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Research Article

Analysis of yield traits, oil content and protein concentration in canola (*Brassica napus* L.) in relation to various nitrogen and seed rates

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Abstract

Nitrogen plays an important role in protein formation, cell improvement, protoplasm and other photosynthetic activities. Therefore, a field study was conducted at Bacha Khan Agricultural Research Farm, Bacha Khan University, Charsadda, during 2015-2016. The experiment was laid down according to Randomized Complete Block design (RCBD) having three replications with plot size of 1.5m x 4m. Two factors were studied, i.e. Nitrogen levels (0, 50, 75 & 100 kg ha^{-1}) and Seed rates (3, 6 and 9 kg ha^{-1}). Seed rates resulted in maximum emergence (55 m^{-2}), plant height (147 cm), thousand grains weight (3.4 g) and grain yield (2026 kg ha^{-1}) were recorded with seed rate of 9 kg ha^{-1} while minimum days to maturity (155), maximum oil content (45%), Absolute growth rate (AGR) (7.4 g m^{-2} day^{-1}), grain nitrogen content (2.6 %) and straw nitrogen content (1.5 %) were recorded with the seed rate of 3 followed by 6 kg ha^{-1}. Except emergence, nitrogen performed better and maximum plant height (147 cm), 1000 grains weight (3.5 g), grain yield (2211 kg ha^{-1}), Absolute growth rate (AGR) (10.3 g m^{-2} day^{-1}), Nitrogen content in grain (2.7 %) and nitrogen content in straw (1.6 %) were achieved with 100 kg N ha^{-1} while minimum days to maturity (155) and grain oil content (44%) were obtained with 50 kg N ha^{-1}. Grain yield and oil content of canola increased with seed rate 6 kg followed by 9 kg ha^{-1} while 100 & 50 kg N ha^{-1} enhanced grain yield & oil content.

Keywords: *Brassica napus* L; Canola; Nitrogen levels; Oil content; Protein content; Seed rates

Introduction

Canola (*Brassica napus* L.) is from family Brassicaceae and is used as a vegetable oil in cooking and also as animal feed. It's the world 3rd biggest vegetable oil after palm-oil and soybean **[1]**. In Pakistan, canola is grown on both irrigated and rainfed area as oil seed crop. **[2]** While it is grown for fodder purpose as well as serves as a source of edible oil. Edible oil is one of the basic and major requirements of our daily diet. Pakistan is encountered with a deficiency of edible oil

because of its high consumption about 2.325 million tons, while only 0.606 million tones met through country production while the rest is imported every year. Canola is grown to approx. 217 thousand hectare area with 192-thousand-ton output with an average yield of (886 kg $ha^{-1)}$. Whereas in Khyber Pakhtunkhwa (KPK), it occupied 14.3 thousand hectare of area with production of 6.7 thousand tons with an average production of 469 kg ha^{-1}[3, 4].

Nitrogen plays an important role in increasing crop output. Nitrogen is a basic constituent of protein formation, cell improvement, protoplasm and other photosynthetic activates [5]. If it compares to other cereals, canola requires the most amount of nutrients and nitrogen. Many studies showed that growth and yield of canola could be improved significantly by increasing the dose of nitrogen [6]. But the use of excess nitrogen application can reduce or negatively affect grain yield and quality [7]. More nitrogen applied or improper application can increase nitrogen ratio in grains, which decrease the amount of oil. Increasing nitrogen chemicals and plant population increases grain yield and more yield per hectare attained by the nitrogen application of 225 kg ha^{-1} and seeds up-to 90-plants per meter [8, 9]. 110 plants in one-meter square is optimized and enhanced yield parameters [10]. Canola grain yield increased with increasing plant population and nitrogen levels [11] because nitrogen is a part of chlorophyll and green pigments in the plant which is a part of its body [12]. Increasing the rate of nitrogen fertilizer and plants per meter square increased and boost grain yield in canola [13]. It confirms from different researches that nitrogen fertilizer increased seed yield of canola and also increased the capacity of oil [14, 15].

