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Effect of different sources of nutrients, organic manures and biofertilizers on growth, yield, and nutrient uptake of kharif onion (*Allium cepa* L.)

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Abstract

An investigation to study the effect of different sources of nutrients on growth, yield, nutrient content and nutrient uptake of *kharif* onion was carried out at BHU-Krishi Vigyan Kendra, Institute of Agricultural Sciences, BHU (Rajiv Gandhi South Campus), Barkachha, Mirzapur during *kharif* seasons of 2013-14 and 2014-15. There were 6 treatments and five replications involving two inorganic levels and four organic levels over control (NPK @100:50:0 kg ha^{-1}). Results revealed that significantly maximum plant height, number of leaves, bulb diameter and nutrient uptake is recorded with the application of N (50% through vermicompost-VC + 50% through Urea) + PSB + *Azotobacter* (T_6) followed by the application Control (T_1) in both the seasons under investigation. The results also indicated that the highest bulb weight, and bulb yield in both *kharif* seasons was also obtained with the same treatment (T_6) as compared to other treatments.

Keywords: Organic manure, vermicompost, nutrient content, biofertilizers, growth, yield, onion

Introduction

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops cultivated extensively in India. Onion is liked for its flavour and pungency which is due to the presence of a volatile oil known as '*allyl propyl disulphide*'- an organic compound rich in sulphur. Onion bulbs are rich in minerals like calcium (23 mg/100g) andiron (0.21 mg/100g). Apart from these, onion bulbs contain phosphorus (29mg/100g), carbohydrates (9.34 g/100g), protein (1.1 g/100g), dietary fiber (1.7 g/100g) vitamin C (7.4 mg/100g), folic acid (19 µg/100g) and vitamin B_6 (0.12 mg/100g) [https://ndb.nal.usda.gov/ndb/search/list]. It also contains protein and vitamin C and is used in several ways including fresh, frozen and also as dehydrated bulbs. Dehydrated onion is in great demand which reduces transport cost and storage losses. Onion, apart from all the above, has got good medicinal value also. It contains several anticancer agents which have shown to prevent cancer in animals. A sure cure for sunstroke, it has been used in traditional Indian medicines at home.

Onion is one of the most important commercial vegetable crops grown in India and being exported to other countries. However, the productivity of onion in India is quite low as compared to world's productivity. India is the second largest producer of onion in the world, next to China, accounting for 22.18% of the world area and 18.78% of the world production. In India, onion is being grown in an area of 0.83 mha with production of 13.37 mt and thus, the productivity being16.30 t/ha which is quite low in comparison to several other countries. Among Indian states, Maharashtra is the leading onion growing state and other important states include Karnataka, Gujarat, Bihar, Madhya Pradesh, Andhra Pradesh, Rajasthan, Haryana, Uttar Pradesh and Tamil Nadu. Successful onion production depends on the selection of varieties that are adapted to different conditions imposed by specific environment. *Kharif* onion is an off-season cultivation of the crop for which standardization of varieties is of immense utility (Mohanty and Prusti, 2001). However, very little information is available on cultivation of an important crop like onions in *kharif* seasons in India. More so, nutrition aspects of such a crop remain largely untouched.

Chemical fertilizers are one of the most important inputs for increasing onion production. But the continuous and liberal use of inorganic fertilizers alone affects soil health and thus results in lower or stagnated yields with poor quality produce. Organic farming reduces the cost of production by utilization of organic wastes as fertilizers which are said to be potential source for pollution unless

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they are used in productive and efficient way (Banjare *et al.,* 2015). There is a good scope of increasing onion yield and quality for which nutrient management is one of the most important considerations under organic production system (Patel *et al*., 2005). The present investigation was undertaken to study effects of different sources of plant nutrients, especially organic manures and bio-fertilizers on certain crop performance parameters including growth yield and nutrient uptake of *kharif* onion.

