



Research Article

Effect of Seed Rate and Row Spacings on the Physio-Chemical Traits of Soybean

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Abstract | Soybean is the most important oilseed and rich protein crop throughout the world. A two- years (2007-2008) field trial was carried out to improve the soybean production under integrated agronomic practices. A three replicated experimental design was conducted, which consisted of three different seed rates (60, 75 and 90 kg ha⁻¹) and row spacings (30cm, 45cm, and 60cm). The results exhibited higher plant 55.24cm and 55.14cm at 45 cm row spacing under the interaction of seed rate 60 and 75 kg ha⁻¹, respectively. Whereas maximum leaf area 190.72 cm² and 190.0 cm² were observed from 60cm row spacing. The maximum days to flowering 45.06 and days to maturity 117.28 were recorded at row spacing 60cm with a seed rate of 90 kg ha⁻¹. The row spacing 45 cm with a seed rate of 75 and 90 kg ha⁻¹ showed minimum days 41.67 to 41.94 to leghaemoglobin in nodules. While 60cm row spacing with all seed rates had short time 61.61 to 61.72 days to disappearance leghaemoglobin in the nodule. Furthermore, days to nodule formation and the number of nodules plant⁻¹ were not significantly affected by seed rates, except row spacings. The 60cm row spacing had a positive relationship with nodules formation and their number in plant roots. In the case of crop growth rate (gm⁻² day⁻¹) and net assimilation rate (gm⁻² day⁻¹), both were significantly higher 0.719-0.707 and 17.46 to 17.12 gm⁻² day⁻¹ at 45 cm row spacing in combination with different seed rates. The results for biochemical characteristics of soybean plant exhibited maximum nitrogen 0.485%, phosphorus 0.506% and potassium 0.502% in stem, potassium 1.405% in leaves, potassium 1.753% in pods, protein content 41.87% at seed rate 75 kg ha⁻¹ with row spacing 45cm. The primary conclusion is that the cultivation of soybean at a seed rate 75 kg ha⁻¹ combined with row spacing 45cm beneficial to achieve maximum yield with high nutritional quality.

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Keywords | Soybean, Seed rate, Row spacing, Yield, Nutrition value

Introduction

The soybean is the world's most essential oil and protein crop. Protein content in dry weight-assayed seeds ranges from 38 to 42 percent, with oil content ranging from 19 to 22 percent. Saturated fatty acids such as palmitic (12–13 percent) and stearic (3–4%) are found in soybean oil, as are unsaturated

fatty acids such as oleic (19–23 percent), linoleic (48–58 percent), and linolenic (5–8%). Sugars, monosaccharides (glucose and fructose), oligosaccharides (sucrose), and oligosaccharides (oligosaccharides) are all found in soybean oil (raffinose and stachyose). Soybean seed contains a lot of minerals (Bellaloui *et al.*, 2015). Farmers frequently use completely different seeding rates and row spacings to maximize yields. To

maximize benefit, farmers often use entirely different seeding rates and row spacings. Gaps between yield potential and recorded farm yields are common when different soybean management practices are used (Cassman *et al.*, 2003). Soybean cultivation necessitates detailed data on optimum seeding rates and row spacing.

As the population of soybean plants grows, yield rises until it reaches a straight line at 20 plants per m² resulting in seed yields enhancement as 4.50 Mg ha⁻¹ (Wichert and Talbert, 1993). According to Cox and Cherney (2011), seed yield increased by 7 percent when seeding rate increased from 32.1 to 42.0 seeds m⁻² while it decreased by 4 percent when it decreased from 42.0 to 46.9 seeds m⁻².

Aside from seed rate, row spacing is another factor that influences soybean productivity. Due to the vegetative growth of plants, the dry matter can be increased by up to 41% in comparison with the row spacing of 50cm and the row spacing of 100cm (Board *et al.*, 1990). The maximum no of branches per plant accounts for 14-57 percent of total seed yield in rows of 19 cm (Norsworthy and Shipe, 2005). Increased seed yield when soybean crop was sown under the narrower 76 cm row spacing. Row spacing that is optimal would increase yield by around 17%. (Taylor, 1982). More radiations intercept with a higher LAI, resulting in a higher photosynthesis rate (Lambert and Lowenberg, 2003). Several other researchers have identified major yield improvements as a result of proper row spacing (Holshouser and Whittaker, 2002). Due to a lack of interest on the part of researchers in the study area of Tando Jam (Sindh), data on soybean cultivation is limited. In the present study, the objective was to determine the effect of seed rate and row spacing on physio-chemical characteristics of soybean yields in order to establish production practice technology package know-how for improved crop management.

