Performance of Gobhi Sarson (*Brassica napus* L.) under Integrated Nutrient Management

Abstract

A field experiment was conducted during rabi season (2023-24) at Agricultural Research Farm, School of Agricultural Sciences and Technology, RIMT University Mandi Gobindgarh, to study the effect of integrated nutrient management (INM) in Gobhi Sarson (*Brassica napus* L.). The experimental field was laid out in randomized complete block design with 10 treatments and replicated thrice. The experiment comprised of 10 treatments i.e. T_1 -Control, T_2 -100% Recommended Dose of Fertilizers (RDF) (40:20::N:P_2O_5 kg ha^{-1}), T_3 -125% RDF, T_4 -150% RDF, T_5 -50% RDF + 15 t Farm Yard Manure (FYM) ha^{-1}, T_6 -50% RDF + 20 t FYM ha^{-1}, T_7 -75% RDF + 15 t FYM ha^{-1}, T_8 -75% RDF + 20 t FYM ha^{-1}, T_9 -100% RDF + 15 t FYM ha^{-1} and T_{10} -100% RDF + 20 t FYM ha^{-1}. The result revealed that growth parameters were significantly higher in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} plant population (21.79 m^{-2}), plant height (157.9 cm), number of branches $plant^{-1}$ (17.15), chlorophyll content (55.74) and yield and yield attributes were also significantly higher in treatment T_{10} -100% RDF + 20 t FYM number of siliquae $plant^{-1}$ (291.0), siliqua length (8.423 cm), number of seeds $siliqua^{-1}$ (23.01), 1000 seed weight (3.45 g), seed yield (23.45 q ha^{-1}), straw yield (59.04 q ha^{-1}) and harvest index (28.80 %) were observed. From this study it may be concluded that the combination of RDF and FYM enhanced the overall growth, yield and yield attributes of Gobhi Sarson.

Keywords: Ghobi Sarson,INM, recommended dose of fertilizers, farm yard manure, growth parameters and yield attributes.

Introduction

Oilseeds have prestigious place in Indian agriculture next to cereals. Now-a-day, India is also one of the largest importers of vegetable oils. It contains high number of amino acids, proteins and the fat yields, it makes useful for the well-being of the humans (Abiodum, 2017). Rapeseed-mustard (*Brassicanapus* L.) is the 3rd largest oil crop in the world. It is a *rabi* 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). It is the primary source of high-quality vegetable oil and feed proteins, it has become one of the most valuable agricultural products (Li *etal.*, 2022). It plays an important role in human nutrition and animal feed, occupying a significant position in the diet of people. It is used in industrial application and its oilcake can also serve as manure. It is also used as an ornament because of its diverse flower colour. It's all parts are useful, even the trash which could be used as animal feed or recycled.At global scale 35.95 million hectares area and 71.49 million tonnes production of rapeseed-mustard during 2019-20 (ICAR-DRMR, 2021). In India around 8.06 million hectares area is under rapeseed-mustard along with 11.75 million tonnes production and 1458 kg ha^{-1} productivity during 2021-22 (Agricultural Statistics at a Glance, 2022). The largest rapeseed producing states in India are Rajasthan (44.97%), Haryana (12.44%), Madhya Pradesh (11.32%), Uttar Pradesh (10.60%) and West Bengal (7.53%) during (2014-15 to 2018-19). In Punjab, rapeseed and mustard were grown on 43.9 thousand hectares with a production of 69.3 thousand tonnes during 2021-22. The average yield was 15.79 quintals per hectare or 6.39 quintals per acre (Anonymous, 2023-24).

Rapeseed require relatively large amount of nutrients for realization of yield potential but inadequate supply often leads to low productivity (Rathore *et al.*, 2020). Fertilization of rapeseed with nitrogen, phosphorus and potassium is essential for growth and development of rapeseed crops (Geng *etal.*, 2021). Therefore, substantial increase in crop yield and oil content of the crop could be achieved by application of appropriate dose of NPK fertilizers along with proper dose of secondary and micro nutrients (Tripathi *etal.*, 2010).But inadequate utilization of inorganic resources leads to a low production of rapeseed crops in both quality and quantity in addition to depleting the nutrients in the soil.