Materials and Methods

The experiment was conducted during *kharif* 2013-14 and 2014-15 at BHU-Krishi Vigyan Kendra, Institute of Agricultural Sciences, Banaras Hindu University (Rajiv Gandhi South Campus) Barkachha, Mirzapur. Soil samples were collected from surface soil (0 to 20 cm depth) with wooden tools to avoid any contamination. Composite soil samples were air-dried, ground and passed through 2 mm sieve for chemical analysis. Soil pH and electrical conductivity (EC) were determined by glass electrode and direct reading conductivity meter using 1:2 soil water suspensions (Jackson 1973). The soil samples were analyzed for available nitrogen (Subbiah and Asija, 1956), available phosphorus (Bray and Kurtz, 1954), available potassium in neutral ammonium acetate extractable method by flame photometer (Jackson 1973) and organic carbon (Walkley and Black 1934). The important physical properties of experimental soil sand, silt, clay, bulk density and particle density analyzed as per the standard methods. The physical properties experimental soil was sand (48%), Silt (34%) clay (18%) bulk density (1.366 mg m^{-3}), particle density (2.217 mg m^{-3}) in red laterite soil on slightly acidic in nature respectively (Table 1). The experiment was laid out in randomized block design (RBD) with Six treatments including two levels of inorganic nutrients, *viz.* T_1 and T_2 (T_1 or the control being NPK @100:50:0 kg ha^{-1} through DAP, Urea and muriate of potash, respectively and T_2 being 100% recommended doses of fertilizers-RDF with NPK @ 125 : 50 : 125 kg ha^{-1} through DAP, Urea and muriate of potash, respectively); two levels of nutrients integrated with organic forms, *viz.* T_3 (50% N through FYM+50% N through Urea) and T_4 (50% N through vermicompost + 50% N through Urea). Remaining two levels of nutrients were selected in integration with organic and biological forms, *viz.* T_5 (50% N through FYM + 50% N through Urea + PSB + *Azotobacter*) and T_6 (50% N through vermicompost +50% N through Urea + PSB + *Azotobacter*) with five replications of every treatment. The dosage and method of application of biofertilizers is detailed in the end of this paragraph. The plot size was 2.5 m×3.0 m and the spacing was kept 35 cm × 15 cm between rows and plants, respectively. The test variety was Agrifound dark red (developed by National Horticultural Research and Development Foundation-NHRDF) recommended for cultivation in *kharif* season. Organic manures were spread in the experimental beds uniformly before transplanting of the seedling. As regards dosage and method of application of biofertilizers, a carrier based (Charcoal: Soil as 3:1) formulation of PSB and *Azotobacter* was applied @ 250g per ha for each biofertilizer. The biofertilizer culture formulation was suspended in sufficient water to prepare thick slurry and roots of freshly uprooted onion seedlings were dipped in such slurry for 10-20 minutes and dried in shade before transplanting (Balemi *et al*. 2007). Plant height was measured using a meter rule from the base to the apex of the plants' leaves on 20 randomly selected onion plants. The average was then worked out. The leaves of 20 randomly selected onion plants were manually counted to arrive at the numbers of leaves per plant (Bashir *et al*., 2015). Yield attributes were calculated using standard methods. At harvest, Onions per plot were manually graded using specially constructed wooden sizer to arrive at the mean bulb diameter of the onions. In each plot, all Onion bulbs were weighed and average taken to arrive at the mean bulb weight total yield (Bashir *et al*., 2015). For calculating economics, average yield of the treatment, prevailing market rates of the produce and cost of cultivation of the crop were used. The critical difference was calculated to test the significance of differences among the treatments.

Table 1: Treatment details and physical properties of experimental soil on *kharif* Onion during (2013-14 and 2014-15)

Symbols	Treatments	Physical properties	Characteristics
T_1	Control (NPK @ 100: 50: 0 kg ha^{-1})	Soil type	Red Laterite
T_2	100% Recommended doses of fertilizers-RDF (NPK @ 125 : 50 : 125 kg ha^{-1})	Sand	48 %
T_3	50% N of the RDF through FYM + remaining 50% N through Urea	Silt	34 %
T_4	50% N of the RDF through vermicompost (VC) + remaining 50% N through Urea	Clay	18 %
T_5	50% N of the RDF through FYM + remaining 50% N through Urea + PSB + *Azotobacter*	Bulk density	1.366 Mg m^{-3}
T_6	50% N of the RDF through vermicompost (VC) + remaining 50% N through Urea + PSB + *Azotobacter*	Particle density	2.217 Mg m^{-3}

