42.80	41.69
SE (d)	0.37	0.36	0.26	0.21	0.25	0.16	0.49	0.55	0.37
CD(P=0.05)	0.90	0.89	0.56	0.52	0.61	0.36	1.20	1.35	0.80
Phosphorus Levels									
P_0	21.73	22.94	22.34	9.72	10.29	10.01	31.45	33.23	32.34
P_{30}	23.34	24.52	23.93	10.13	10.79	10.46	33.48	35.32	34.40
P_{60}	25.48	26.77	26.13	11.37	12.08	11.73	36.92	38.85	37.89
SE (d)	0.39	0.43	0.29	0.24	0.28	0.18	0.59	0.65	0.44
CD(P=0.05)	0.77	0.87	0.57	0.48	0.56	0.36	1.18	1.31	0.87
Sulphur Levels									
S_0	21.70	22.81	22.26	9.44	10.04	9.74	31.14	32.85	31.99
S_{20}	23.89	25.16	24.53	10.66	11.24	10.95	34.63	36.40	35.52
S_{40}	24.96	26.26	25.61	11.13	11.88	11.51	36.09	38.14	37.12
SE (d)	0.39	0.43	0.29	0.24	0.28	0.18	0.59	0.65	0.44
CD(P=0.05)	0.77	0.87	0.57	0.48	0.56	0.36	1.18	1.31	0.87

Table 7: P- uptake by chickpea grain, stover and total P- uptake (kg ha^{-1}) in both the years as influenced by Irrigation, Phosphorus and Sulphur levels in mustard + chickpea intercropping.

Treatments	P- Uptake by chickpea grain (kg ha^{-1})			P- Uptake by chickpea stover (kg ha^{-1})			Total P- Uptake by chickpea (kg ha^{-1})		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Irrigation									
I_0	1.48	1.59	1.54	0.6244	0.6756	0.6500	2.11	2.26	2.19
I_1	2.76	2.88	2.82	1.2244	1.2933	1.2589	3.99	4.17	4.08
I_2	3.03	3.17	3.10	1.3711	1.4544	1.4128	4.40	4.63	4.52
I_3	3.06	3.22	3.14	1.3944	1.4967	1.4456	4.46	4.72	4.59
SE (d)	0.10	0.11	0.07	0.0314	0.0355	0.0237	0.13	0.15	0.10
CD(P=0.05)	0.24	0.25	0.16	0.0769	0.0869	0.0517	0.33	0.36	0.22
Phosphorus Levels									
P_0	2.38	2.52	2.45	1.0683	1.1458	1.1071	3.45	3.65	3.55
P_{30}	2.56	2.69	2.63	1.1267	1.2008	1.1638	3.69	3.91	3.80
P_{60}	2.81	2.94	2.88	1.2658	1.3433	1.3046	4.07	4.28	4.18
SE (d)	0.10	0.11	0.07	0.0320	0.0367	0.0243	0.13	0.14	0.09
CD(P=0.05)	0.19	0.21	0.14	0.0639	0.0733	0.0479	0.27	0.29	0.19
Sulphur Levels									
S_0	2.38	2.50	2.44	1.0475	1.1175	1.0825	3.42	3.60	3.51
S_{20}	2.63	2.76	2.70	1.1742	1.2508	1.2125	3.82	4.03	3.93
S_{40}	2.74	2.88	2.81	1.2392	1.3217	1.2805	3.98	4.20	4.09
SE (d)	0.10	0.11	0.07	0.0320	0.0367	0.0243	0.13	0.14	0.09
CD(P=0.05)	0.19	0.21	0.14	0.0639	0.0733	0.0479	0.27	0.29	0.19

Table 8: S- uptake by chickpea grain, stover and total S- uptake (kg ha^{-1}) in both the years as influenced by Irrigation, Phosphorus and Sulphur levels in mustard + chickpea intercropping.

Treatments	S- Uptake by chickpea grain (kg ha^{-1})			S- Uptake by chickpea stover (kg ha^{-1})			Total S- Uptake by chickpea (kg ha^{-1})		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Irrigation									
I_0	1.006	1.077	1.042	0.526	0.568	0.547	1.529	1.644	1.588
I_1	1.873	1.953	1.913	1.030	1.084	1.057	2.903	3.038	2.971
I_2	2.053	2.156	2.105	1.152	1.223	1.188	3.206	3.379	3.293
I_3	2.078	2.184	2.131	1.172	1.258	1.215	3.250	3.442	3.346
SE (d)	0.045	0.050	0.034	0.029	0.032	0.022	0.108	0.115	0.079
CD(P=0.05)	0.111	0.122	0.073	0.070	0.079	0.047	0.263	0.282	0.172
Phosphorus Levels									
P_0	1.617	1.708	1.662	0.899	0.962	0.930	2.517	2.638	2.577
P_{30}	1.735	1.826	1.781	0.948	1.009	0.979	2.686	2.924	2.805
P_{60}	1.903	1.993	1.948	1.063	1.129	1.096	2.963	3.065	3.014
SE (d)	0.046	0.052	0.035	0.030	0.033	0.022	0.104	0.112	0.076