Materials and Methods

Study site, climate and soil

Tando Jam (25.4299° N, 68.5426° E) is located in Sindh's lower region, just 20 kilometres from Hyderabad. Annual rainfall falls less of potential evapotranspiration, preventing crop production without irrigation. The most of rain falls during the summer monsoon season, due to occasional westerly waves that reach the country's southern regions. Total annual rainfall ranges from 145 to 155 mm. Because of the Arabian Sea, the study region is slightly cooler and more humid (Kazi *et al.*, 2016). The soil has a clay loam texture, low organic matter (0.54-0.58 percent) and high exchangeable potassium (165 mg kg⁻¹) but low nitrogen (70-30 percent) and phosphorus (3.00-3.51 mg kg⁻¹). Table 1 lists the basic soil characteristics.

Experimental design and management practices

A two-year (2007-08) field experiments were conducted to improve soybean production under integrated agronomic practices. There was three replicated experimental design, which consisted of three different seed rates (60, 75 and 90kg ha⁻¹), row spacings (30, 45 and 60cm). Plot size was 3 x 5 m² = 15 m². One deep ploughing followed by shallow ploughing and levelling, after soaking dose when soils come into condition cross ploughing followed by plankin-gapplied. The soybean variety NARC-I was sown on 15th May of each year. The sowing method was drilling, fertilizer ½ bags of DAP per acre at sowing time. First irrigation 26 days after sowing. Plant protection measures, particularly insect pest control by insecticides, were according to local farmer practices. The beans were harvested when the leaves have fallen, and the lowest pods have turned yellowish and dried and seed moisture content was dropped to 12-13%.

Table 1: Basic physical and chemical properties of soil at different depths.

Depth (cm)	BD (gcm ⁻³)	Particle fraction (%)			Soil texture (USDA)	pH value	θ _s (cm ³ cm ⁻³)	θ _{fc} (cm ³ cm ⁻³)	θ _{wp} (cm ³ cm ⁻³)	Ks (cmd ⁻¹)
		Sand	Silt	Clay						
0~20	1.43	33.2	46.8	20.3	Clay loamy	7.5	0.48	0.270	0.126	16.28
20~40	1.44	33.4	45.8	19.3	Clay loamy	7.5	0.38	0.291	0.133	14.89
40~60	1.32	30.6	44.5	24.9	Loamy	7.6	0.35	0.292	0.144	15.23
60~80	1.52	35.4	48.4	16.2	Loamy	7.6	0.37	0.261	0.112	6.13
80~100	1.52	37.4	46.4	16.2	Loamy	7.6	0.337	0.263	0.113	6.12

Note: **BD**: bulk density; **θ_s**: soil saturated water content (0 kPa); **θ_{fc}**: SWC at field capacity (33.34 kPa); **θ_{wp}**: SWC at permanent wilting point (1500 kPa); **Ks**: saturated hydraulic conductivity.

Data collection and statistical analysis

Days to flowering were calculated using various dates of physiological maturity and sowing, while days to maturity were calculated using various dates of physiological maturity and sowing. When root red colour nodules emerged, the days to leghaemoglobin were counted. When the colour of the nodules changed to green, the days to disappearance of leghaemoglobin were counted. Equations 1-3 were used to quantify and calculate leaf area (cm^2), crop growth rate ($\text{g}^{-2} \text{ day}^{-1}$) and net assimilation rate (NAR, $\text{g}^{-2} \text{ day}^{-1}$) (Sagoo, 2012). The Kjeldahl method was used to calculate total nitrogen concentrations in the plant. The phosphorus and potassium contents of the plant were calculated using the Cavell, 1955, process, which was also used by Bellaloui *et al.* (2015). To evaluate the effect of different seed rates and row spacings on soybean growth and yield, all collected data were statistically analyzed using Statistix 8.1 software. At the 0.05 probability level, the means of each treatment were compared using the least significant difference (LSD) test (Leghari *et al.*, 2019).

$$\text{LAI} = \frac{\text{Leaf area}_{\text{plant}}}{\text{Ground area}} \dots \dots (1)$$

Where;

LAI = Leaf area index.

$$\text{CGR} = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times (\text{area}) \dots (2)$$

Where;

CGR: Crop growth rate; W_1 and W_2 : Dry weight; t_1 and t_2 : Time.

$$\text{NAR} = \frac{\text{TDM}}{\text{LAD}} \dots (3)$$

$$\text{LAD} = [(\text{LAI}_1 + \text{LAI}_2) \times (t_2 - t_1)] / 2$$

$$\text{NAR} = W_2 - W_1 / (t_2 - t_1) \times 1 / \text{leaf area}$$

Where;

Net assimilation rate, TDM: Total dry matter; LAD: Total leaf area duration; LAI_1 : Leaf area index at initial developmental growth stage; LAI_2 : Leaf area index at final growth (maturation) stage; t_1 : Time corresponding to initial developmental stage; t_2 : Time corresponding to maturation stage.

