Research Article

Yield Response of Castor (*Ricinus communis* L.) to NPK Fertilizers under Arid Climatic Conditions

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Abstract | This study was carried out to access the response of castor (*Ricinus communis* L. Var. DS-30) for varying level of Nitrogen, phosphorus and potassium under arid climatic conditions of Bahawalpur on clay loam soil. This experiment was laid out in randomized complete block design. Data on plant height, branches per plant, capsules per plant, number of seeds per capsule and yield was taken into account at maturity and statistically analyzed. All yield contributing traits showed positive response with increase in fertilizer rate. Maximum yield was found at T6 (NPK @ 40:30:15) and T6 and T7 (NPK @ 40:30:30) showed parity for seed yield. Significant difference was not observed in increase in yield due to the addition of potassium but branches per plant showed substantial difference. Highly significant positive correlation was observed for yield and yield contributing traits.

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Introduction

Castor (*Ricinus communis* L.) locally named as '*Arind*' or '*Arindi*', belongs to family *Euphorbiaceae,* and is one of the most important non-edible oilseed crops, which is grown all around the world (Radhamani et al., 2012). Primarily this plant is important for the production of best quality lubricant due to the presence of an unusual fatty acid 'ricinoleic acid' in large quantity. Being oil containing crop, it is getting attention for production of biodiesel, to minimize the consumption of fossil fuel, as alternate energy source (Da Silva et al., 2006; Nahar, 2015). Beside this, due to the uniform ricinoleic acid content, its oil is also utilized in traditional medicines, paints and cosmetics and has many other industrial uses (Da Silva et al., 2006; Cheema et al., 2013)

Despite the fact that castor is an important medicinal and industrial crop, it has not yet realized as commercial crop and not opted by the farmer as emphasis is given to the other major crops like, cotton, rice, wheat and sugarcane etc. Cultivation of castor is limited to marginal lands of the country due to competition with major crops which results in low yield. It was grown on an area of 2.25 thousand hectare with total production of 2.3 thousand tons during the year 2016 (www.fao.org). One other reason of low yield is the lack of sufficient amount of water available for the crop to mature and improper fertilizer inputs avail-

ability for this crop. Whilst, castor is drought tolerant plant and can be grown on wide climatic regimes and is an ideal crop for arid and semi-arid zones with humid climate (Falasca et al., 2012), the availability of balanced nutrients is very necessary for high yield. Castor can also be grown as potential oilseed crop on all kinds of lands, which are not alkaline and are well drained, where no other important crop could be grown (Cheema et al., 2013).

Table 1: *Soli analysis of experimental site.*

Soil pH	**8.2**
EC	1.7 ds/m
Organic Matter	0.82 %
Phosphorus	6.2 ppm
Potassium	282 ppm
Soil Saturation	48 %
Soil Texture	Clay-Loam Soil

In Pakistan, 27 percent of total area is considered as arid to semi-arid region. The climatic conditions of Sindh, Baluchistan and some areas of Punjab specifically, Bahawalpur division, (Cholistan desert) are suitable and potential sites for the cultivation of castor. Production of castor is not according to its potency due to lesser availability of irrigated water and proper application of nutrients at marginal lands (Arif et al., 2015). According to estimation, one ton grain yield per hectare removes 30 kg of Nitrogen, 12 kg of Phosphorus and 10 kg of potassium (Kumar et al., 2015). So the depletion of nutrients is very common. As these nutrients play major role in yield, so the optimum amount of these nutrients needs to be identified for better yield of castor at marginal lands. Previously, it was found that addition of NPK fertilizers significantly increase seed yield in castor in irrigated condition (Pacheco et al., 2008; Neto et al., 2009; Hadvani et al., 2010).

The objective of this study was to analyze the nutrient requirement of castor variety DS-30 to get its maximum potential under arid climatic condition of Bahawalpur, Pakistan.

Materials and Methods

Experiment was carried out in experimental area of Arid Zone Research Institute, Bahawalpur, Pakistan in 2014. Castor variety DS-30 was shown on well cultivated soil in Randomized Complete Block Design in third week of July. Soil analysis was done before sowing of crop (Table 1). Average metrological conditions of the experimental site were also recorded (Table 2). This crop is grown in summer and autumn season and matures in 120 to 150 days.