The use of organic manure improves soil tenacity while also supplying macronutrients and micronutrients to the soil (Arbad and Ismail, 2011). Farm Yard Manure improves soil structure, increasing the microbial activity of soil to improve its mineral supply and also the plant nutrients. However, compared to the quick nutrient release of chemical fertilizers, organic fertilizers have low nutrient concentrations and nutrient released is very slow to support crops in a short duration. Chemical fertilizers or organic manures alone cannot sustain the desired levels of crop production under continuous farming. So, the beneficial approach to overcome this problem is Integrated Nutrient Management (INM) which is the reduction of chemical fertilizers combined with the application of organic manure. Such combination improved soil health (Prasad *etal.*, 2017). It also increased plant growth, yield and crop productivity. The aim of INM is to increase crop yield per unit area and to preserve soil productivity for next generation by integrated use of organic and chemical sources nutrients (FAO, 1995). INM is important to utilize the benefits of organic manures, compost, crop residue agricultural wastes, biofertilizers and their significant effects with chemical fertilizers. This will increase the supply of nutrients in the soil and efficiency with which they are used, thereby enhancing soil health and environmental safety as well as productivity and agricultural sustainability (Shekhawat *etal.*, 2012). INM can improve the monetary acquiesce of mustard base crop sequences almost to 35% than without of FYM management (Gupta *et al*., 2014). INM is a useful strategy that may provide plants with adequate amounts of the majority of macronutrients and micronutrients in an economic manner. It can also reduce the number of chemical fertilizers used, improve the physiochemical and environmental conditions of soil, safeguard the soil nutrient balance in the long run to an optimum level for sustaining the desired crop productivity and fine the safety ways to depose of agricultural wastes (Selim *et al*., 2017). Considering the significance of this facts, the present investigation entitled **"Integrated Nutrient Management in Gobhi sarson (*Brassica napus* L.)** was planned and carried out at Agriculture Research Farm, Department of Agriculture, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh during the *rabi* season (2023-24).

Materials and methods

The field experiment was conducted at the Agriculture Research Farm, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab during *rabi* season 2023-24. The experimental site is associated in Punjab at 30.6642ºN latitude and 76.2914ºE longitude at an altitude of 268.04 meters above mean sea level.

The experimental field was laid out in randomized complete block design with 10 treatments and replicated thrice. The experiment comprised of 10 treatments i.e. T_1- Control, T_2 -100% RDF (40:20::N:P_2O_5 kg ha^{-1}), T_3 -125% RDF, T_4 -150% RDF, T_5 -50% RDF + 15 t FYM ha^{-1}, T_6 -50% RDF + 20 t FYM ha^{-1}, T_7 -75% RDF + 15 t FYM ha^{-1}, T_8 -75% RDF + 20 t FYM ha^{-1}, T_9 -100% RDF + 15 t FYM ha^{-1} and T_{10} -100% RDF + 20 t FYM ha^{-1}. The gohhi sarson cultivar ADV 405 was sown by hand sowing at a depth 4-5 cm and row to row 45cm and plant to plant 10 cm. Seed rate of 3.75 kg ha^{-1} was used in a plot size of 4.5m × 3.5m. Half dose of urea and full dose of single supper phosphate were applied as basal dose and remaining half dose applied with first irrigation. These were incorporated as per treatments. The farm yard manure from dairy farm was applied as basal application of treatment wise. The data on growth parameters viz. plant population at harvest (m^{-2}), plant height (cm), number of branches plant^{-1}, chlorophyll content and yield attributes viz, number of siliquae plant^{-1}, siliqua length (cm), number of seeds siliqua^{-1}, 1000 seed weight (g), seed yield (q ha^{-1}), straw yield (q ha^{-1}) and harvest index (%) were observed.