Results and Discussion

Effect of seed rate and row spacings on the physio-chemical traits of soybean

The optimal seed rate and row spacing are crucially important to obtain maximum soybean productivity. Similar researchers also stated that dense planting adversely affects the yield and quality of soybean (Edwards and Purcell, 2005) by increasing the plant's competition for water, nutrients, light, space, etc. Therefore, highly increased seed rate and row spacing both have a negative impact on the physicochemical characteristics of soybean.

Physiological traits of soybean

Effect of seed rate and row spacing on the physiological traits of soybeans shown in Figure 1. The research findings indicated that seed rate and row spacing both exhibited various soybean traits. The enhanced height of plants 55.24 cm and 55.14 cm was observed at 45 cm row spacing under the interaction of seed rates 60 and 75 kg ha^{-1} , respectively. Enhanced leaf area 190.72 cm^2 and 190.0 cm^2 observed from 60 cm row spacing. The maximum days to flowering 45.06 and days to maturity 117.28 were recorded at row spacing 60 cm with a seed rate of 90 kg ha^{-1} . The row spacing 45 cm with a seed rate of 75 and 90 kg ha^{-1} showed highly positive response to days 41.67-41.94 to leghaemoglobin in nodules. While 60 cm row spacing with all seed rates had a short time of 61.61 to 61.72 days to disappearance leghaemoglobin in the nodule our findings were confirmed with Holshouser and Whittaker (2002).

Furthermore, days to nodule formation and the number of nodules plant^{-1} were not significantly affected by seed rates, except row spacing. The 60 cm row spacing had a positive relationship with nodules formation and their number in plant roots. In the case of crop growth rate ($\text{gm}^{-2} \text{ day}^{-1}$) and net assimilation rate ($\text{gm}^{-2} \text{ day}^{-1}$), both were significantly higher 0.719-0.707 $\text{gm}^{-2} \text{ day}^{-1}$ and 17.46-17.12 $\text{gm}^{-2} \text{ day}^{-1}$ at 45 cm row spacing in combination with different seed rates. Thus, dry matter and grain yield were increased as well. However, the effect of the seed rate was not obvious. The results of this study agree with previous research of Holshouser and Whittaker (2002), Harder *et al.* (2007) they reported that narrow row spacing about 76cm improves plant growth over wide row planted soybeans with over 4,45,000 plants ha^{-1} compared to highly less seeding at the same row spacing.

