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Effect of residual fertility on yield of Indian mustard (*Brassica juncea* L. Czern & Coss)

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Abstract
The present investigation was conducted during *rabi* season of 2018-19 and 2019-20 at Medicinal Plants Research and Development Centre (MRDC) of G. B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar (Uttarakhand) India, to study the effect of residual fertility of sweet basil (*Ocimum basilicum*) crop on yield of succeeding mustard crop. The experimental soil was sandy clay loam in texture, neutral in reaction, medium in organic carbon, low in available nitrogen and high in available phosphorus, exchangeable potassium and available sulphur. After the harvest of sweet basil crop mustard crop was grown on residual fertility of basil crop with different varieties (Kranti, PR 20 and NRCHB 101) as main plot treatment and residual fertility of basil crop as sub plot treatments with one recommended dose of fertilizer (RDF) which replaced RDF of basil crop. Succeeding mustard crop, gave higher number of siliquae per plant, number of seeds per siliqua, length of siliqua, 1000 seed weight, seed yield and stover yield with the application of recommended dose of fertilizers which was *on a par* with the residual fertility level of 120 kg N+60 kg P_2O_5+40 kg K_2O+40 kg S ha^{-1} of basil. On the basis of present study, it can be inferred that the yield of mustard variety NRCHB 101 was found higher compared to Kranti and PR 20 when grown on residual fertility level of 120 kg N+60 kg P_2O_5+40 kg K_2O+40 kg S ha^{-1} of sweet basil.

Keywords: NRCHB 101, Kranti, PR 20, residual fertility, sweet basil and mustard

1. Introduction

The population of country increasing rapidly, to meet out the food demand of growing population we need to produce more food per unit area, for that use of fertilizers are necessary. Agricultural productivity and quality depends on nutrition of the plant. Use of fertilizers is one way to supply these nutrients. But long term or excessive use of chemical fertilizers has adverse effect on soil, environment and human health. Excess fertilizers may lead to heavy metal accumulation which affects the plant growth (Schwartzkopff, 1972) [3]. Excess fertilizers can result in water eutrophication and accumulation of nitrate (Savci, 2012) [32]. Excessive phosphorus adversely affects water quality (Mullins, 2009) [25]. The net loss of phosphorus in crop land worldwide is estimated to be 10.5 million metric tons per years (Liu *et al*., 2008) [19]. Levels of metals such as cadmium are increasing in the developed countries (Page *et al*., 1987) [26]. Use of inorganic fertilizer, continuously for several years, often lead to decline in factor productivity and cause unsustainability in production system (Smith *et al*., 2000 and Harrison and Webb 2001) [42, 13]. Similarly, increased prices and limited availability of fertilizer entail judicious use of chemical fertilizers, so that soil and environment can be saved from the hazardous chemical fertilizers which adversely affect human, animal and soil micro flora.

Sweet basil (*Ocimum basilicum* L.) is one of the most important essential oil-bearing crops and good source of linalool and methyl chavicol, which is widely used in various pharmaceutical preparations. India is the largest producer of sweet basil in the world. In India, Sweet basil is mainly grown in Uttar Pradesh and *tarai* belt of Uttarakhand. The major cropping systems being followed in this area are rice- wheat and rice-mustard (Brassica juncea). Due to diversification in agriculture now a days farmers also adopting sweet basil as a *kharif* season crop. Sweet basil- mustard cropping system is more economical because the cost of cultivation of mustard is less than wheat (Patra *et al*., 2000) [27]. Mustard is the most important edible oilseed crop which occupies more than 70% of the area under rapeseed-mustard group of crops grown in India. It is a winter season crop that requires relatively cool temperature, a fair supply of soil moisture during the growing season and a dry harvest period (Banerjee *et al*., 2010) [5]. India occupies third position in rapeseed-mustard production in the world after China and Canada. It plays an important role in the oilseed economy of the country. In India, during 2017-18 the mustard crop had production of about 8.32 Mt from an area of 5.96