Results and Discussion

The data (Table-2a) indicated that the plant height increased significantly in all the treatments as compared to control (T_1). Maximum plant height was recorded with the application of 50% N through vermicompost and 50% N through Urea + PSB + *Azotobacter* (T_6) on different intervals after transplanting of the crop, *viz.* 30 days, 60 days and at the time of harvesting of crop). Abdissa *et al*. (2011) has conducted studies on the influence of N and P fertilization on the plant growth, bulb yield and quality of onion and concluded that better N fertilization in onion had positive effects on the growth parameters of the plant including plant height, leaf length and number of leaves per plant. The data reveal that although plant height of *kharif* onion as a growth parameter, recorded significant increase as compared to control in every stage of crop tested, yet organic sources of plant nutrition had much positive effect on this parameter elucidating the role of organic manure in cultivation of *kharif* onion. Several scientists are of the opinion that vermicompost, when used as manure, enhances production of several plant growth promoters and enzymes, and also promotes beneficial bacteria and mycorrhizae (Gupta 2005, Bashir *et al*., 2015). Addition of manures to the soil not only improves soil structure, facilitating roots to go deeper in search of nutrients but also increase soil porosity making plenty of air and water available for enhanced microbial activity in the soil; thus, the availability of higher quantity of nutrients, improvement in the physical properties of soil and increased activity of microbes with higher levels of organics might have helped in increasing plant height in different stages of crop. Similarly, significantly increased plant height, number of leaves per plant in onion crop with application of vermicompost and FYM has also been reported by Reddy and Reddy (2005). Biofertilizer inoculation and PSB helps the plants to attain better vegetative growth and increases yield by 10-30 percent (Mohandas 1999).

The data on number of leaves (Table 2b) indicates that this growth parameter of *kharif* onion significantly increased as compare to control (T_1). Again, as with the previous growth parameter (plant height), this parameter also exhibited more or less similar trend with highest number of leaves in the treatment with the application of 50% N through vermicompost and 50% N through Urea + PSB + *Azotobacter* (T_6) on different intervals after transplanting of the crop, *viz.* 30 days, 60 days and at the time of harvesting of crop.

The results clearly indicate that the use of different sources of nutrients organic manure and bio-fertilizer improved all the yield attributes, *viz.* the bulb diameter, bulb weight and yield of *kharif* onion (Table-3). Significant increase in values representing bulb diameter, bulb weight and yield of onion were recorded under all the treatments over the control (T_1) during the test season (*kharif*) of both the years. The bulb diameter (5.55 to 7.87 and 5.54 to 7.99 cm during 2013-14 and 2014-15, respectively; Table-3), bulb weight (66.0 to 177.2 and 65.2 to 179.6 g during 2013-14 and 2014-15, respectively; Table-3) and yield of onion (300 to 415 and 295 to 408 q/ha, during 2013-14 and 2014-15, respectively; Table-3) increased with increasing levels of applied organics manures and bio-fertilizers and it was observed to be highest with application of 50% N through vermicompost and 50% N through Urea + PSB + *Azotobacter* (T_6) as compared to the control (T_1) at the time of harvesting of the crop during both the years of experimentation. Further, the yields wear significantly superior with the conjoint use of organic, inorganic and bio-fertilizers over the sole use of organic fertilizers.

Table 2a: Effect of different treatments on sources of nutrients growth attribute (plant height) of *kharif* Onion

Treatment	Growth attributes (Plant height in cm)					
	30Days		60 Days		At Harvesting	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T1	17.16	17.13	26.26	26.28	35.89	35.90
T2	22.18	22.27	30.70	30.79	40.71	40.73
T3	24.31	24.75	33.50	33.64	43.42	43.44
T4	26.24	26.64	36.53	36.70	46.44	46.47
T5	27.66	28.13	40.03	40.20	49.80	49.89
T6	29.89	30.07	40.60	40.78	51.87	51.92
SEm±	0.012	0.025	0.006	0.012	0.005	0.004
CD (P = 0.05)	0.036	0.074	0.018	0.036	0.015	0.011

Table 2b: Effect of different treatments on sources of nutrients growth attribute (number of leaves) of *kharif* Onion