Results and Discussion

Growth parameter

Data regarding plant population and plant height were shown in Table 1.

Plant population at harvest (m^{-2}): Plant population refer to the total number of plants present at unit area of land. It was measured in per square meter. The total numbers of plants in each plot were counted 2 days before harvesting. With the increase in RDF, the plant population was increased and significantly higher plant population was observed in treatment T_4 -150%RDF (21.08 m^{-2}), T_3 -125% RDF (20.51 m^{-2}) and T_2 -100% RDF (40:20: N: P_2O_5 kg ha^{-1}) (17.30 m^{-2}) than treatment T_1- control (13.95 m^{-2}). Among integrated nutrient management treatments significantly higher plant population was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (21.79 m^{-2}), T_9 -100% RDF + 15 t FYM ha^{-1} (21.33 m^{-2}), T_8 -75%RDF + 20 t FYM ha^{-1} (17.10 m^{-2}), T_7 -75% RDF + 15 t FYM ha^{-1} (16.96 m^{-2}) than treatment T_1- control (13.95m^{-2}). The plant population in treatment T_5 -50% RDF + 15 t FYM ha^{-1} (15.45 m^{-2}) and T_6 -50% RDF + 20 t FYM ha^{-1} (15.65 m^{-2}) found statistically at par with treatment T_1- control (13.95 m^{-2}). The data revealed that maximum plant population was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (21.79 m^{-2}) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (21.33 m^{-2}), T_4 -150%RDF (21.08 m^{-2}), T_3 -125% RDF (20.51 m^{-2}) and minimum in treatment T_1- control (13.95m^{-2}) was observed. Similar results were recorded by Deekshith *etal*., (2023).

Plant height (cm): Plant height is one of the parameters which indicates the growth of the plant. Its measurement is often used to monitor the effect of different treatments on crop growth. At 75 DAS, increase in plant height with treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (80.5 cm) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (78.2 cm.) and T_4 -150% RDF (77.2 cm). At 100 DAS, increase in plant height with treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (122.3 cm) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (118.6 cm.) and T_4 -150% RDF (116.3 cm). At 125 DAS, increase in plant height with treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (155.7 cm) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (151.9 cm.). At harvest, with the increase in RDF, the plant height was increased and significantly higher plant height was observed in treatment T_4 -150%RDF (152.3 cm), T_3 -125% RDF (150.9 cm) and T_2 -100% RDF (40:20: N: P_2O_5 kg ha^{-1}) (146.9 cm) than treatment T_1- control (128.7 cm). Among integrated nutrient management treatments significantly higher plant height was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (157.9 cm), T_9 -100% RDF + 15 t FYM ha^{-1} (154.4 cm), T_8 -75%RDF + 20 t FYM ha^{-1} (143.9 cm), T_7 -75% RDF + 15 t FYM ha^{-1} (141.8 cm), T_6 -50% RDF + 20 t FYM ha^{-1} (139.9 cm), T_5 -50% RDF + 15 t FYM ha^{-1} (137.2 cm) than treatment T_1- control (128.7 cm). The data revealed that the maximum plant height was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (157.9 cm) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (154.4 cm.), T_4 -150%RDF (152.3 cm) and minimum in treatment T_1- control (128.7 cm) was observed. This may be due to adequate supply of FYM and inorganic fertilizers facilitates the prolonged availability of nutrients in the soil, thereby promoting efficient nutrient utilization by plants and resulting in increased plant height. Similar results were also recorded by Bisht *et al.* (2018); Bijani *et al.*, (2022); Kaur and Singh (2022).

Data regardingnumber of branches plant^{-1} and chlorophyll content were shown in Table 2.