Mha with an average productivity of 1397 kg ha^{-1} (Agriculture statistics, Govt. of India, 2018) [1]. Due to poor yield, oil seed production in the country does not meet the requirement of growing population. There are several factors which are responsible for the low productivity of mustard crop in the country, agronomy particularly nutrient management practices is one of them. Nutrient management practices are based on cropping system to be suitable on sustainable basis. The mustard crop was chosen to utilize the left over nutrients after harvest of sweet basil crop. The basil crop being important industrial oil bearing crop remains in the field for nearly three months. Nutrients which were applied to the sweet basil remain in soil which can be utilized by succeeding mustard crop. As mustard crop in general, have high sulphur requirement owing to higher seed and oil yield (Aulakh *et al*., 1980 and Singh and Shahu, 1986) [4], thus it is beneficial to take mustard as sequential crop rather than any other cereal crop. An attempt has been made to assess the yield performance of mustard crop on residual nutrients of *Ocimum basilicum* crop so that all the left over nutrients can be utilize efficiently.

2. Material and methods
2.1 Experimental site
The experiment was carried out during *rabi* season of 2018-19 and 2019-20 at Medicinal Plants Research and Development Centre (MRDC) of G.B. Pant University of Agriculture and Technology, Pantnagar, District U.S. Nagar (Uttarakhand), India. The experimental site classified as humid sub-tropical climate zone with severe hot and dry summers and cold winters (locally known as the *tarai* region). It situated at 29 º N and 79.3º E latitude and at an altitude of 243.84 metre above mean sea level. The average rainfall of the region is 140 cm per annum of which about 85-90% is received from June to September. The maximum and minimum temperature ranges from 30 ºC to 43 ºC and 4.5 ºC to 26.7 ºC in summer and winter respectively. The soil of the experimental site was sandy clay loam in texture, having neutral pH (7.1 and 6.9), medium in organic carbon (0.74 and 0.75%), medium in available nitrogen (278 and 276 kg ha^{-1}), high in available phosphorus (28.2 and 29.3 kg ha^{-1}) and potassium (307 and 305 kg ha^{-1}) and sulphur (28.3 and 29.5 kg ha^{-1}) during 2018-19 and 2019-20, respectively.

2.2 Experimental design and treatment details
The experiment was laid out in split plot design (SPD) with three replications having three main plot treatments and six sub plot treatments. Sweet basil (*Ocimum basilicum*) variety CIM- Saumya was taken as annual with only single cut in *kharif* season. After harvest of sweet basil mustard crop varieties Kranti, NRCHB 101 and PR-20 were grown on residual nutrients with one treatment as recommended dose of fertilizer (RDF) to compare the mustard yield with residual fertility. The treatments details used in succeeding mustard crop have been presented in Table 1.

Table 1: Treatments details of the mustard experiment

Main plot treatments: Mustard varieties	
M_1	Kranti
M_2	PR-20
M_3	NRCHB-101
Sub – plot treatments: Residual nutrients of basil crop	
F_1	120 kg N + 40 kg P_2O_5 + 20 kg K_2O + 20 kg S ha^{-1} (RDF)
F_2	100 kg N + 60 kg P_2O_5 + 40 kg K_2O + 20 kg S ha^{-1} (Residual)
F_3	100 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (Residual)
F_4	120 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} (Residual)
F_5	120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 20 kg S ha^{-1} (Residual)
F_6	120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (Residual)

2.3 Oil content (%) estimation
Oil content (%) was estimated by using FT-NIR (Fourier Transform Near Infrared Reflectance) spectroscopy.

2.4 Observations recorded
Observations like plant height, number of branches, number of siliquae per plant, number of seeds per siliqua, length of siliqua, 1000 seed weight were recorded from five plants in net plot area and averaged. The seed yield, stover yield and biological yield were recorded from the net plot area and converted into hectare basis.