CD(P=0.05)	0.093	0.103	0.068	0.059	0.067	0.044	0.207	0.225	0.151
Sulphur Levels									
S_0	1.617	1.698	1.657	0.882	0.940	0.911	2.498	2.670	2.584
S_{20}	1.784	1.873	1.829	0.988	1.052	1.020	2.772	2.835	2.804
S_{40}	1.857	1.957	1.907	1.041	1.108	1.075	2.896	3.123	3.010
SE (d)	0.046	0.052	0.035	0.030	0.033	0.022	0.104	0.112	0.076
CD(P=0.05)	0.093	0.103	0.068	0.059	0.067	0.044	0.207	0.225	0.151

Table 9: Phosphorus and sulphur status in soil after harvesting of both intercrop in both the years as influenced by Irrigation, Phosphorus and Sulphur levels in mustard + chickpea intercropping.

Treatments	Phosphorus status in soil after harvesting			Sulphur status in soil after harvesting		
	2009- 10	2010- 11	Pooled	2009- 10	2010- 11	Pooled
Irrigation						
I_0	9.17	9.45	9.31	12.47	12.69	12.58
I_1	9.13	9.40	9.27	12.50	12.75	12.63
I_2	9.23	9.51	9.37	12.40	12.66	12.53
I_3	9.31	9.59	9.45	12.30	12.54	12.42
SE(d)	0.10	0.10	0.07	0.16	0.19	0.12
CD (P=0.05)	N.S	N.S	N.S	N.S	N.S	N.S
Phosphorus Levels						
P_0	8.03	8.28	8.16	12.43	12.68	12.56
P_{30}	9.65	9.994	9.80	12.42	12.66	12.54
P_{60}	9.95	10.25	10.10	12.40	12.63	12.52
SE (d)	0.12	0.12	0.08	0.18	0.21	0.14
CD (P=0.05)	0.23	0.24	0.16	N.S	N.S	N.S
Sulphur Levels						
S_0	9.07	9.33	9.20	11.45	11.40	11.43
S_{20}	9.23	9.52	9.38	12.75	13.13	12.94
S_{40}	9.33	9.61	9.47	13.05	13.44	13.25
SE(d)	0.12	0.12	0.08	0.18	0.21	0.14
CD (P=0.05)	N.S	N.S	N.S	0.36	0.41	0.27

Conclusion

The growing Indian population enhanced the oilseed and pulses demand. The burgeoning human population in India needs higher oilseeds and pulses production for fulfilling the dietary fat and protein requirement. It is requires to mitigating the demand of oil and protein. On the basis of two years field experiment made during the *Rabi* 2009-10 and 2010-11, it may be concluded that the application of two time irrigation (one each at pre-flowering and grain filling stage of mustard) with 60 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1} was very effective and good combination of moisture and nutrients for mustard + chickpea intercropping system in sandy loam soils for obtained the maximum returns.