Number of branches plant^{-1}: Plant branches provide canopy architecture to the plant and is a major yield contributing factors. At 75 DAS, increase in number of branches plant^{-1} with treatment T_{10} - 100% RDF + 20 t FYM ha^{-1} (12.3) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (11.7). At 100 DAS, increase in number of branches plant^{-1} with treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (13.11) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (12.8) and T_4 -150% RDF (12.5). At 125 DAS, increase in number of branches plant^{-1} with treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (15.7) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (15). At harvest, with the increase in RDF, the number of branches plant^{-1} was increased and significantly higher number of branches plant^{-1} was observed in treatment T_4 -150% RDF (15.67), T_3 -125% RDF (15.30) and T_2 -100% RDF (40:20: N: P_2O_5 kg ha^{-1}) (15.00) than treatment T_1- control (12.05). Among integrated nutrient management treatments significantly higher number of branches plant^{-1} was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (17.15), T_9 -100% RDF + 15 t FYM ha^{-1} (16.00), T_8 -75%RDF + 20 t FYM ha^{-1} (15.03), T_7 -75% RDF + 15 t FYM ha^{-1} (14.33), T_6 -50% RDF + 20 t FYM ha^{-1} (14.30), T_5 -50% RDF + 15 t FYM ha^{-1} (13.38) than treatment T_1- control (12.05). The data revealed that the maximum number of branches plant^{-1} was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (17.15) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (16.00) and minimum in treatment T_1- control (12.05) was observed. This may be due to adequate supply of FYM and organic fertilizers often results in a balance supply of nutrients which is crucial for overall plant health and development including branch formation. Similar results were also recorded by Mandal and Sinha (2002); Bijarnia *et al*., (2017).

Chlorophyll content (µmol m^{-2}): Chlorophyll content is an essential parameter in the photosynthesis process determining leaf spectral variation in visible brand. It is estimated by using a SPAD meter. At 75 DAS, increase in chlorophyll content with treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (48.73) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (47.00). At 100 DAS, increase in chlorophyll content with treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (52.83) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (52.13) and T_4 -150% RDF (51.20). At 125 DAS, with the increase in RDF, chlorophyll content was increased and significantly higher chlorophyll content was observed in treatment T_4 -150% RDF (54.03), T_3 -125% RDF (53.29) and T_2 -100% RDF (40:20: N: P_2O_5 kg ha^{-1}) (50.16) than treatment T_1- control (45.00). Among integrated nutrient management treatments significantly higher chlorophyll content was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (55.74), T_9 -100% RDF + 15 t FYM ha^{-1} (54.43), T_8 -75%RDF + 20 t FYM ha^{-1} (49.09), T_7 -75% RDF + 15 t FYM ha^{-1} (48.14) than treatment T_1- control (45.00). The chlorophyll content in treatment T_5 - 50% RDF + 15 t FYM ha^{-1} (46.47) and T_6 -50% RDF + 20 t FYM ha^{-1} (47.10) found statistically at par with treatment T_1- control (45.00). The data revealed that maximum chlorophyll content was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (55.74) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (54.43), T_4 -150% RDF (54.03) and minimum in treatment T_1- control (45.00) was observed. This may be due to balance supply of essential nutrients from inorganic fertilizers and improved soil health from FYM which collectively enhanced photosynthetic efficiency and chlorophyll synthesis in the plant. Similar results were also recorded by Kumawat *et al.*, (2014); Bijarnia *et al.* (2017).

Table 1: Performance of Gobhi Sarson under integrated nutrient management on plant population and plant height of Gobhi Sarson (*Brassica napus* L.)

Treatments	Treatment combinations	Plant population at harvest (m^{-2})	Plant height (cm)			
			75 DAS	100 DAS	125 DAS	At harvest
T_1	Control	13.95	60.9	90.7	124.6	128.7
T_2	100% RDF (40:20: N: P_2O_5 kg ha^{-1})	17.30	72.2	110.6	143.9	146.9
T_3	125% RDF	20.51	74.7	113.7	147.0	150.9
T_4	150%RDF	21.08	77.2	116.3	149.6	152.3
T_5	50% RDF + 15 t FYM ha^{-1}	15.45	64	100.9	134.2	137.2
T_6	50% RDF + 20 t FYM ha^{-1}	15.65	66.1	103	136.5	139.9
T_7	75% RDF + 15 t FYM ha^{-1}	16.96	68.3	105.2	138.6	141.8
T_8	75% RDF + 20 t FYM ha^{-1}	17.10	71.5	107.5	140.7	143.9
T_9	100% RDF + 15 t FYM ha^{-1}	21.33	78.2	118.6	151.9	154.4
T_{10}	100% RDF + 20 t FYM ha^{-1}	21.79	80.5	122.3	155.7	157.9
C.D. (p=0.05)		2.070	4.59	6.69	6.31	5.73
SE(m)±		0.691	2.03	2.96	2.79	2.65
C.V.		6.611	8.91	8.56	5.89	5.91