Experimental plot size was 60 m^2 (6m x 10m) with 75 cm row to row spacing and plant to plant distance in three replications. Seven different treatments containing different doses of NPK were applied including one control having no fertilizer. Fertilizer doses of each treatment are given in Table 3.

Whole Phosphorus and Potassium whereas half Nitrogen (Urea having 46% N) fertilizer dose was applied at the time of seed bed preparation and remaining half Nitrogen was top dressed at 2nd irrigation. All other cultural practices include four irrigations (each after one month) two weeding (as and when required) and insect control according to standard IPM procedure. Data were recorded for different yield contributing traits and yield at maturity i.e. plant height (in cm), branches per plant, number of capsules per plant, number of seeds per capsule and total yield per hectare (in Kg) for all the plots.

Whole recorded data was analyzed statistically according to Steel et al. (1997) and comparison of treatment

Table 2: *Metrological data of experimental site (July to December 2014).*

Month	**Average Temperature (°C)**			**Average Humidity (%)**	**Average Rain Fall (mm)**	**Average Pressure (mbar)**
	High	**Low**	**Average**			
July	44	37	42	30	4.22	995.7
August	42	36	40	35	2.01	999.1
September	44	33	37	37	24.18	1003.2
October	38	30	35	26	0.5	1011.1
November	32	23	28	25	0.5	1014.8
December	26	16	22	26	0	1018

Source: *Met Station, Arid Zone Research Institute, PARC, Bahawalpur.*

Table 3: *Doses of Nitrogen, Phosphorus and Potassium in each treatment.*

Treatments	Nitrogen (kg/ha) (Urea)	Phosphorus (kg/ha) (P_2O_5)	Potassium (kg/ha) (K_2O)
T1	0	0	0
T2	20	15	0
T3	40	15	0
T4	40	15	15
T5	40	30	0
T6	40	30	15
T7	40	30	30

means for its significance was based on the procedure by Carmer and Swanson (1971) by using computer software 'Statistix 8.1'.

Results and Discussion

The data related to the effect of NPK doses on total seed yield and yield contributing traits of castor is given in Table 4. There is significant difference among treatments for yield and yield contributing parameters. Plant height is an important factor in terms of biomass. Perusal of data given in Table 4 reveals that different rate of fertilizers have significantly affect on the plant height. Statistically, maximum plant height (345cm) was obtained when Nitrogen and Phosphorus rate was 40 and 30 kg ha^{-1} respectively. While, the other treatments T3, T4, T6 and T7 showed statistical parity. In the same way T2, T3 and T4 are also statistically at par with each other. Lowest plant height (190.80cm) was observed when no fertilizer dose was applied. Table 5 shows the positive correlation between plant height and total yield per hectare which is highly significant. Therefore the plants showing more plant height also shows higher yield. Similar results were also observed by the Work of Glass (2003) who reviewed the effect of N in physical and morphological characters of plants. Increase in level of nitrogen increase the chlorophyll content which increase the photosynthetic activity of plant and increases biomass. Stunted plant height was observed in the presence of insufficient supply of nitrogen (Pashazadeh and Başalma, 2012) which effects the functioning of chloroplast (Blumenthal et al., 2008).

Maximum number of branches is a crucial factor in castor seed yield. More the number of branches will leads towards more number of capsule/plant; ultimately increase in yield (Vanaja et al., 2008). In this study it was found that NPK significantly affected number of branches per plant Fig 1(b). From the data given in Table 4, it is shown that maximum number of branches per plant was recorded from T6 and it showed statistical parity with T7. Lowest number of branches was obtained when no fertilizer were applied. Correlation studies shows that Number of branches per plant are highly significant total yield (Table 5). The plots showing more number of branches per plant are also showing yield increase significantly. Similar results were also found when crop was provided with increased level of N and P (Srinivas et al., 2005; Vanaja et al., 2008; Jamil et al., 2017)

Number of capsules per plant is a major yield contributing trait in castor (Lakshmamma et al., 2005). Perusal of data showed that statistically maximum number of capsule per plant (155.60) was obtained from T6, followed by T5, T7 (Table 4) Figure 1(c) Lowest number of capsule per plant (80.10) was noted in the absence of mineral nutrition. In case of mineral nutrition, increase in nitrogen level increases the number of capsules per cluster (Jamil et al., 2017). Correlation between number of capsules per plant and total yield is positive and highly significant (Table 5). Positive