Treatment	Growth attributes (Number of leaves) (2013-14 and 2014-15)					
	30 Days		60 Days		At Harvesting	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T1	3.60	3.40	7.60	7.40	9.00	8.80
T2	3.20	3.60	7.60	7.00	8.80	9.20
T3	3.40	3.00	8.00	7.60	9.00	9.20
T4	3.80	4.00	8.20	7.80	9.20	9.40
T5	3.80	3.80	8.00	8.40	9.00	9.60
T6	4.20	4.40	8.60	8.80	9.60	10.00
SEm±	1.26	1.41	1.21	1.82	1.66	1.47
CD (P = 0.05)	0.33	0.41	0.47	0.36	0.42	0.39

Table 3: Effect of different treatments on sources of nutrients yield attributes of *kharif* Onion

Symbols	Yield attributes					
	Bulb Diameter (cm)		Bulb Weight (g)		Yield (Q/ha)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T1	5.55	5.54)	66.0	65.2	300	295
T2	6.23	6.64	82.2	90.6	330	320
T3	7.12	7.24	127.4	130.4	365	360
T4	7.30	7.46	140.2	145.2	395	389
T5	7.49	7.74	154.2	165.4	410	402
T6	7.87	7.99	177.2	179.6	415	408
SEm±	0.043	0.053	0.587	0.536	1.264	0.822
CD (P = 0.05)	0.126	0.153	1.732	1.577	3.729	2.426

The highest yield of onion wasrecorded under T_6 and lowest yield was recorded in the control (T_1) during both the years. The increase is yield was much higher when FYM was replaced with vermicompost in equal amounts. The increased yield attributes with combined application of diverse sources of nutrients might be due to rapid availability and utilization of nutrients, by creation of favourable soil environment for various metabolic plant processes in favour of enhanced carbohydrate production, which eventually get distributed to reproductive parts ultimately contributing to increase in yield. However, there seem to be more than one process involved and the increase in yield parameters may also be due to increased rate of release of macro and micronutrients during the course of microbial decomposition (Choudhary *et al*. 2003). One other probable reason with much validity may be that better root proliferation; more uptakes of nutrient, higher number of leaves, and more photosynthesis cumulatively enhance food accumulation which ultimately increases size and weight of bulb. The increase in yield due to integrated nitrogen levels has also been reported by several workers Saxena *et al*. (2008), Sharma *et al*. (2009), Singh *et al*. (2010), Bagali *et al*. (2012) and Singh *et al.* (2013).

Application of the use of different sources of nutrients including organic manures and biofertilizers significantly increased the nutrient content of *kharif* onion (Table 4) was recorded under all the treatments over control during the both years respectively. When vermicompost, PSB and *Azotobacter* were applied in equal amounts, the content of major nutrient, *viz.* N, P and K increased significantly in the case of vermicompost as compared to the FYM during both the years of experimentation. However highest nutrient content in onion bulbs was recorded in case of 50% N through vermicompost and 50% N through Urea + PSB + *Azotobacter*. The main reason for the higher nutrient content of N, P and K in

Table 4: Effect of different treatments on sources of nutrients, Organic manure and bio-fertilizers on nutrient content (%) of Onion Bulb during 2013-14 and 2014-15

Treatments	Nutrient Content (%)					
	Nitrogen		Phosphorus		Potassium	
	2014	2015	2014	2015	2014	2015
T1	1.20	1.11	0.22	0.18	1.03	0.83
T2	1.40	1.36	0.30	0.28	1.15	1.11
T3	1.49	1.42	0.37	0.32	1.25	1.15
T4	1.58	1.50	0.42	0.38	1.45	1.31
T5	1.68	1.62	0.46	0.41	1.61	1.42
T6	1.70	1.65	0.48	0.44	1.68	1.58
SEm±	0.006	0.004	0.008	0.005	0.024	0.043
CD (P = 0.05)	0.017	0.013	0.003	0.016	0.008	0.015

onion bulbs due to the application of vermicompost may be attributed to better supply of nutrients through this manure since assimilation of the compost by earthworms makes these nutrients readily available to the plants. Similar findings have also been reported by Singh *et al.* (2014).