Table 2: Performance of Gobhi Sarson under integrated nutrient management on number of branches plant^{-1} and chlorophyll content of Gobhi Sarson (*Brassica napus* L.)

Treatments	Treatment combinations	Number of branches plant^{-1}				Chlorophyll content (µmol m^{-2})		
		75 DAS	100 DAS	125 DAS	At harvest	75 DAS	100 DAS	125 DAS
T_1	Control	8.3	9.55	11.2	12.05	41.6	44.00	45.00
T_2	100% RDF (40:20: N: P_2O_5 kg ha^{-1})	10.9	11.9	14.03	15.00	44.69	49.17	50.16
T_3	125% RDF	11.2	12.2	14.6	15.30	46.20	50.23	53.29
T_4	150%RDF	11.48	12.5	14.8	15.67	46.73	51.20	54.03
T_5	50% RDF + 15 t FYM ha^{-1}	9.32	10.67	12.45	13.38	42.60	45.17	46.47
T_6	50% RDF + 20 t FYM ha^{-1}	8.88	10.8	13.3	14.30	42.89	46.10	47.10
T_7	75% RDF + 15 t FYM ha^{-1}	10.2	11.3	13.7	14.33	43.71	47.13	48.14
T_8	75% RDF + 20 t FYM ha^{-1}	10.7	11.7	14.1	15.03	44.14	48.20	49.09
T_9	100% RDF + 15 t FYM ha^{-1}	11.7	12.8	15	16.00	47.00	52.13	54.43
T_{10}	100% RDF + 20 t FYM ha^{-1}	12.3	13.11	15.7	17.15	48.73	52.83	55.74
C.D. (p=0.05)		0.80	0.74	0.96	1.16	1.78	2.07	2.41
SE(m)±		0.36	0.33	0.43	0.52	0.80	0.93	1.08
C.V.		10.77	8.93	9.76	10.92	5.65	5.96	6.82

Table 3: Performance of Gobhi Sarson under integrated nutrient management on yield attributes viz. number of siliquae plant^{-1}, siliqua length, number of seeds siliqua^{-1}, test weight, seed yield, straw yield and harvest index.

Treatments	Treatment combinations	Number of siliquae plant^{-1}	Siliqua length (cm)	Number of seeds siliqua^{-1}	1000 seed weight (g)	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
T_1	Control	182.3	6.717	17.00	2.49	10.49	37.21	22.00
T_2	100% RDF (40:12: N: P_2O_5 kg ha^{-1})	260.0	7.770	20.32	3.00	16.88	46.33	26.70
T_3	125% RDF	270.0	7.967	20.67	3.10	18.01	49.52	26.80
T_4	150%RDF	280.0	8.030	21.00	3.22	19.50	51.67	27.40
T_5	50% RDF + 15 t FYM ha^{-1}	203.0	7.550	18.67	2.60	12.06	40.29	23.00
T_6	50% RDF + 20 t FYM ha^{-1}	221.0	7.613	19.00	2.70	13.15	42.05	23.84
T_7	75% RDF + 15 t FYM ha^{-1}	223.0	7.637	19.31	2.80	14.31	44.08	24.50
T_8	75% RDF + 20 t FYM ha^{-1}	253.7	7.673	20.00	2.90	15.67	45.72	25.90
T_9	100% RDF + 15 t FYM ha^{-1}	283.0	8.100	21.50	3.30	20.65	53.62	27.80
T_{10}	100% RDF + 20 t FYM ha^{-1}	291.0	8.423	23.01	3.45	23.45	59.04	28.80
C.D. at 5%		30.105	0.695	2.274	0.372	3.030	5.642	2.634
SE(m)		10.055	0.232	0.759	0.124	1.012	2.665	0.880
C.V.		7.059	5.189	6.562	7.271	10.66	6.947	5.934