Heavy winter rains damages plant density and many reports confirmed that reduction in plant population in canola reduced grain yield significantly [16]. High plant population is susceptible to lodging and other risk in the form of disease and low yield [17]. Optimum seed rates and plant density ensure crop competition and control weeds [18]. It's proven that Plant-populations decreased from 80 to 40 plants m^{-2} can produce more seed yield [19]. Seed rate of 32 m^2 to 65 seeds m^{-2} produced good and significant oil content production [20]. Seed rate is considered important factor to optimize plant density [21]. Seed rates enhance and positively influence the yield and yield contributing characters of canola [22].

Materials and methods

A field study of various nitrogen and seed rates on canola was conducted at Bacha Khan Agricultural Research Farm (BARF), Bacha Khan University, Charsadda during 2015-2016. The purpose of this trail was to evaluate yield traits, oil content and protein concentration in grains and straw. The experiment was done according to Randomized Complete Block (RCB) Design having three replications with plot size of 1.5m x 4m. Two factors were studied, i.e. nitrogen levels (0, 50, 75 & 100 kg ha^{-1}) and seed rates (3, 6 and 9 kg ha^{-1}). Nitrogen was applied to the field in two equal split doses. Half dose of nitrogen was added to the field during seed sowing time and the other half was applied at first irrigation. Agronomic, physiological and lab data was recorded during the experiment.

Results and discussion

Emergence m^{-2}

Emergence of canola varied by seed rates while the application of nitrogen had no clear influence on emergence m^{-2} as shown in (Table 1). Emergence m^{-2} was considerably increased by increasing seed rate and more emergences (51.1 seedlings) were noted with 9 kg seed rate ha^{-1} as compared to 3 kg ha^{-1}. Similar result was reported by [22] who reported that increasing seed rate increased emergence. Among N application non-

significant effect of nitrogen was found, as seedling consumes less nutrients. Similar result was also reported by [23].

Days to maturity

Table-1 showed variation in days to maturity by various levels of nitrogen, seed rates and interaction N x SR in canola. More days (159) were taken in maturity stage when 100 kg N ha^{-1} was applied as match to control plots. Increasing the levels of nitrogen delayed the maturity stage of the canola crop due to extension in vegetative production. Similar variation was noted by [24] that increase levels of nitrogen treatments can delay the vegetative stage of crop and increase the vegetative growth. Between different seed rates, 9 kg seed ha^{-1} took (158 days) in maturity stage, while minimum of (155 days) to maturity were taken with 3 kg seed rate ha^{-1}. Same results were reported by [25]. In case of interaction, minimum days were noted with the sole treatments of 50 kg N and 3 kg seed rate ha^{-1} as shown in (Figure 1)

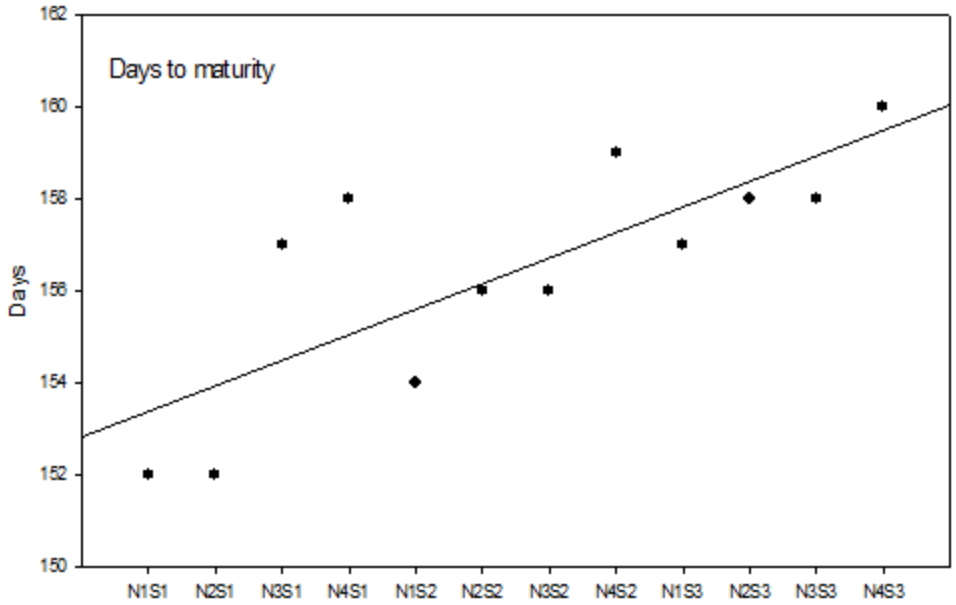
Plant height (cm)