Nutrient uptake of onion crop was also found to be associated and dependent upon the quality and quantity of the nutrients supplied. The data obtained establish that all the treatments showed significant increase in nutrient uptake when diverse sources of nutrients including organic manure and biofertilizer were integrated with chemical fertilizers were supplied as compare to control (Table 5). When compared in equal amounts for nutrient uptake vermicompost showed significantly better uptake of nutrients than not only farmyard manure but it was far better than chemical fertilizers supplied for the major three plant nutrients, *viz.* N, P and K. Application of vermicompost and bio-fertilizer in integration with chemical fertilizer (T_6) increased uptake of N, P and K to maximum extent, being 70.5, 19.9 and 69.7 kg ha^{-1}, respectively during

Table 5: Effect of different treatments on sources of nutrients, organic manure and bio-fertilizers on nutrient uptake by *kharif* Onion

Treatments	Nutrient uptake (Kg ha^{-1})					
	N		P		K	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T1	36.0	29.5	6.6	5.3	30.0	23.6
T2	46.2	43.5	9.9	8.9	37.9	35.2
T3	54.3	51.1	13.5	11.5	45.6	41.4
T4	62.4	58.3	18.5	18.7	57.2	50.5
T5	68.8	65.1	18.8	16.4	65.6	57.0
T6	70.5	69.3	19.9	17.9	69.7	64.4
SEm±	0.359	0.260	0.288	0.341	0.239	0.299
CD (P = 0.05)	1.509	0.767	0.967	0.115	0.081	0.076

the first year of experiment (2013-14) and 69.3, 17.9 and 64.4 kg ha^{-1}, respectively during the second year (2014-15) of investigation. Similar results have also been reported by Singh *et al*. (2014). Nutrient uptake with application of vermicompost seems to be increased due to the fact that earthworm castings contain five to eleven times more nitrogen, phosphorus and potassium as does the normal soil. Similar effects of organic sources as well as integration of different sources of nutrients on nutrient uptake and soil fertility have also been reported by various workers (Tiwari *et al.* 2002 and Sutaria *et al*. 2010).

Organic carbon content in the soil was found to be the maximum with treatment having integration of organic manure (vermicompost) and biofertilizers (T_6) among all the treatments during the both the years(4.1 and 6.9 kg ha^{-1}, respectively). However, all the treatments were recorded to be significantly superior to the control in terms of nutrient availability after harvest. The increase in organic carbon content corresponding to the application of organic manures seems to be owing to the fact that these manures activate many species of soil organisms which release phytohormones that may stimulate the plant growth and absorption of nutrients and such organisms need nitrogen for their multiplication (Ouda and Mahadeen 2008).

The data reveal the fact that the treatment comprising application of 50% N through vermicompost and 50% N through Urea + PSB + *Azotobacter* (T_6) maintained highest available nitrogen content (180.57 and 304.44 kg ha^{-1}) during both the years of experimentation and was significantly superior to the control (T_1) as observed at the completion of experiment. However, the available nitrogen content was found to increase significantly in all the treatments over control (T_1) at the completion of the experiment as is evident from the data presented in Table-6. Higher growth parameters of onion crop recorded with application of diverse sources of nutrients supplied through incorporation of organic manures and biofertilizers might be due to ample supply of nitrogen which encourages the vegetative growth and it also might have led to enhancement in carbohydrate synthesis. Also, nitrogen being an important constituent of chlorophyll, amino acids, proteins and nucleic acids promotes the cell multiplication and cell elongation, which ultimately accelerate the vegetative growth of the plant. Also, application of vermicompost, which contains all the essential plant nutrients in appropriate proportions and provides the soil with more stable humus, has been found to augment plant performance. These findings are in agreement with those of Devi and Limi Ado (2005) and Mozumder *et al*. (2007)

Available phosphorus content was recorded to increase to significant levels over control in all the treatments in comparison to the control (Table 6). Application of 50% N through vermicompost and 50% N through Urea + PSB + *Azotobacter* (T_6) recorded maximum increase (10.2 and 11.5 kg ha^{-1}, during 2013-14 and 2014-15, respectively). Increase in available phosphorus content of the soil due to incorporation of organic manure may be attributed to the direct addition of P as well as solubilization of P through phosphorus solubilizing bacteria (PSB) which has cumulatively resulted in the significant increase in the yield of onion crop. These findings corroborate the results obtained by Navale *et al*. (2008), Mehta *et al*. (1995) and Subbian (1994).