2.3 Statistical analysis
Experimental data was analysed by using standard procedure for split plot design (SPD) with the help of computer having analysis programme for SPD (STPR-3), programmed by the Department of Mathematics and Statistics, College of Basic Sciences and Humanities, G.B. Pant University of Agriculture and Technology, Pantnagar -263 145. The conclusions were drawn based on critical difference at 5% level of significance.

3. Results and discussion
3.1 Plant height
The plant height of the crop did not differ significantly with respect to different varieties, but residual nutrients had significant effect on it (Table-2). Though, plant height did not differ significantly among varieties but remained maximum in variety NRCHB 101 followed by Kranti during both the years. The minimum plant height was recorded in variety PR 20 during both the years. The plant height remained significantly higher with the application of recommended dose of fertilizers (120 kg N + 40 kg P_2O_5 + 20 kg K_2O + 20 kg S ha^{-1}) as compared to all residual fertility treatments during both the years. However, it was *on a par* with residual fertility of 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1}(F_6) during first year and with 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (F_6) and 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 20 kg S ha^{-1} (F_5) during second year of experimentation.

3.2 Number of branches per plant
The varieties did not differe significantly with respect to number of branches while residual fertility status of *Ocimum basilicum* significantly influenced the number of branches of mustard crop during both the years (Table-2). Kranti variety produced maximum number of branches followed by NRCHB 101 during both the years while PR-20 variety had minimum number of branches during both the years. Application of RDF (120 kg N + 40 kg P_2O_5 + 20 kg K_2O + 20 kg S ha^{-1}) produced significantly higher number of branches compared

to resuidual fertility treatments. However, RDF, was *on a par* with the residual fertility treatment 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (F_6) during both the years.

3.3 Number of siliquae per plant

Number of siliquae per plant differed significantly among mustard varieties during both the years. The significantly higher number of siliquae per plant was recorded with variety NRCHB 101 compared to other varieties (Table-2). The variety PR 20, gave significantly higher number of siliquae compared to Kranti during both the years. The minimum number of siliquae per plant was recorded in variety Kranti during both the years. Residual fertility of *Ocimum basilicum* crop also had significant effect on number of siliquae. The significantly higher number of siliquae was recorded with recommended dose of fertilizers (RDF: 120 kg N + 40 kg P_2O_5 + 20 kg K_2O + 20 kg S ha^{-1}) as compared to other treatments during both the years.

3.4 Length of siliqua

Different mustard varieties and residual fertility status of *Ocimum basilicum* influenced siliqua length significantly during both the years of experimentation (Table-2). The variety, NRCHB 101 recorded higher siliqua length compared to PR 20 and Kranti during both the years. The significantly higher length of siliqua was recorded with recommended dose of fertilizers (120 kg N + 40 kg P_2O_5 + 20 kg K_2O + 20 kg S ha^{-1}) compared to residual fertility treatments during both the years. However, RDF was *on a par* with residual fertility of treatment 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (F_6) and 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 20 kg S ha^{-1} (F_5) during first year.

3.5 Number of seeds per siliqua

Number of seeds per siliqua was significantly influenced by different varieties of mustard and residual fertility status of *Ocimum basilicum* during both the years (Table-3). The significantly higher number of seeds per siliqua was recorded with variety NRCHB 101 during both the years. However it was *on a par* with variety PR 20 during first year of experimentation. The minimum number of seeds per siliqua was recorded in variety Kranti during both the years. Residual fertility status of *Ocimum basilicum* crop improved the number of seeds per siliqua and significantly higher number of seeds was obtained in the plots treated with recommended dose of fertilizers (120 kg N + 40 kg P_2O_5 + 20 kg K_2O + 20 kg S ha^{-1}) during both the years of study. However, RDF was *on a par* with residual fertility of 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (F_6) and 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 20 kg S ha^{-1} (F_5) during both the years.