Significant variation of nitrogen and seed rate were noted for plant height while interaction N x SR had no effect as reported in (Table 1). Plots treated with the sole treatment of Nitrogen @ 100 kg ha^{-1} resulted (147 cm) taller plants as compared to control. Similar result was observed by [26, 27]. Among seed rate treatments, (140 cm) taller plant was observed when 9 kg seed rate ha^{-1} as compared to 3 and 6 kg seed rate ha^{-1}. Increasing in height of plant was observed with increasing seed rate may be due to competitions of plant for environmental factors [28].

Table 1. Represent data on emergence m^{-2}, days to maturity, plant height (cm), of canola as influenced by different nitrogen levels and seeding rates

Treatments Nitrogen (kg ha^{-1})	Emergence m^{-2}	Days to maturity	Plant height (cm)
0	47.1 a	154c	131d
50	44.8 c	155c	135c
75	46.7 b	157b	139b
100	45.2 c	159a	147a
LSD Value	**-**	**1.11**	**1.17**
Seed rates (kg ha^{-1})			
3	33.6b	155c	136c
6	49a	157b	138b
9	55.1a	158a	140a
LSD Value	**6.55**	**0.96**	**1.97**
LSD Value for interaction	**-**	**1.92**	**-**
S x N	**Ns**	******	**Ns**

Means with letters differ significantly according to Least-Significant- Difference (LSD) test (P<0.05), ns stands for non-significant difference and* at P < 0.05 level, respectively



N_1 = 0, N_2 = 50, N_3 = 75, N_4 = 100, S_1 = 3, S_2 = 6, S_3 = 9

Figure 1. Days to maturity of canola as affected by interaction of different nitrogen levels and seed rates

Thousand grains weight (g)

1000 grains weight of canola was influenced significantly by various seed rates, nitrogen and as well as interaction N x SR as presented in (Table 2). Maximum 1000 grains weight (3.5 g) was noted in plot treated with @ 100 kg N ha^{-1} as compared to others nitrogen treatments. The result is in line with the finding of **[28]** that nitrogen can increase and enhance 1000 grains weight. Among seed rate application, maximum 1000 grains weight (3.4 g) was recorded with 9 kg seed rate ha^{-1} and minimum (3.2 g) was observed with 3 kg seed rate ha^{-1}. **[29]**. In case of combinations, heaviest 1000 grains weight was observed when the combine treatments of 75 kg nitrogen, 9 kg seed rate ha^{-1} were used as shown in (Figure 2)

Grain yield (kg $ha^{-1)}$

Nitrogen rates and seed rates had significantly impacted grain yield while interaction N x SR had no effect as reported in (Table 2). Maximum grain yield (2211 kg ha^{-1}) was produced with nitrogen @ 100 kg ha^{-1}, while control plot recorded (1518 kg ha^{-1}) grain yield. Between seed rate treatments, more grain yield (2026 kg ha^{-1}) was attained with 9 kg seed rate ha^{-1} was used as compared to 3 kg seed rate ha^{-1}. The result is agreed with the findings of **[30, 31]**. Grain yield enhanced by increasing seed rates in canola.

Oil concentration in grains (%)

Nitrogen levels, seed rates as well as their combination N x SR differed significantly, oil concentration in canola crop as shown in (Table 2). Oil content is inversely affected by nitrogen application. Maximum oil content (45, 44 and 40 %) were obtained with the application of nitrogen applied at 50 and 75 as compare to 100 kg N ha^{-1} **[32]**. Among the application of seed rates, 6 kg ha^{-1} gave maximum (45 %) oil as compared to all others treatments. Higher seed rate increased plant competition for nutrients and other environmental factors, while lower seed rate decreased plant competition and hence resulted in higher oil content %. Similar result by **[33]**. In case of the interaction, maximum oil content was gained with the interactive treatments of 75 kg nitrogen and 3 kg seed rate ha^{-1} as shown in (Figure 3).