Available potassium was found to be maximum (144 and 149 kg ha^{-1}) in the T_6 as compared to the control (T_1) during both the years of experimentation, respectively (Table-6). The beneficial effect of vermicompost or FYM on available potassium status may be prescribed due to the addition potassium directly in the soil. Potassium is an activator of enzymes involved in protein and carbohydrate metabolism and plays an important role in the translocation of photosynthates

Table 6: Effect on physico-chemical properties of experimental soil under different treatments as sources of nutrients after harvesting

Symbols	pH		Organic Carbon (%)		kg ha^{-1}					
					N		P		K	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T1	6.5	6.5	3.5	3.4	154.57	150.39	10.2	9.2	145	143
T2	6.6	6.6	4.1	4.1	180.65	180.76	9.9	9.6	141	140
T3	7.2	7.2	3.4	5.3	150.37	233.56	10.1	9.9	140	140
T4	7.3	7.3	3.5	6.1	151.58	269.89	10.2	10.1	145	146
T5	7.0	7.0	4.0	6.5	176.28	264.98	9.5	10.8	142	147
T6	7.1	7.1	4.1	6.9	180.57	304.44	10.2	11.5	144	149
SEm±	0.082	0.081	0.066	0.061	0.457	3.955	0.067	0.089	0.487	0.388
CD (P=0.05)	0.243	0.240	0.196	0.181	1.350	11.668	0.197	0.262	1.437	1.145

from leaves to bulbs in onion. The added potassium might have resulted in increased synthesis and translocation of photosynthates, which were further utilized in building up of new cells leading to better vigour and more number of leaves per plant. Several workers have also reported increased plant height and number of leaves per plant (Singh *et al*. 1997, Varu *et al*. 1997) with increased levels of nitrogen, phosphorus and potassium.

सारांश

कृषि विज्ञान केन्द्र, कृषि विज्ञान संस्थान, काशी हिन्दू विश्वविद्यालय (राजीव गाँधी दक्षिणी परिसर) बरकछा, मीरजापुर पर विभिन्न स्रोतों से प्राप्त पौध–पोषक तत्त्वों का खरीफ प्याज की फसल के पौध वृद्धि, उपज, पोषक तत्वों की मात्रा और पोषक तत्वों के प्रदर्शन पर प्रभाव का एक अध्ययन किया गया। इस अनुसन्धान कार्य को यादृच्छिक प्रखण्ड परिकल्पना अभिन्यास के अंतर्गत संचालित किया गया। इस अभिन्यास में 6 उपचारों में प्रत्येक के 5 प्रतिरूप रखे गये थे। उपचारों में दो कार्बनिक स्तर तथा शेष चार अकार्बनिक स्तर के रखे गये थे। नियन्त्रण के अंतर्गत सामान्य कृषक व्यवहार (नत्रजनःफॉस्फोरसःपोटाश क्रमशः 100:50:0 किग्रा प्रति हेक्टेयर) को रखा गया था। अनुसन्धान के परिणामों से स्पष्ट हुआ कि दोनों वर्षों के खरीफ मौसम में उपचार संख्या 6 (जिसमें नत्रजन की आधी मात्रा कार्बनिक रूप से केंचुआ खाद द्वारा तथा शेष आधी मात्रा को अकार्बनिक उर्वरक यूरिया के माध्यम से दिया गया तथा इसके साथ जैव–उर्वरकों में पीएसबी और अजोटोबैक्टर को संयोजित किया गया था) से फसल के अध्ययन गुणों यथा पौधे की लम्बाई, पत्तियों की संख्या, कंद का व्यास और पोषक तत्वों के प्रदर्शन पर सर्वाधिक उत्तम प्रभाव पाया गया। इसके अलावा फसल के आर्थिक प्राचलों यथा कंद की उपज एवं उनके भार में भी उपचार संख्या 6 के अंतर्गत सर्वाधिक उल्लेखनीय वृद्धि हुई।

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