Table 4: *Mean performance of yield and yield related components in Castor at different fertilizer doses.*

	Plant Height (cm)	Branches per Plant	Capsule per Plant	Seeds per Capsule	Yield per Hectare (kg)
T1	190.80 d	3.1000 e	80.10 d	2.0333 c	1185.6 e
T2	250.40 c	4.4000 cde	110.70 c	2.5333 abc	1482.4 d
T3	280.07 bc	4.9000 bcd	119.30 bc	2.4000 bc	1778.4 c
T4	275.20 bc	3.2000 de	130.40 bc	2.7000 abc	2048.3 bc
T5	345.00 a	5.9000 bc	136.60 ab	2.9000 abc	2173.6 ab
T6	290.57 b	7.8000 a	155.60 a	3.5000 a	2371.2 a
T7	288.40 b	6.5000 ab	135.40 ab	3.1000 ab	2272.4 ab

Note: *Any two means not sharing a letter in common differs significantly at P ≤ 0.05.*

Table 5: *Correlation (r) coefficients among yield contributing traits of Castor.*

	Plant Height	Branches per Plant	Capsule per Plant	Seeds per Capsule	Yield per Hectare
Plant Height	1.000				
Branches per Plant	0.5295*	1.000			
Capsule per Plant	0.6753**	0.6720**	1.000		
Seeds per Capsule	0.4846*	0.4918*	0.4886*	1.000	
Yield per Hectare	0.7346**	0.6328**	0.8613**	0.6593**	1.000

*: *Correlation is significant at P ≤ 0.05 level;* **: *Correlation is highly significant at P ≤ 0.01 level.*