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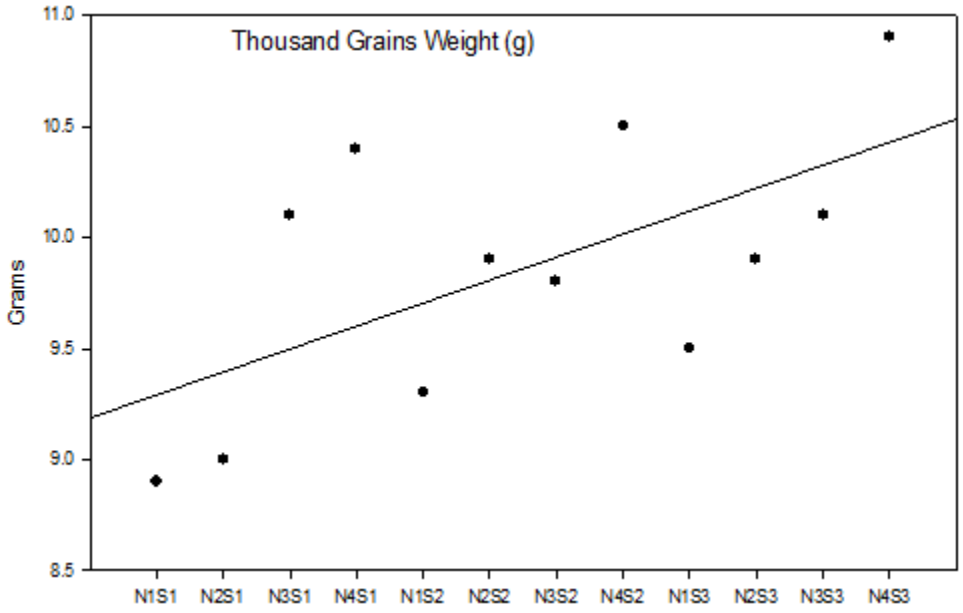
Table 2. Represent data on thousand grains weight (g), grain yield (kg ha^{-1}) and oil content (%) of canola as impacted by different nitrogen levels and seed rates

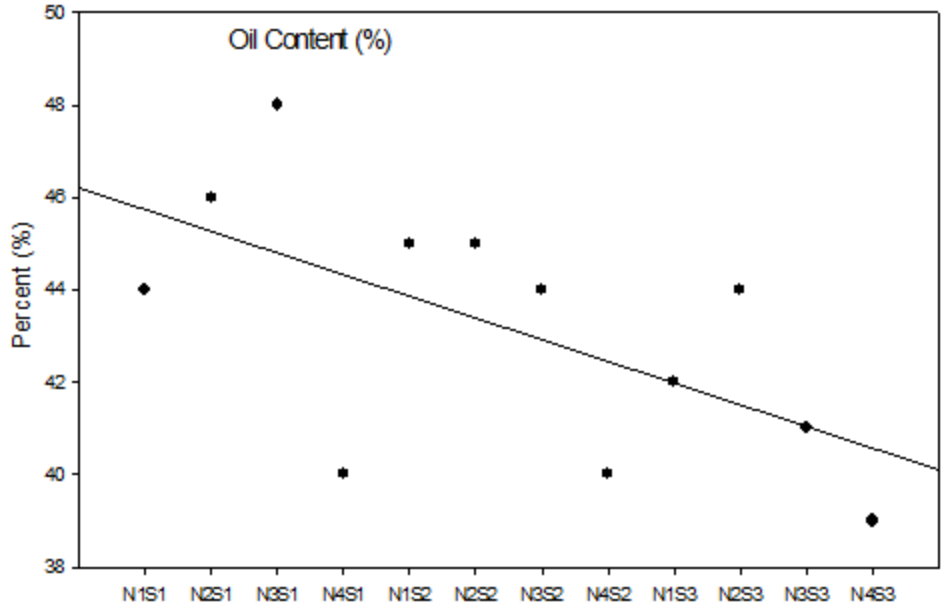
Treatments Nitrogen (kg-ha^{-1})	1000 grains weight (g)	Grain yield (kg ha^{-1})	Oil content (%)
0	3.1d	1518b	44b
50	3.2c	1679b	45a
75	3.3b	2041a	44b
100	3.5a	2211a	40c
LSD Value	**0.07**	**195.28**	**0.96**
Seed rates (kg ha^{-1})			
3	3.2c	1688b	44b
6	3.3b	1873ab	45a
9	3.4a	2026a	42c
LSD Value	**0.08**	**225.49**	**0.83**
LSD Value for interaction	**0.14**		**1.66**
S x N	**	**Ns**	**