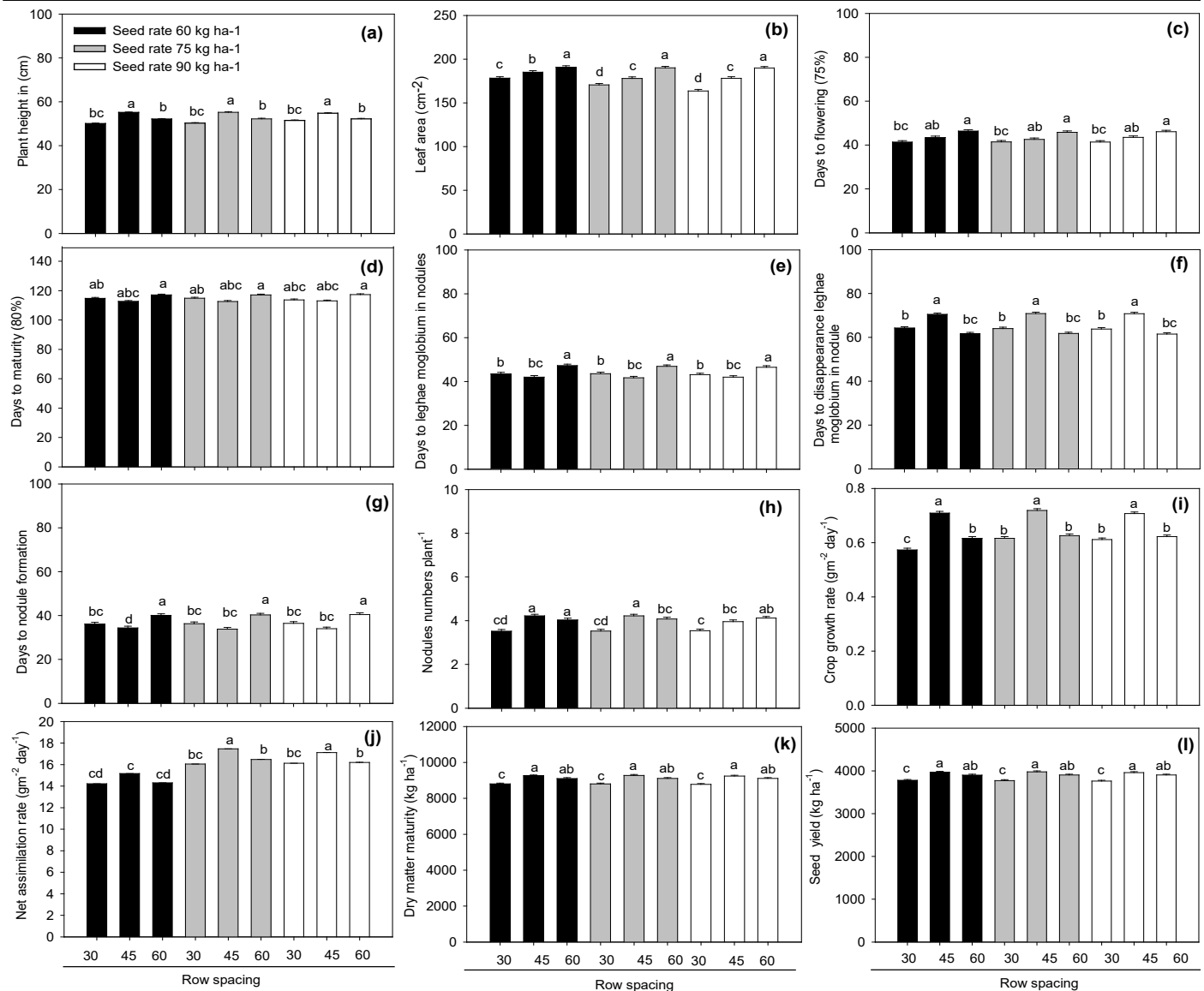


Figure 1: Effect of different seed rates and row spacing on different soybean traits.

Our above findings confirmed by researchers they stated that plant productivity was influenced by increased population density when the seed rate was increased excessively (Ball *et al.*, 2000). Optimum row spacing increases the light interception of crop about 95% compared to 100 cm of row spacing (Weber *et al.*, 1966; Oplinger and Philbrook, 1992; Cox *et al.*, 2012).

Bio-chemical traits of soybean

The effect of the seed rate and the row spacing on the physiological traits of soybean is shown in Figure 2. The results showed that maximum nitrogen 0.485% in the stem, phosphorus 0.506%, kinetic 0.502% in stem, kinetic 1.405% in leaves and kinetic 1.753% in pods, protein content 41.87% applied seed rate 75 kg ha⁻¹ at row spacing 45 cm. Whereas, the higher concentration of P in leaves was 1.318% at seed rate 60 kg ha⁻¹ in combination with row spacing 45 cm. Furthermore, the low oil content of 18.27% was observed

at 60 kg ha⁻¹ seed with row spacing of 30 cm. In the case of NPK concentrations and protein content, the low nitrogen 0.405% and Phosphorus 0.407% in the stem, phosphorus 1.202% in leaves, Kinetic 1.308% in leaves, protein 32.199% at 60 kg ha⁻¹ seed rate with row spacing 30 cm. While K (%) in pods was 1.668% at 90 kg ha⁻¹ seed rate with row spacing 30 cm. Results indicate that seed rate and row spacing has a major effect on the NPK concentrations in stem and leaves, protein, and oil content. These results are in line with Bellaloui *et al.* (2015) reported that planting soybean seeds at variable rates and different row spacing result in different plant responses. Optimum seed rate and row spacing enhanced seed protein and P concentrations. The increases in protein concentrations could be due to decreases in carbohydrates (Wilcox and Shibles, 2001) and variation of biosynthesis of oil could be due to higher enzymic activity after increased nutrients absorption of the plant from the soil, light