3.6 1000 seed weight (g)

Test weight (1000 seed weight) of the seeds significantly influenced by the different varieties of mustard and residual fertility of previous *kharif* season crop during both the years. The significantly higher 1000 seed weight (g) of mustard was recorded with the variety NRCHB 101 during both the years of experimentation. However, it was *on a par* with PR 20 during first year of experimentation (Table-3). The minimum 1000 seed weight (g) was observed with the variety Kranti during both the years of study. The significantly higher 1000 seed weight (g) was recorded with the application of RDF (120 kg N + 40 kg P_2O_5 + 20 kg K_2O + 20 kg S ha^{-1}) compared to residual fertility treatments during both the years of study. However, it was *on a par* with residual fertility of treatment 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (F_6) during first year of experimentation.

3.7 Seed yield (kg ha^{-1})

Seed yield of mustard significantly varied with different mustard varieties and residual fertility status of *kharif* season *crop* (Table-3). The significantly higher seed yield of 1578 kg ha^{-1} and 1442 kg ha^{-1} was recorded with variety NRCHB 101 as compared to other varieties during 2018-19 and 2019-20, respectively. Mustard variety PR 20 and Kranti both produce similar seed yield and remained *on a par* with each other. The minimum seed yield was recorded in variety Kranti during both the years. Residual fertility status of kharif season crop also influenced the seed yield of mustard crop significantly. RDF (120 kg N + 40 kg P_2O_5 + 20 kg K_2O + 20 kg S ha^{-1}) produced significantly higher seed yield of 1744 kg ha^{-1} and 1596 kg ha^{-1} as compared to residual fertility treatments during 2018-19 and 2019-20, respectively. However, RDF was *on a par* with the residual nutrients of 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (F_6) during first year of experimentation. Among all residual fertility treatments 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (F_6) performed better and gave significantly higher seed yield of 1585 and 1330 kg ha^{-1} as compared to other residual fertility treatments during 2018-19 and 2019-20, respectively. However, it remained *on a par* with 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 20 kg S ha^{-1} (F_5) during both the years. The minimum seed yield was recorded with residual fertility status of 100 kg N + 60 kg P_2O_5 + 40 kg K_2O + 20 kg S ha^{-1} (F_2) during both the years.

3.8 Stover yield (kg ha^{-1})

The significantly higher stover yield of 3911 and 3582 kg ha^{-1} was recorded with variety NRCHB 101 as compared to other varieties during 2018-19 and 2019-20, respectively. The minimum stover yield was recorded with the variety Kranti during both the years (Table-3). Residual fertility status of *kharif* crop was also influenced the stover yield significantly. The significantly higher stover yield 4031 and 3680 kg ha^{-1} was recorded with the recommended dose of fertilizers (RDF) compared to residual fertility treatments during 2018-19 and 2019-20, respectively. However, it was *on a par* with 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (F_6) and 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 20 kg S ha^{-1} (F_5) during both the years of experimentation.

3.9 Biological yield (kg ha^{-1})

The significantly higher biological yield of 5489 and 5024 kg ha^{-1} was recorded in the variety NRCHB 101 compared to other varieties during 2018-19 and 2019-20, respectively. Variety PR 20 was *on a par* with Kranti during both the years. The minimum biological yield was recorded in variety Kranti during both the years (Table-4). Residual nutrients left over after *kharif* crop also significantly influenced the biological yield of succeeding mustard crop. The significantly higher biological yield of 5776 and 5277 kg ha^{-1} was recorded with the application of RDF as compared to other residual fertility status treatments during 2018-19 and 2019-20, respectively. However, it was *on a par* with 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (F_6) during both the years of experimentation.