Yield and yield attributes

Data regarding number of siliquae plant^{-1}, siliqua length, number of seeds siliqua^{-1}, test weight, seed yield, straw yield and harvest index were shown in Table 3.

Number of siliquae plant^{-1}: The number of siliquae refers to the total count of siliquae produced by an individual plant. With the increase in RDF, number of siliqua plant^{-1} was increased and significantly higher number of siliqua plant^{-1} was observed in treatment T_4 -150% RDF (280.0), T_3 -125% RDF (270.0) and T_2 -100% RDF (40:20: N: P_2O_5 kg ha^{-1}) (260.0) than treatment T_1- control (182.3). Among integrated nutrient management treatments significantly higher number of siliqua plant^{-1} was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (291.0), T_9 -100% RDF + 15 t FYM ha^{-1} (283.0), T_8 -75%RDF + 20 t FYM ha^{-1} (253.7), T_7 -75% RDF + 15 t FYM ha^{-1} (223.0) and T_6 -50% RDF + 20 t FYM ha^{-1} (221.0) than treatment T_1- control (182.3). The number of siliqua plant^{-1} in treatment T_5 -50% RDF + 15 t FYM ha^{-1} (203.0) found statistically at par with treatment T_1- control (182.3). The data revealed that maximum number of siliqua plant^{-1} was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (291.0) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (283.0), T_4 -150% RDF (280.0) and minimum in treatment T_1- control (182.3) was observed. This may be due to adequate supply of FYM and inorganic fertilizers leading to increased flower formation and subsequent siliquae production. Similar results were also recorded by Mandal and Sinha (2002), Bijani *et al*., (2022).

Siliqua length (cm): With the increase in RDF, the siliqua length was increased and significantly higher siliqua length was observed in treatment T_4 -150% RDF (8.030 cm), T_3 -125% RDF (7.967 cm) and T_2 -100% RDF (40:20: N: P_2O_5 kg ha^{-1}) (7.770 cm) than treatment T_1- control (6.717 cm). Among integrated nutrient management treatments significantly higher siliqua length was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (8.423 cm), T_9 -100% RDF + 15 t FYM ha^{-1} (8.100 cm), T_8 -75%RDF + 20 t FYM ha^{-1} (7.673 cm), T_7 -75% RDF + 15 t FYM ha^{-1} (7.637 cm), T_6 -50% RDF + 20 t FYM ha^{-1} (7.613 cm) and T_5 -50% RDF + 15 t FYM ha^{-1} (7.550 cm) than treatment T_1- control (6.717 cm). The data revealed that maximum siliqua length was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (8.423 cm) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (8.100 cm), T_4 -150% RDF (8.030 cm), T_3 -125% RDF (7.967 cm) and minimum in treatment T_1- control (6.717 cm) was observed. This may be due to adequate supply of FYM and inorganic fertilizers ensures a balanced supply of nutrient, soil fertility and leading to better yield attributes such as siliqua length. Similar results were also recorded by Prasad *et al*., (2020).

