RESEARCH ARTICLE

EFFECT OF DIFFERENT LEVELS OF PHOSPHORUS THROUGH VARYING SOURCES ON PRODUCTIVITY AND OIL CONTENT OF MUSTARD

Dhram Prakash*, Sunita Sheoran and Ankit

Department of Soil Science, CCS Haryana Agricultural University, Hisar
Email: dhramprakashteotia@gmail.com

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Abstract: A field experiment was conducted to study the impact of different levels and sources of P application on performance of mustard under pearl millet-mustard cropping system at Research farm, Soil Science, CCS HAU, Hisar. The experiment was laid out in randomized block design with three replications, consisting of eleven treatments. The results showed that among the different treatments, seed and stover yield of mustard varied between 15.37 to 23.16 and 65.70 to 85.82 q ha^{-1}, respectively. Application of 20 kg P_2O_5 ha^{-1} through SSP led higher seed and stover yield as compared to P application through DAP or RP. Application of half of recommended dose of P through chemical fertilizers along with FYM showed lower seed and stover yield of mustard as compared to application of recommended dose of P via chemical fertilizers. However, the plots receiving P via RP in combination with FYM showed accrual in seed yield of mustard over sole application of RP. The oil content in seed samples of mustard varied between 38.70 to 39.30 % under the different treatments, however, effect of various sources of P on oil content in mustard seed was found non-significant.

Keywords: Indian mustard, Phosphorus, FYM, Rock phosphate, Seed, Stover, Oil content

INTRODUCTION

India is the fourth largest edible oil economy of 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. Rapeseed mustard accounting for over 13.2 per cent of the world's edible oil supply is the third important edible oil source after soyabean and palm (Mishra *et al*., 2010). 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 (Gautam *et al*., 2019). Rapeseed-mustard contributes about 28.6% of total oilseeds production among seven edible oilseeds cultivated in India and ranks second after groundnut (Singh *et al*., 2017 and Singh *et al*., 2018). Indian mustard (*Brassica juncea* L.) is cultivated on about 5.6 million ha area in India and predominantly grown in Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh and Gujarat and some non-traditional areas of South India including Karnataka, Tamil Nadu, and Andhra Pradesh (Solanki and Sharma, 2016). Because of its ability to germinate and grow at low temperature, the oil seed Brassicas can be grown in the cooler agricultural regions and at higher elevations, also as winter crop in the temperate zones. Mustard (*Brassica juncea* L.), popularly known as raya, rai or lahi, is an important *rabi* season oilseed crop of family *cruciferae* in north India. Rajasthan ranks first in area and production of rapeseed and mustard with 2.50 million ha area and 3.71 million tonnes production (Anonymous, 2017).

Mustard is the major source of edible oil throughout the country and rich in calcium, manganese, copper, iron, selenium, zinc, vitamin A, B, C and proteins. The oil content in mustard varies from 37 to 49 percent depending on soil fertility, agronomic practices and environmental conditions. Mustard seed and oil are used as condiment in the preparation of pickles, flavouring curries and vegetables. It is also used in the preparation of hair oil, medicines, soap making, lubrication, in tanning industry and for softening leather (Singh, 2001 and Prasad *et al*., 2016). Green stems and leaves are good source of green fodder for cattle. The leaves of young plant are used as green vegetable as they supply enough sulphur and minerals in the diet.

Among three major plant nutrients, P stands next to N and has a vital role in enhancing and sustaining crop productivity worldwide. An adequate supply of P to the plants is important in laying down the primordia for its reproductive parts, for uniform maturity of crops and seed formation. It has often been called the "Master key of Agriculture". It is a constituent of ADP, sugar phosphate, phospholipids and nucleic acid, proteins and several co-enzymes, which are of the great importance in energy transformation, physiological and metabolic processes of the plants (Prasad *et al*., 2016). Further, it is necessary for transfer of genetic characteristics and beneficial for root development, vigorous growth, better yield and quality, nodule formation and nitrogen fixation in legume crops (Nawange *et al*., 2011). Phosphorus plays a great role for synthesis of certain vitamins (B12, biotin and thiamine), metabolism of carbohydrates, proteins and oil formation of flavored compounds in crucifers.