3.10 Harvest index

Harvest index was computed, dividing seed yield by its respective biological yield. The mustard varieties did not differ significantly with respect to harvest index. However, residual fertility status of previous *kharif* season crop significantly influenced the harvest index of the mustard crop (Table-4). The maximum harvest index was recorded with Kranti variety of mustard during both the years. However, PR 20 and NRCHB 101 also gave similar results during first and second year of study, respectively. Residual fertility status had significant effect on harvest index of the mustard crop during both the years. RDF and residual fertility treatment 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (N_6) gave same value of harvest index (0.3) which was significantly higher over other treatments of residual fertility during both the years. However, both the treatments were *on a par* with 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 20 kg S ha^{-1} (F_5) and 100 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (F_3) during first year and with 120 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} (F_4) during second year.

3.11 Oil content (%)

The oil content (%) did not differ significantly among varieties and also did not influenced significantly with the residual fertility status (Table-4). The maximum oil content (41.6 %) was recorded in variety NRCHB 101 during first year of experimentation, while similar value of oil content (41.6 %) was reported in variety Kranti during second year. Minimum oil content was recorded in variety PR 20 during both the years. Residual fertility status of *Ocimum basilicum* also did not influence the oil content significantly. Maximum oil content (42.2 and 41.8 %) was recorded in residual fertility treatment 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (N_6) during both the years, respectively. The minimum oil content (40.8 and 41 %) was recorded in RDF during 2018-19 and 2019-20, respectively.

3.12 Oil yield (kg ha^{-1})

The varieties and residual fertility status after harvest of *Ocimum basilicum* significantly influenced the oil yield during both the years. The significantly higher oil yield 657 and 599 kg ha^{-1} was recorded with variety NRCHB 101 during 2018-19 and 2019-20, respectively (Table-4). The minimum oil yield was recorded in variety Kranti during both the years of experimentation. Residual fertility status of *Ocimum basilicum* crop significantly influenced the oil yield and gave significantly higher oil yield of 712 and 655 kg ha^{-1} with recommended dose of fertilizers (RDF) during 2018-19 and 2019-20, respectively. The RDF (F_1) was *on a par* with the residual fertility of 120 kg N + 60 kg P_2O_5 + 40 kg K_2O + 40 kg S ha^{-1} (F_6) during both the years. The minimum oil yield was recorded with residual fertility of 100 kg N + 60 kg P_2O_5 + 40 kg K_2O + 20 kg S ha^{-1} (F_2) during both the years.

Table 2: Plant height (cm), Number of branches plant^{-1}, Number of siliquae plant^{-1} and Length of siliqua (cm) of mustard crop as influenced by varieties and residual fertility levels at harvest stage during *rabi* season of 2018-19 and 2019-20.

Treatments	Plant height		No. of branches plant^{-1}		No. of siliquae plant^{-1}		Length of siliqua (cm)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Variety (M)								
M_1: Kranti	162.5	153.7	5.1	5.3	182.3	176.8	4.9	4.1
M_2: PR-20	148.2	153.4	3.8	4.9	274.7	278.3	5.4	4.4
M_3: NRCHB 101	166.9	154.8	4.7	5.2	465.5	465.7	5.7	5.0
SEm±	-	-	-	-	1.1	0.8	0.1	0.1
CD (P= 0.05)	NS	NS	NS	NS	4.4	3.0	0.2	0.5
Residual fertility levels (F)								
F_1: RDF (120:40:20:20)	181.3	164.4	5.5	6.2	340.0	338.7	5.9	5.2
F_2: 100:60:40:20	138.1	144.4	3.6	4.1	275.3	276.7	4.8	3.9
F_3: 100:60:40:40	145.9	147.0	4.0	4.7	287.0	290.0	5.0	4.1
F_4: 120:60:40:0	155.4	152.0	4.3	5.0	301.3	300.7	5.2	4.4
F_5: 120:60:40:20	163.8	156.1	4.7	5.3	314.0	311.7	5.5	4.6
F_6: 120:60:40:40	170.8	159.9	5.2	5.6	327.3	324.0	5.7	4.7
SEm±	4.8	3.0	0.2	0.2	4.0	2.7	0.2	0.1
CD (P= 0.05)	14.0	8.8	0.7	0.6	11.5	7.8	0.4	0.4

Table 3: Number of seed siliqua^{-1}, 1000 seed weight (g), seed yield (kg ha^{-1}) and stover yield (kg ha^{-1}) of mustard crop as influenced by varieties and residual fertility levels at harvest stage during *rabi* season of 2018-19 and 2019-20.