Number of seeds siliqua^{-1}: Number of seeds siliqua^{-1} is also one of the major yields contributing character. With the increase in RDF, number of seeds siliqua^{-1} was increased and significantly higher number of seeds siliqua^{-1} was observed in treatment T_4 -150% RDF (21.00), T_3 -125% RDF (20.67) and T_2 -100% RDF (40:20: N: P_2O_5 kg ha^{-1}) (20.32) than treatment T_1- control (17.00). Among integrated nutrient management treatments significantly higher number of seeds siliqua^{-1} was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (23.01), T_9 -100% RDF + 15 t FYM ha^{-1} (21.50), T_8 -75%RDF + 20 t FYM ha^{-1} (20.00) than treatment T_1- control (17.00). The number of seeds siliqua^{-1} in treatment T_7 -75% RDF + 15 t FYM ha^{-1} (19.31), T_6 -50% RDF + 20 t FYM ha^{-1} (19.00) and T_5 -50% RDF + 15 t FYM ha^{-1} (18.67) found statistically at par with treatment T_1- control (17.00). The data revealed that maximum number of seeds siliqua^{-1} was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (23.01) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (21.50), T_4 -150% RDF (21.00) and minimum in treatment T_1- control (17.00) was observed. This may be due to adequate supply of FYM and inorganic fertilizers enhance reproductive processes, ensure seed development and contributing to productive siliqua development. Similar results were also recorded by Kumar *et al.*, (2005), Prasad *et al.*, (2020).

1000 seed weight (g): 1000 seed weight is an essential parameter as it gives an indication of seed chemical composition, seed dampness, insects infestation and seed maturation. With the increase in RDF, 1000 seed weight was increased and significantly higher 1000 seed weight was observed in treatment T_4 -150% RDF (3.22 g), T_3 -125% RDF (3.10 g) and T_2 -100% RDF (40:20: N: P_2O_5 kg ha^{-1}) (3.00 g) than treatment T_1- control (2.49 g). Among integrated nutrient management treatments significantly higher 1000 seed weight was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (3.45 g), T_9 -100% RDF + 15 t FYM ha^{-1} (3.30 g) and T_8 -75%RDF + 20 t FYM ha^{-1} (2.90 g) than treatment T_1- control (2.40 g). The 1000 seed weightin treatment T_7 -75% RDF + 15 t FYM ha^{-1} (2.80 g), T_6 -50% RDF + 20 t FYM ha^{-1} (2.70 g) and T_5 -50% RDF + 15 t FYM ha^{-1} (2.60 g) found statistically at par with treatment T_1- control (2.49 g). The data revealed that maximum 1000 seed weight was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (3.45 g) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (3.30 g), T_4 -150% RDF (3.22 g) and minimum in treatment T_1- control (2.49 g) was observed. This may be due to adequate supply of FYM and inorganic fertilizers overall plant growth which collectively contribute to higher quality seed with better 1000 seed weight. Similar results were also recorded by Kumar *etal.* (2005), Prasad *et al.* (2020).

Seed yield (q ha^{-1}): Seed yield is the harvested production per unit of harvested area of crop production and is net result of various agronomic inputs influencing growth and yield attributing characters during life cycle of crop. With the increase in RDF, the seed yield was increased and significantly higher seed yield was observed in treatment T_4 -150% RDF (19.50 q ha^{-1}), T_3 -125% RDF (18.01 q ha^{-1}) and T_2 -100% RDF (40:20: N: P_2O_5 kg ha^{-1}) (16.88 q ha^{-1}) than treatment T_1- control (10.49 q ha^{-1}). Among the integrated nutrient management treatments significantly higher seed yield was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (23.45 q ha^{-1}), T_9 -100% RDF + 15 t FYM ha^{-1} (20.65 q ha^{-1}), T_8 -75%RDF + 20 t FYM ha^{-1} (15.67 q ha^{-1}), T_7 -75% RDF + 15 t FYM ha^{-1} (14.31 q ha^{-1}) than treatment T_1- control (10.49 q ha^{-1}). The seed yield in treatment T_5 -50% RDF + 15 t FYM ha^{-1} (12.06 q ha^{-1}) and T_6 -50% RDF + 20 t FYM ha^{-1} (13.15 q ha^{-1}) found statistically at par with treatment T_1- control. The data revealed that maximum seed yield was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (23.45 q ha^{-1}) which was significantly higher than T_9 -100% RDF + 15 t FYM ha^{-1} (20.65 q ha^{-1}) and minimum in treatment T_1- control (10.49 q ha^{-1}) was observed. The increased in yield attributes to increase in supply of nutrients as well as micronutrients and organic + inorganic source which lead to more certain of photosynthesis and their translocation from source and sink. Similar results were also recorded by Mandal and Sinha (2002), Ratanoo *et al.* (2021).