Means with letters differ-significantly according to-Least Significant Difference (LSD) test (P<0.05), ns stands for non-significant difference and* at P < 0.05 level, respectively



N_1 = 0, N_2 = 50, N_3 = 75, N_4 = 100, S_1 = 3, S_2 = 6, S_3 = 9

Figure 2. Thousand grains weight of canola as affected by interaction of different nitrogen levels and seed rates



$N_1 = 0$, $N_2 = 50$, $N_3 = 75$, $N_4 = 100$, $S_1 = 3$, $S_2 = 6$, $S_3 = 9$

Figure 3. Oil content (%) of canola as affected by interaction of different nitrogen levels and seed rates

Absolute growth rate (AGR g m^{-2} day^{-1})

The application of nitrogen, seed rate and their combinations N x SR showed significant variation for absolute growth rate (AGR) as shown in (Table 3). Higher absolute growth rate (AGR) (2.7 g m^{-2} day^{-1}) was noted with the treatment of nitrogen @ 100 kg ha^{-1}, while less mean value of absolute growth rate (AGR) (1.9 g m^{-2} day^{-1}) were recorded in control plots. Among various seed rate, a greater mean value of absolute growth rate (AGR) (2.6 g m^{-2} day^{-1}) was noted in plots received seed rate @ 3 kg ha^{-1} while 9 kg ha^{-1} seed rate gave minimum absolute growth rate (AGR) (2.0 g m^{-2} day^{-1}). In case of interaction, maximum absolute growth rate (AGR) (12.0 g m^{-2}-day^{-1}) was observed with the sole application of seed rate 3 kg and nitrogen 100 kg ha^{-1} as compared to all others possible combinations as reported in (Figure 4). The same finding was discussed by [34], that the application of nitrogen enhances the growth and the ratio of growth.

Nitrogen content in grain (%)

Nitrogen, seed rate and their combinations N x SR varied significantly nitrogen content in grains as shown in (Table 3). Maximum nitrogen content in grains (2.7 %) was observed with 100 kg N $ha^{-1}$and minimum of (1.9 %) was observed in control plots. Among various seed rate levels maximum N content in grains (2.6 %) was noted with 3 kg seed rate ha^{-1}, while 9 kg seed rate ha^{-1} gave minimum (2.0 %) nitrogen content in grains. In case of interactions, seed rate of 3 kg and nitrogen 100 kg ha^{-1} was superior and produced (2.9 %) nitrogen content in grains as compared to all other combinations as presented in (Figure 4). The result is supported by the findings of [35].

Nitrogen content in straw (%)