Treatments	No. of seed siliqua^{-1}		1000 seed weight (g)		Seed yield (kg ha^{-1})		Stover yield (kg ha^{-1})	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Variety (M)								
M_1: Kranti	12.4	12.2	3.4	3.4	1244	969	2993	2332
M_2: PR-20	13.4	11.0	4.5	4.4	1275	1051	3128	2612
M_3: NRCHB 101	13.8	13.8	4.5	4.6	1578	1442	3911	3582
SEm±	0.1	0.4	0.03	0.02	30	50	82	135
CD (P= 0.05)	0.5	1.8	0.1	0.1	123	200	332	546
Residual fertility levels (F)								
F_1: RDF (120:40:20:20)	15.1	14.1	4.4	4.5	1744	1596	4031	3680
F_2: 100:60:40:20	11.6	9.9	3.8	3.8	1031	788	2718	2027
F_3: 100:60:40:40	12.3	10.9	4.0	4.0	1110	921	2753	2344
F_4: 120:60:40:0	12.7	12.2	4.1	4.0	1271	1110	3313	2720
F_5: 120:60:40:20	13.6	12.9	4.2	4.3	1453	1186	3551	3105
F_6: 120:60:40:40	14.1	13.7	4.3	4.3	1585	1330	3698	3177
SEm±	0.6	0.6	0.03	0.04	80	73	185	202
CD (P= 0.05)	1.6	1.7	0.1	0.1	231	211	537	585

Table 4: Biological yield (kg ha^{-1}), Harvest index, Oil content (%) and Oil yield (kg ha^{-1}) of mustard crop as influenced by varieties and residual fertility levels at harvest stage during *rabi* season of 2018-19 and 2019-20.

Treatments	Biological yield (kg ha^{-1})		Harvest index		Oil content (%)		Oil yield (kg ha^{-1})	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Variety (M)								
M_1: Kranti	4237	3301	0.29	0.29	41.4	41.6	516	403
M_2: PR-20	4403	3666	0.29	0.28	41.2	41.1	525	433
M_3: NRCHB 101	5489	5024	0.28	0.29	41.6	41.5	657	599
SEm±	113	185	-	-	-	-	14	23
CD (P= 0.05)	454	744	NS	NS	NS	NS	58	93
Residual fertility levels (F)								
F_1: RDF (120:40:20:20)	5776	5277	0.30	0.30	40.8	41	712	655
F_2: 100:60:40:20	3749	2815	0.28	0.28	41.1	41.1	425	324
F_3: 100:60:40:40	3863	3265	0.29	0.28	41.6	41.3	461	381
F_4: 120:60:40:0	4584	3829	0.28	0.29	41.3	41.3	525	459
F_5: 120:60:40:20	5004	4291	0.29	0.28	41.7	41.6	606	494
F_6: 120:60:40:40	5282	4506	0.30	0.30	42.2	41.8	668	557
SEm±	264	274	0.003	0.003	-	-	33	31
CD (P= 0.05)	765	793	0.007	0.008	NS	NS	96	90