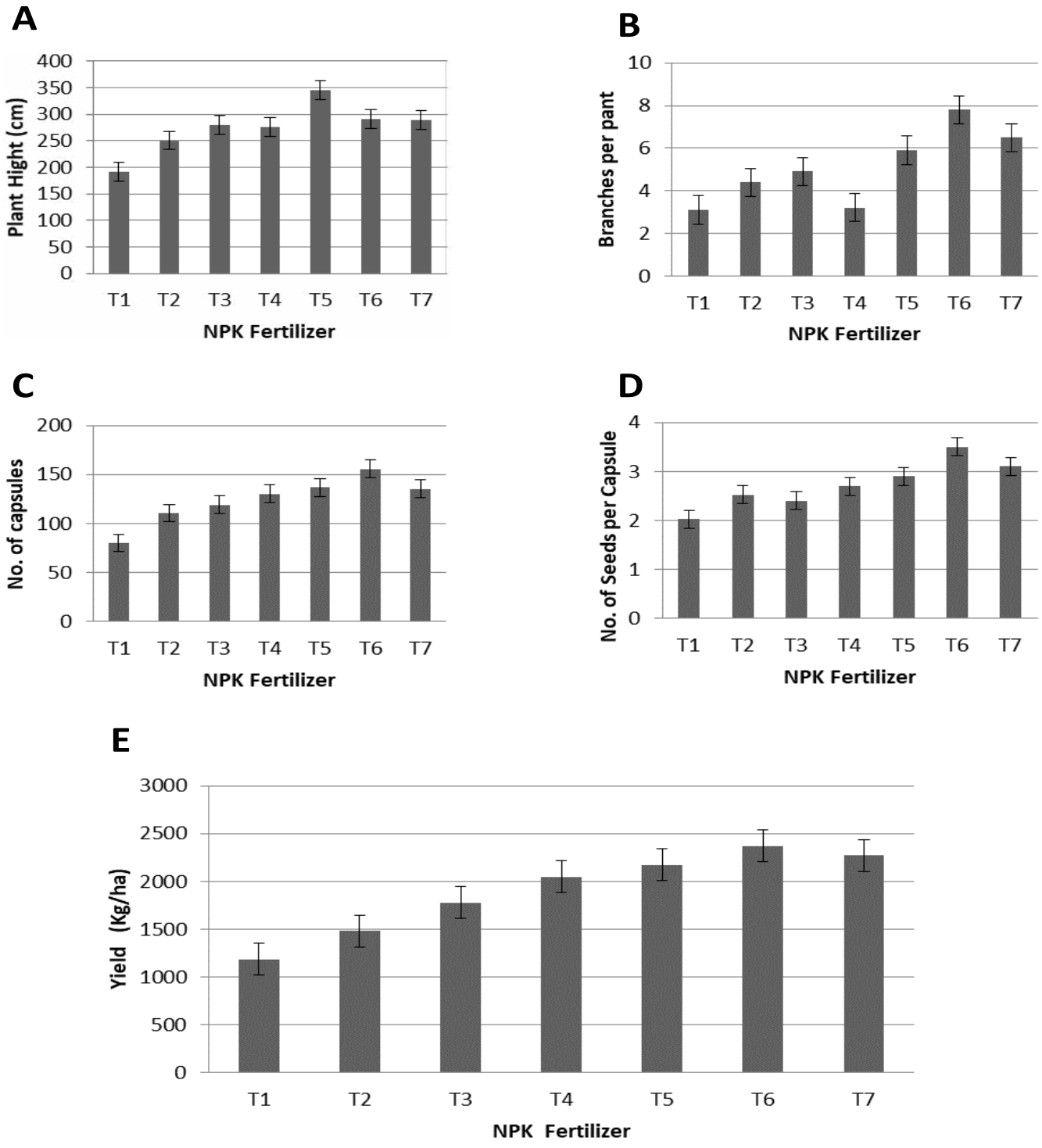

Figure 1: *Effect of different doses of mineral fertilizers at average (A) Plant Height, (B) Branches per Plant, (C) Number of Capsules per Plant, (D) Number of Seeds per Capsule and (E) Yield per Hectare.*

correlation between number of capsules and total yield indicates the increase is number of capsules also increase the total yield (Table 4). Our results that increase in capsule per plant with increase of nitrogen and phosphorus is in-line with (Chatzakis et al., 2011; Pashazadeh and Başalma, 2012).

The data given in Table 4 showed that maximum number of seeds per capsule (3.5) was obtained when maximum amount of nitrogen and phosphorus (@40:30 kg ha^{-1} respectively) was applied, but it showed statistical similarity with T2, T4, T5 and T7. Lowest number of seeds per capsule (2.03) was recorded in the absence of any nutritional amendment in soil. Graphical representation in Figure 1(d) shows the average number of seeds per capsule in each treatment. Number of seeds per capsule has highly significant positive correlation with total yield. Our results are similar to the findings of Koutroubas et al. (2000) and Sowmya et al., (2015).

Seed yield is the most important character which is taken under consideration for improvement in crop production. Data presented in Table 4 shows that increasing rate of fertilizers significantly affected the crop yield. Statistically maximum yield (2371.2 kg ha^{-1}) was observed when NPK was applied at the rate of 40:30:15 kg ha^{-1} respectively. It also showed statistical parity with T7 and T5. Lowest seed yield (1185.6 Kg ha^{-1}) was recorded when no fertilizer dose was applied in control block. Graphical representation of the data is shown in Figure 1(e). All the associated traits like plant height, branches per plant, number of capsules per plant and number of seeds per capsule has highly significant positive correlation with yield. These traits are important for further selection of specific treatments or crop variety to enhance total yield of this crop. Increase in seed yield due to addition of mineral nutrition was also reported by Neto et al. (2009), Pacheco et al. (2008) and Hadvani et al. (2010) in castor.

Conclusions

The evaluation of variety DS-30 under arid climatic conditions showed that different doses of mineral nutrients significantly effects plant height, branches per plant, number of capsules per plant, number of seeds per capsule and total yield. It is also found that the amount of Nitrogen, Phosphorus and Potassium at the rate of 40:30:15 kg ha^{-1} respectively is the most suitable to obtain maximum yield in the said local environmental condition.

Author's Contributions

MM Yousaf conceived the idea and done over all supervision of the experiment. M Hussain, MJ Shah and B Ahmad planned and executed the experiment in field. MM Raza helped in data collection and analysis. M Zeshan collected the data, done statistical analysis and wrote the manuscript. Kazim Ali helped in data analysis and writing the manuscript.

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