Soil P is a finite, non-renewable and limited resource. Good agronomic management requires adequate supply of P through manure or fertilizer for crop production sustenance. Rapeseed shows a high efficiency of P uptake because of high influx-rate

*Corresponding Author

through the root hairs (Bharose *et al*., 2011). Under P deficiency conditions, it is withdrawn form order tissue and translocated to meristematic tissue, where metabolism is more rapid and leaves are finged with brownish colour. Approximately 15-20 per cent of applied fertilizer P is utilized by the crops and rest gets fixed in the soil and unavailable for crop plants (Toro, 2007). Thus, P availability is the major problem for crop productivity concerning not only its actual deficiency in soil but also its availability to crop plants. For increasing P availability, integrated phosphorus management (IPM) is the only viable strategy. The IPM helps to restore soil fertility and sustain crop productivity. More than 65% of total area of oilseeds cultivation in country is under un-irrigated conditions and it is clear from production data that oil seed productivity is increased through improved management practices. India is the third largest producer of rapeseed-mustard but its average yield in India is very less due to the lack of optimum use of nutrients, improper water management and inadequate nutrition specially P and S. In view of this, the present investigation was undertaken to find out the response of mustard to different levels of phosphorus through various P fertilizers and FYM.

MATERIALS AND METHODS

A field experiment was conducted during *Rabi*, 2020 on coarse loamy, *Typic Ustochrept* soil at research farm, Department of Soil Science, CCS Haryana Agricultural University, Hisar (India) to study the effect of different levels and sources of P application on yield and oil content of mustard. The experimental site is located at 29^o16'N latitude and 75^o7'E longitude in north-west part of India. The climate of the area is semi arid with a mean annual precipitation of 443 mm and mean annual temperature of 24.8^0C. The physico-chemical properties of surface soil (0-15 cm) were analyzed at the start of experiment to ascertain the initial fertility status and are presented in Table 1. The following eleven treatments with three replications were laid out in randomized block design:

Treatment no.	**Pearl millet (HHB 299)**	**Mustard (RH 725)**
T_1	Control	Control
T_2	P_{60SSP}	P_{20SSP}
T_3	P_{60DAP}	P_{20DAP}
T_4	P_{60RP}	P_{20RP}
T_5	P_{60RP}	P_{20SSP}
T_6	P_{60RP}	P_{20DAP}
T_7	$FYM_{7.5}$ t+P_{30SSP}	$FYM_{7.5}$ t +P_{10SSP}
T_8	$FYM_{7.5}$ t+P_{30DAP}	$FYM_{7.5}$ t +P_{10DAP}
T_9	$FYM_{7.5}$ t +P_{30RP}	$FYM_{7.5}$ t +P_{10RP}
T_{10}	$FYM_{7.5}$ t +P_{30RP}	$FYM_{7.5}$ t +P_{10SSP}
T_{11}	$FYM_{7.5}$ t +P_{30RP}	$FYM_{7.5}$ t +P_{10DAP}

RP-Rock phosphate, SSP-Single super phosphate

The farmyard manure (FYM) was applied at the time of mustard sowing and its composition was as: 0.74, 0.46 and 1.12 % N, P and K, respectively. The rock phosphate contains 28% P as its chemical composition. Mustard (RH725) was sown in October, 2020 with row spacing of 30 cm in 5 m x10 m sizes plots. The complete dose of P (DAP, SSP and RP) and half dose of N through urea was applied at the time of mustard sowing as per treatments. The remaining half dose of N was top dressed 30 days after sowing at the time of second irrigation. Mustard was harvested manually in last week of March, 2021. Weight of completely dried bundles from each plot was noted down as biological yield. At the time of threshing, clean and dried grains from each plot were weighed with the help of electronic balance in kg ha^{-1} and converted into q ha^{-1}. Stover yield was obtained by subtracting grain yield from the biological yield.

RESULTS AND DISCUSSION

Seed and Stover yield

With the application of P through various sources, seed yield of mustard varied between 15.37 to 23.16 q ha^{-1} (Table 2). The lowest and highest seed yield of mustard was recorded in control plots and the plots receiving 20 kg P_2O_5 ha^{-1} through SSP (T_5), respectively. All the treated plots showed significant increase in seed yield of mustard over untreated plots. Application of P positively influenced the photosynthesis and biosynthesis of proteins and phospholipids that resulted in increased seed yield (Singh and Thenua, 2016 and Kumar *et al*., 2017).