4. Discussion

Nitrogen and sulphur enhances cell division, elongation and expansion of the cells. Nitrogen and sulphur play important role in carbohydrate accumulation through photosynthesis and these carbohydrates are metabolized into amino-acid and finally into protein, which allowed the plant to grow faster (Bhari *et al.* (2000) [8] and Sharma *et al.* (2007) [35]. The number of branches is the result of plant genetic makeup and all the factors which required for growth and development of the plant. Nutrients are one of the important factors which influence the growth of the plant. They are the component of many metabolically important compounds (Marschner, 2002) [23] would involve directly or indirectly in cell division, cell enlargement and tissue and organ formation leading to formation of more number of branches. Nitrogen and sulphur both take parts in various metabolic processes of the plant. They also help in cell differentiation and apical bud formation. Increased in number of branching might be due to increasing plant height and increasing in nitrogen availability, which ultimately increased number of branches per plant (Dongarkar *et al.*, 2005) [12]. The bearing capacity of siliquae per plant is the genetic potential of the varieties. However, the application of nutrients helps plant, to express its full potential. More number of branches produces more number of siliquae. In the absence of adequate nutrients plants do not performed well and produced less number of siliquae as nutrient play important roles in various enzymatic activities of the plants. Nutrients are also the part of various structures of the plant. The number of siliquae per plant of mustard significantly increased with the application of nitrogen and sulphur which was also reported by Bhalerao (2001) [7] and Kumar *et al.* (2011) [18]. The length of siliqua was governed by genetic makeup of the plant. However, under the deficiency of nutrients, small or malformed siliquae are developed which are small in size and bears less number of seeds. The treatments which received adequate amount of nutrients performed better and gave more length of siliqua as compared to treatments in which inadequate nutrients were present.

Number of seeds per siliqua depends on the genetic character of the varieties and has less chance to change with adoption of agronomic practices (Hunn and Schuster, 1975) [14]. However, for the development of seed optimum nutrients are required. Cheema *et al.* (2001) [10] also reported an increase in number of seeds per siliqua with the application of nitrogen up to 120 kg ha^{-1}. Under higher level of nitrogen, the translocation of photosynthates from sources to sink is increased which resulted in increase in number of seed per siliqua. The 1000 seed weight was depends on the boldness of the seed which increases the weight of seeds. It is also a varietal character which determines the size of seeds. Beside genetic control it also depends on climatic conditions. 1000 seed weight is the result of source and sink balance of plant and the treatment having all the nutrients in balanced amount maintained this relationship. The more uptake of nitrogen resulted in more seed size which increases the 1000 seed weight. Similar findings were also reported by Kumar *et al.*, (2002) [16], Kumar and Yadav (2007) [17] and Tomar and Singh (2007) [43].

Different varieties performed in a different way in a given set of climatic condition. They have their own genotypic potential to respond for the different growth factors like moisture, nutrients, light and soil characteristics. In the present study all the three varieties of mustard performed in a different way in a same set of condition on the basis of their genotypic potential. In a individual variety, yield capacity of is the function of the number of plants per unit area, number of siliquae per plant, number of seeds per siliqua, length of siliqua and 1000 seed weight. More yield attributes resulted in more yield of the crop. Mustard have high sulphur requirement owing to higher seed and oil yield (Aulakh *et al.*, 1980 and Singh and Shahu, 1986) [4]. Application of nitrogen and sulphur along with phosphorus and potassium helps in the formation of reproductive structures for sink strength and increased production of assimilates to fill the economically important sink (Begum *et al.*, 2012) [6].