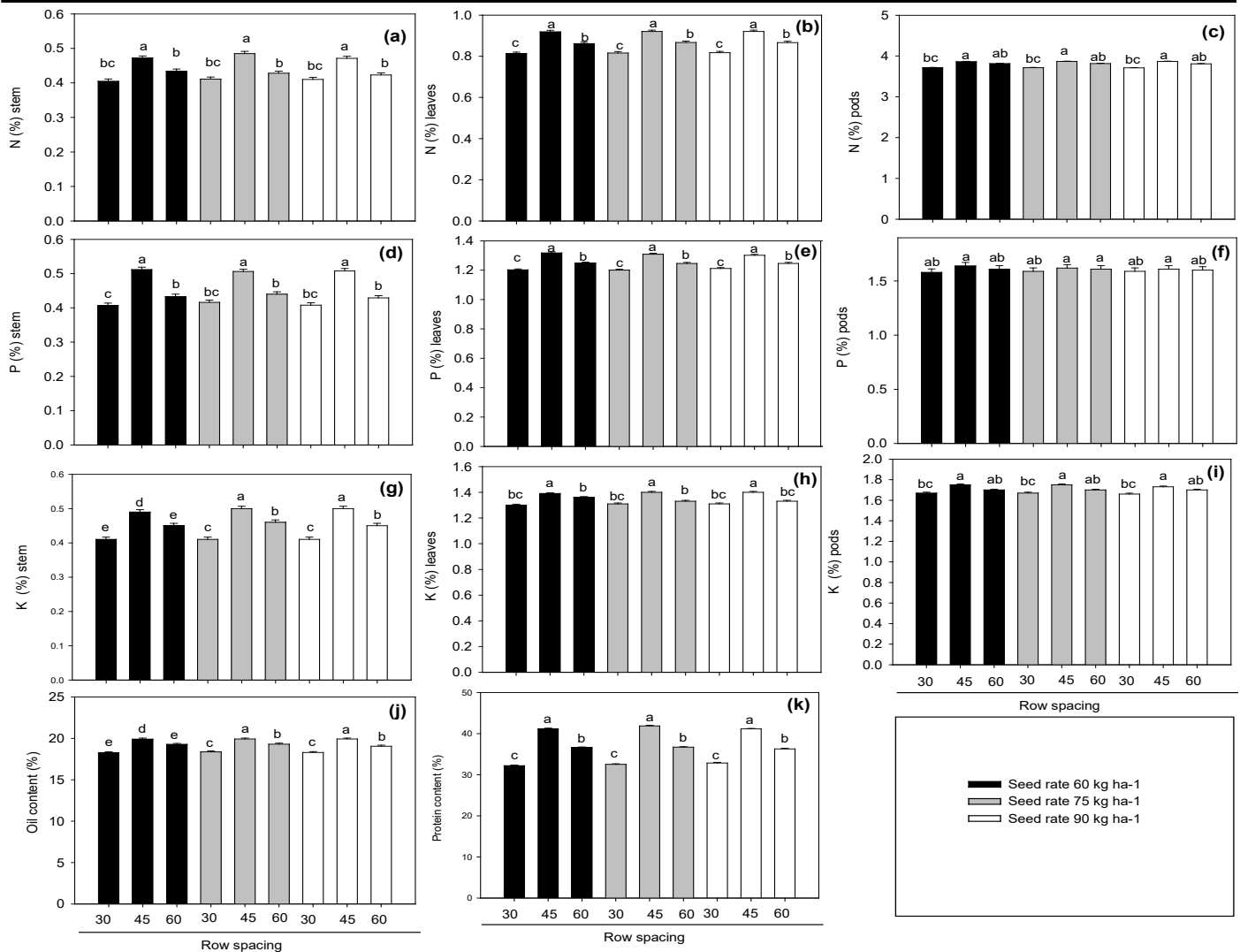


Figure 2: Effect of different seed rates and row spacing on the biochemical traits of soybean.

interception, early canopy closure (Bellaloui *et al.*, 2014; Andrade *et al.*, 2002; Taylor *et al.*, 1982).

Conclusions and Recommendations

This research demonstrated a different physio-chemical response soybean to variable seed rate and row spacings. Excessive and seed rate and highly increased and reduced row spacings had an adverse effect on the growth and nutrition value of soybean. Cultivation of soybean at a seed rate of 75 kg ha⁻¹ in combination with the spacing 45 cm row to row would be beneficial to achieve maximum oil yield and protein concentrations. The biochemical response of soybean was more obvious than physiological to different combinations of seed rate and the row spacing. The seed rate alone had no significant effect on both plants' physiological and biochemical characteristics. The findings of this study provide insights into the improvement of the production technology of soybean.

Novelty Statement

Keeping in view the importance of edible oil production, production technology of soybean *i.e.*, sowing rate and row spacing traits was determined in manuscript.

Author's Contribution

Rasool Bux Kalhoro: Main Author and wrote the manuscript.

Ghulam Mustafa Laghari: Guided in research work.

Ghulam Hyder Jamro and Muhammad Ibrahim Keerio: Co-supervisor, guided and Did research work.

Conflict of interest

The authors have declared no conflict of interest.

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