This beneficial effect could be ascribed to the enhanced growth, more flowering, pod setting and seed formation with P application and also producing bold sized seeds with more accumulation of photosynthates. Moreover, cumulative effect of P application for increasing seed yield might be due to its key role in root development, energy translocation and metabolic processes which increased the translocation of photosynthates towards sink development. These finding are in accordance with the outcomes of Sahu *et al*. (2004); Gangwal *et al*. (2011) and Solanki *et al*. (2015). Among the various P fertilizers application of 20 kg P_2O_5 ha^{-1} through SSP recorded higher seed yield of mustard (22.67 or 23.16 q ha^{-1}) as compared to DAP (21.23 or 21.59 q ha^{-1}) or RP (20.93 q ha^{-1}), however, the effect was non-significant. This may be attributed to the more availability of P to mustard plant through SSP as compared to DAP and RP. The similar results were also reported by Singh and Thenua, (2016) and Singh *et al*. (2017). Application of half of recommended dose of P through SSP or DAP along with 7.5 t FYM ha^{-1} recorded non-significantly lower seed yield of mustard as compared to application of recommended dose of P through SSP or DAP. This might be due to the fact that the higher supply of readily available P through fertilizers might have helped in early root initiation and establishment of the crop, thereby, leading to the increased crop productivity (Gangwal *et al*., 2011). It also might be attributed to enhanced microbial activity with P application in rhizosphere through development of fibrous and deep root system of plant, thereby, recycled the nutrients from deeper layer to upper layer of soil. Similar results were observed by Singh and Thenua (2016); Jadav *et al*. (2016) and Chauhan *et al*. (2020). While, the plots receiving 20 kg P_2O_5 ha^{-1} through RP in combination with 7.5 t FYM ha^{-1} (22.75 q ha^{-1}) showed accrual in seed yield of mustard over the application of recommended dose of P through RP (20.93 q ha^{-1}). These results are in accordance with the findings of Alam *et al*. (2010) and Kumar *et al*. (2017) who observed that combined application of fertilizer P and FYM had synergistic effect on seed and stover yield of mustard. The gradual release and steady supply of plant nutrients from FYM throughout the growing period of plants maintained the photosynthetic efficiency and metabolites production at higher level (Kumawat *et al*., 2014 and Pathak and Pal, 2016).

The stover yield of mustard followed the similar trend to that of seed yield and ranged between 65.70 to 85.82 q ha^{-1} (Table 2). Regardless of the treatment, application of P fertilizers either alone or in conjunction with FYM significantly increased the stover yield of mustard as compared to absolute control plots, however, the stover yield of mustard did not differ significantly among all the treated plots. The considerable increase in stover yield with P application could be attributed to the fact that P stimulates the early root development, thereby, efficient utilization of nutrients from the deeper soil layer (Potdar *et al*., 2019). Similar to seed yield, among the various P fertilizers stover yield of mustard followed the trend as: SSP (84.62 or 85.82 q ha^{-1}) >DAP (81.34 or 82.85 q ha^{-1}) >RP (80.46 q ha^{-1}), however, the effect was statistically non-significant. Application of half of recommended dose of P through SSP or DAP along with 7.5 t FYM ha^{-1} recorded non-significantly lower stover yield of mustard as compared to application of recommended dose of P through SSP or DAP. While, the plots receiving 20 kg P_2O_5 ha^{-1} through RP in combination with 7.5 t FYM ha^{-1} (83.51 q ha^{-1}) showed higher stover yield of mustard as compared to the application of recommended dose of P through RP (80.46 q ha^{-1}). Incorporation of FYM has significant influence on plant height, number of branches per plant, dry matter accumulation and number of siliqua per plant over untreated plots that resulted in increased stover yield of mustard (Kumawat *et al*., 2014 and Pathak and Pal 2016).

Oil content and Harvest index

The effect of different sources and levels of P application on oil content and harvest index of mustard is presented in Table 3. Oil content in mustard seed varied between 38.70 to 39.30 % under different treatments. The highest and lowest oil content of mustard seed was recorded with the application of 20 kg P_2O_5 ha^{-1} through SSP and untreated control plots, respectively. An increase in oil content of mustard seed might be attributed to higher synthesis of fatty acids in presence of ATP and phosphate. The results are in line with the observations of Bharose *et al*. (2011) and Chouksey *et al*. (2017). The effect of different levels of P through varying sources on oil content of mustard seed was found non-significant. Among the various P fertilizers, application of SSP recorded non-significantly higher oil content of mustard seed as compared to RP or DAP. Application of half of recommended dose of P through chemical fertilizers (SSP or DAP or RP) along with 7.5 t FYM ha^{-1} recorded non-significantly lower oil content of mustard seed as compared to the application of recommended dose of P through chemical fertilizers. These findings are in conformity with the outcomes of Sipai *et al*. (2015) and Pathak and Pal (2016). Increase in oil content of mustard seed with integrated use of FYM and inorganic fertilizers over untreated plots was also reported by Singh and Rai (2004) and Nagdive *et al*. (2007).