Adequate supply of nitrogen facilitated better growth and development of crop plant, enhanced nutrient uptake and resulted in significantly increase in yield attributes. Similar results have also been reported by Sharma (2008) [35-36] on cumulative response of growth and yield attributes. To determine the seed yield obtained by sulphur assumed due to better response of growth and yield contributing characters. Seed yield increased due to enhanced rate of photosynthesis and carbohydrate metabolism as influenced by sulphur application. Sulphur, augmented the translocation of photosynthate to sink site. The results are in close conformity with that of Singh and Meena (2004) [39] and Rajput *et al.* (1993) [30]. Higher seed yield with increasing rate of nitrogen was also reported by Mankotish and Sharma, 1997 [22]; Mirzashahi *et al.*, 2000 [24] and Siadat *et al.*, 2010 [37]. Sulphur, with its involvement in the metabolic processes, enhances the meristematic activity and thus causes higher apical growth with expansion of photosynthetic surface (Piri *et al.,* 2011) [28]. Adequate nutrient supply increases the seed and stover yield by improving the setting pattern of number of branches per plant, number of leaves per plant, number of siliquae per plant and length of siliqua (Chitale and Bhambri, 2001) [11]. All the mustard varieties used production factor and produce biomass yield on the basis of their genetic potential. NRCHB 101 found to have the capacity to produce more dry matter as compared to other varieties due to its genetic potential. It might have the capacity to utilize production factors more efficiently and accumulate more photosynthates which gave more growth and biological yield. Within the variety, the variation in biomass yield might be due to inadequate supply of nutrients. The result confirms the findings of Singh and Singh (1984) [39]. Similar results were also reported by Ali *et al.* (1995) [3]. Increase in dry matter production of mustard with the application of sulphur was also reported by Singh and Meena (2004) [39].

Harvest index is influenced by economic and biological yield and increase with increase in economic yield while inversely related to biological yield (Malhi *et al.,* 2007) [21]. More harvest index indicate more economic yield. It represents an increased physiological capacity to mobilize photosynthates to economically important parts (Jamal *et al*., 2006) [15]. The higher harvest index represents higher capacity to mobilize carbohydrates towards economic sinks when fertilized with adequate amount of sulphur and nitrogen.

The oil content of the mustard did not change in different varieties due to varietal oil synthesis potential NRCHB 101 performed well under normal climatic condition but Kranti has the potential to perform well under adverse climatic conditions as the weather condition were not favorable during second year of experimentation. Application of nutrients gave less oil content as compared to residual fertility treatments. Application of nitrogen helps to convert the photosynthates into protein which decrease the oil content in the seed, on the other hand sulfur increased the oil content. Sulphur is an integral part of mustard oil and therefore, it played a significant role in the synthesis of oil. Sulphur is involved in conversion of primary fatty acid metabolites to end product of fatty acid. Similar results were also reported by Chandel *et al*., 2002 [9]; Singh and Meena, 2003 [38] and Sharma, 2008 [35-36]. The oil content in mustard seed decreased with increasing levels of nitrogen application up to 120 kg N ha^{-1}. These findings are supported by Premi and Kumar (2004) [29].

Oil yield depends on seed yield and oil content (%) of the seeds. Higher seed yield gave more oil yield irrespective of content of oil. While higher seed yield with high oil content gave more oil yield as compared to less oil content. The variation in oil yield with respect to different varieties was also due to variation in seed yield as oil content of the varieties did not differ significantly. However, nutrients play important role in the oil synthesis. Beneficial effect of sulphur fertilization, up to the dose of 60 kg S ha^1, on oil content was reported by Malarz *et al.* (2011) [20]. Oil concentration in the treatments fertilized with sulphur fertilizer was increased as compared to without sulphur treatments. Ahmad *et al.* (2007) [2] also recorded the lowest values of oil content in the treatment where sulphur was not applied. The concentration of oil increased from 41–42.2% after application of 20 kg S ha^{-1}. Cheema *et al.* (2001) [10] and Saleem *et al.* (2001) [31] reported that increasing the levels of nitrogen, increased the oil yield of brassica significantly.

5. Conclusion

On the basis of present study, it can be inferred that the mustard variety NRCHB 101 gave higher seed yield compared to Kranti and PR 20 when grown using recommended dose of fertilizer (120 kg N + 40 kg P_2O_5 + 20 kg K_2O + 20 kg S ha^{-1}) which was *on a par with the* residual fertility of 120 kg N, 60 kg P_2O_5, 40 kg K_2O and 40 kg S ha^{-1}. Thus residual fertility of basil crop 120 kg N, 60 kg P_2O_5, 40 kg K_2O and 40 kg S ha^{-1} can be recommended for harnessing the residual effect on mustard crop.

6. References

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