Straw yield (q ha^{-1}): Straw yield is the measure of the vegetative growth under the various treatments. With the increase in RDF, straw yield was increased and significantly higher straw yield was observed in treatment T_4 -150% RDF (51.67 q ha^{-1}), T_3 -125% RDF (49.52 q ha^{-1}) and T_2 -100% RDF (40:20: N: P_2O_5 kg ha^{-1}) (46.33 q ha^{-1}) than treatment T_1- control (37.21 q ha^{-1}). Among integrated nutrient management treatments significantly higher straw yield was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (59.04 q ha^{-1}), T_9 -100% RDF + 15 t FYM ha^{-1} (53.62 q ha^{-1}), T_8 -75%RDF + 20 t FYM ha^{-1} (45.72 q ha^{-1}) and T_7 -75% RDF + 15 t FYM ha^{-1} (44.08 q ha^{-1}) than treatment T_1- control (37.21 q ha^{-1}). The straw yieldin treatment T_6 -50% RDF + 20 t FYM ha^{-1} (42.05 q ha^{-1}) and T_5 -50% RDF + 15 t FYM ha^{-1} (40.29 q ha^{-1}) found statistically at par with treatment T_1- control (37.21 q ha^{-1}). The data revealed that maximum straw yield was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (59.04 q ha^{-1}) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (53.62 q ha^{-1}) and minimum in treatment T_1- control (37.21 q ha^{-1}) was observed. This may be due to the adequate supply of FYM and inorganic fertilizers enhance the vegetative growth, resulting in potentially higher straw yield. Similar results were also recorded by Mandal and Sinha (2002), Kumar *etal.* (2005).

Harvest index (%): Harvest index is one of the factors that contributes in improvement of any crop to a certain extent. With the increase in RDF, straw yield was increased and significantly higher harvest index was observed in treatment T_4 -150% RDF (27.40 %), T_3 -125% RDF (26.80 %) and T_2 -100% RDF (40:20: N: P_2O_5 kg ha^{-1}) (26.70%) than treatment T_1- control (22.00 %). Among integrated nutrient management treatments significantly higher harvest index was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (28.80 %), T_9 -100% RDF + 15 t FYM ha^{-1} (27.80 %) and T_8 -75%RDF + 20 t FYM ha^{-1} (25.90 %) than treatment T_1- control (22.00 %). The harvest indexin treatment T_7 -75% RDF + 15 t FYM ha^{-1} (24.50 %), T_6 -50% RDF + 20 t FYM ha^{-1} (23.84 %) and T_5 -50% RDF + 15 t FYM ha^{-1} (23.00 %) found statistically at par with treatment T_1- control (22.00 %). The data revealed that maximum harvest index was observed in treatment T_{10} -100% RDF + 20 t FYM ha^{-1} (28.80 %) which was at par with T_9 -100% RDF + 15 t FYM ha^{-1} (27.80 %), T_4 -150% RDF (27.40 %), T_3 -125% RDF (26.80 %) and minimum in treatment T_1- control (22,00 %) was observed. Similar results were also recorded by Bijarnia *et al.* (2017).

Conclusion

From this investigation, the combined application of T_{10}-100% RDF+ 20 t FYM ha^{-1} was performed more effective than all other treatments. It may be concluded that the combination of T_{10}-100% RDF + 20 t FYM ha^{-1} enhanced the overall growth, yield and yield attributes of Gobhi Sarson. This integrated approach has the potential to improve crop productivity and reduce inadequate used of fertilizers. Therefore, farmers cultivating rapeseed are recommended to adopt this treatment combination to improve overall crop performance.

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Reference

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