Harvest index of mustard crop varied from 23.39 to 27.24 % under various treatments (Table 3). The lowest and highest harvest index was recorded with untreated control plots and application of 10 kg P_2O_5 ha^{-1} through RP along with 7.5 t FYM ha^{-1}, respectively. This might be due to increased plant growth and metabolic process with higher levels of P as well as its resultant positive effect on yield attributes that led to higher seed yield. These observations corroborate with the findings of Khatkar *et al.* (2009) and Gangwal *et al.* (2011). Among the various P fertilizers applied, application of SSP recorded higher harvest index of mustard crop as compared to DAP or RP, however, the effect was non-significant. The results of present study are similar to the finding of Solanki and Sharma (2016) that harvest index was not influenced significantly with P fertilization. Effect of combined application of FYM and P fertilizers on harvest index of mustard was non-significant over sole application of P fertilizers. Improvement in soil physical and microbiological properties, increased availability of native and applied nutrients and better proliferation of roots with integrated use of organic and inorganic fertilizers might have helped for better plant growth and development (Potdar *et al*., 2019).

Table 1. Physico-chemical properties of soil at the start of experiment

Property	**Value**
Texture	Sandy loam
pH (1:2)	8.13
EC (dS m^{-1})	0.35
Organic carbon (%)	0.83
$CaCO_3$ (%)	1.1
Available N (kg ha^{-1})	177.24
Available P (kg ha^{-1})	9.27
Available K (kg ha^{-1})	520.00

Table 2. Effect of different levels of phosphorus through varying sources on mustard yield

Treatment no.	**Mustard**	**Mustard yield (q ha^{-1})**	
		Seed	**Stover**
T_1	Control	15.37	65.70
T_2	P_{20SSP}	22.67	84.62
T_3	P_{20DAP}	21.23	81.34
T_4	P_{20RP}	20.93	80.46
T_5	P_{20SSP}	23.16	85.82
T_6	P_{20DAP}	21.59	82.85
T_7	$FYM_{7.5}$ t +P_{10SSP}	21.43	82.21
T_8	$FYM_{7.5}$ t +P_{10DAP}	21.09	80.11
T_9	$FYM_{7.5}$ t +P_{10RP}	22.75	83.51
T_{10}	$FYM_{7.5}$ t +P_{10SSP}	21.76	81.16
T_{11}	$FYM_{7.5}$ t +P_{10DAP}	20.72	80.36
CD (0.05)		3.71	9.62

Table 3. Effect of different levels of phosphorus through varying sources on harvest index and oil content of mustard

Treatment no.	**Mustard**	**Harvest Index (%)**	**Oil content (%)**
T_1	Control	23.39	38.70
T_2	P_{20SSP}	26.79	39.30
T_3	P_{20DAP}	26.10	39.13
T_4	P_{20RP}	26.01	39.03
T_5	P_{20SSP}	26.99	39.17
T_6	P_{20DAP}	26.06	39.10
T_7	$FYM_{7.5}$ t +P_{10SSP}	26.07	38.97
T_8	$FYM_{7.5}$ t +P_{10DAP}	26.33	38.97
T_9	$FYM_{7.5}$ t +P_{10RP}	27.24	38.83
T_{10}	$FYM_{7.5}$ t +P_{10SSP}	26.81	39.03
T_{11}	$FYM_{7.5}$ t +P_{10DAP}	25.78	38.90
CD (0.05)			NS

CONCLUSION

On the basis of aforesaid findings, it may be concluded that application of 20 kg P_2O_5 ha^{-1} through SSP recorded higher seed and stover yield of mustard as compared to DAP and RP. Application of 10 kg P_2O_5 ha^{-1} through SSP or DAP along with 7.5 t FYM ha^{-1} showed non-significantly lower crop productivity of mustard as compared to the application of 20 kg P_2O_5 ha^{-1} through P fertilizers. However, the plots receiving P via RP in combination with FYM showed accrual in seed yield of mustard over the sole application of RP. The oil content in mustard seed varied between 38.70 to 39.30 % under different treatments, however, effect of different levels and sources of P on oil content of mustard seed was found non-significant. Thus, there is a need to verify the results at multi-location trials across the country following diverse soil and climate conditions.

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