References

1. Arnon II. Biochemistry of phosphorus in plants. In soil and fertilizer phosphates in. 1953.
2. Dell B, Huang LB. Physiological response of plants to low boron. Plant and soil. 1977; 193:103-120.
3. Economic survey. Statistical Appendix. Ministry of Home Affairs. Government of India, 2013, A17-A19. Available at http:// indianbudget.nic.in
4. GOI (Government of India) Annual Report (2015-16); National Mission on Oilseeds and Oil Palm. Department of Agriculture, Cooperation and Farmers Welfare. Ministry of Agriculture and Farmers Welfare, GOI, New Delhi, 2015-16.
5. Johnson CM, Ulrich A. Analytical methods for use in plant analysis, California Agricultural Experiment Statistics Bulletin, 766. University of California, Experimental station, Berkeley, 1959.
6. Majid A, Simpson GM. Yield and quality of mustard (*Brassica juncea* L.) as affected by irrigation pattern. Pakistan Journal of Soil Science. 1999; 16:5-10.
7. Mehta TK, Shaktawat MS, Singh SM. Influence of sulphur, phosphorus and farmyard manure on yield attributes and yield of maize (*Zea mays*) in southern Rajasthan condition. Indian Journal of Agronomy. 2005; 53(3):203-205.
8. Nawange DD, Yadav AS, Singh RV. Effect of phosphorus and sulphur application on growth, yield attributes and yield of chickpea (*Cicer arietinum* L). Legume Res. 2011; 34(1):48-50.
9. Orlovius K, Kirkby EA. Fertilizing for high yield and quality oilseed rape. IPI Bulletin No. 16, International Potash Institute, 2013.
10. Piri I, Nik MM, Tavassoli A, Rastegaripour F. Effect of irrigation intervals and sulphur fertilizer on growth analyses and yield of *Brassica juncea*. African Journal of Microbiology Research. 2011; 5:3640-3646.
11. Raut R, Abdul HF, Hadole SS, Jeughale GS. Effect of irrigation and sulphur on concentration, uptake and availability of sulphur, nitrogen and phosphorus in mustard (*B. juncea*). J Soils Crops. 2000; 10(1):145-148.
12. Ray K, Pal AK, Sengupta K. Effect of irrigation and sulphur on Indian mustard. Germany, Lambert Academic Publishing, 2014, 1-94.
13. Singh AK, Singh SB, Singh AP, Awnindra Singh K, Mishra SK, Sharma AK. Effect of different soil moisture regimes on biomass partitioning and yield of chickpea genotypes under intermediate zone of J & K. Journal of food Legumes. 2010; 23(2):156-158.
14. Singh M, Singh HB, Giri G. Dry matter accumulation and NP-uptake by mustard and chickpea as influenced by intercropping and levels of nitrogen and phosphorus. Annals of Agricultural Research. 1997; 18(3):135-142.
15. Singh M, Singh HB, Giri G. Quality, biometric and economics aspects of mustard and chickpea as influenced

by intercropping and N and P fertilization. Annals of Agricultural Research. 1998; 19(1):61-65.

16. Singh RK, Singh AK, Kumar R. Effect of fertility levels on nutrient uptake, yield and quality of Indian mustard [*Brassica juncea* (L.) Czern. & Coss] varieties under late sown condition. Environment and Ecology. 2010; 28:1764-1767.
17. Singh SB, Thenua OVS. Effects of phosphorus and sulphur fertilization on yield and NPS uptake by mustard (*Brassica juncea* L.). Progressive Research: An International Journal. 2016; 11(1):80-83.
18. Singh Satybhan. Effect of irrigation schedules and different levels of nutrients on growth, yield and quality of chick pea (*Cicer arietinum* L.). Progressive Research- An International Journal. 2017; 12(1):91-95.
19. Singh Satybhan, Thenua OVS, Singh Virendra. Effects of irrigation schedules and nutrient levels on mustard (*Brassica juncea* L.). International Journal of Recent Advances in Multidisciplinary Research. 2017; 4(11):3056-3059.
20. Singh Satybhan, Thenua OVS, Singh Virendra. Effect of phosphorus and sulphur fertilization on yield and quality of mustard & chickpea in intercropping system under different soil moisture regimes. Journal of Pharmacognosy and Phytochemistry. 2018; 7(2):1520-1524.
21. Singh Satybhan, Singh Virendra, Shukla Rabish Datt, Dubey Divanker. Influences of sulphur and zinc levels on soybean and residual effect on succeeding crop in soybean-wheat cropping system. International Journal of Chemical Studies. 2018; 6(3):1130-1134.
22. Tabatabai MA, Bremner JM. A simple turbidometric method of determination total NPS in plant material. Agronomy journal. 1970; 62:805-806.
23. Thenua OVS, Singh SP, Shiv Kumar BG. Productivity and economics of chickpea (*Cicer arietinum*) - fodder sorghum (*Sorghum bicolor*) cropping system as influenced by P sources, bio-fertilizers and irrigation to chickpea. Indian Journal of Agronomy. 2010; 55(1):22-27.
24. Tondon HLS, Messick DL. Practical of sulphur guide. The Sulphur Institute, Washington DC. 2007, 1-2.
25. Chattopaddhyay S, Ghosh GK. Response of rapeseed (*Brassica juncea* L.) to various sources and levels of sulphur in red and lateritic soils of West Bengal, India. International Journal of Plant, Animal and Environmental Sciences. 2012; 2(4):50-59.
26. Ghosh GK, Sarkar AK, Mondal D. Efficacy of phosphogypsum as source of sulphur for mustard (*Brassica juncea* L). Journal of Nuclear Agriculture and Biology. 1999; 28:164-168.