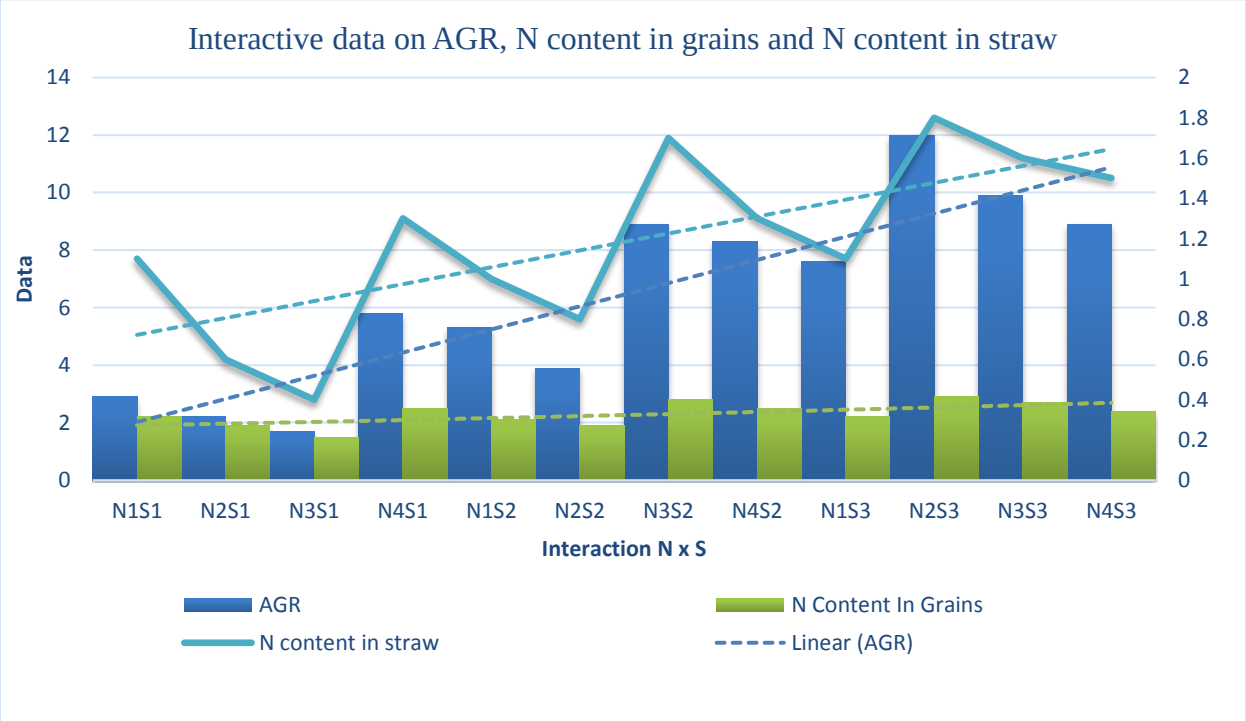
Nitrogen content (%) in straw was affected significantly with the application of nitrogen, seed rate and their combinations N x SR as shown in (Table 3). Maximum nitrogen content in canola straw (1.6 %) was noted when nitrogen was applied @ 100 kg ha^{-1} and minimum (0.7 %) was observed in control plots. Regarding seed rates application, higher nitrogen content in straw (1.5 %) was noted with 3 kg seed rate ha^{-1} while 9 kg seed rate ha^{-1} gave minimum (0.9%) of nitrogen content. In case of combination, a greater nitrogen content in straw (1.8 %) was recorded when nitrogen 100 kg and seed rate

3 kg ha^{-1} was used as match with all other possible combinations as presented in (Figure 4) [35].

Table 3. Represent data on absolute growth rate (AGR), nitrogen content in canola grains and nitrogen content in canola straw as impacted by nitrogen levels and seed rates

Treatments Nitrogen (kg ha^{-1})	AGR (%)	N in Grains (%)	N in straw (%)
0	2.3d	1.9d	0.7d
50	5.0c	2.2c	1.0c
75	8.3b	2.5b	1.4b
100	10.3a	2.7a	1.6a
LSD Value	**0.43**	**0.11**	**0.6**
Seed rates (kg ha^{-1})			
3	7.4a	2.6a	1.5a
6	6.4b	2.3b	1.1b
9	5.5c	2.0c	0.9c
LSD Value	**0.37**	**0.1**	**0.05**
LSD Value for interaction	**0.75**	**0.20**	**0.11**
S x N	**	**	**

Means with letters-differ significantly according-to Least Significant-Difference (LSD) test (P<0.05), ns stands-for non-significant difference and* at P < 0.05 level, respectively



$N_1 = 0$, $N_2 = 50$, $N_3 = 75$, $N_4 = 100$, $S_1 = 3$, $S_2 = 6$, $S_3 = 9$

Figure 4. Absolute growth rate (AGR), nitrogen content in grains and nitrogen content in straw of canola as affected by interaction of different nitrogen levels and seed rates

Conclusion

It's concluded from the results of the experiment that seed rate of 9 kg ha^{-1} increased grain yield of canola while oil content (%) could be increased with 6 kg seed rate ha^{-1}. Nitrogen application at 100 kg ha^{-1} enhanced grain yield and could be recommended for maximum grain yield but nitrogen applied at 50 kg ha^{-1} produced maximum oil content (%) in canola and could be recommended for obtaining higher oil content (%).

Authors' contributions

Conceived and designed the experiments: SN Khan & Z Hussain, Performed the experiments: SN Khan, Z Hussain, WA Shah & R Amin, Analyzed the data: M Ishaq, A Khan, M Ahmad & S Uddin, Contributed materials/ analysis/ tools: M Wisal, S Allah & M Ali, Wrote the paper: M Ishaq.

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