



CULTIVATION OF LATE-SEASON POTATOES AFTER GREEN MANURE CROPS

Usmanov Nosir Nurmanovich, Doctor of Agricultural Sciences (DSc), Professor, Postgraduate Education Department, Military Aviation Institute, University of Military Security and Defense of the Republic of Uzbekistan
usmon.nosir@inbox.ru

Article history:	Abstract:
Received: 26 th September 2025 Accepted: 24 th October 2025	<p>This study evaluates the growth, biomass, and seed productivity of autumn-sown green manure crops on saline-irrigated soils in Kashkadarya. Species tested include rapeseed, oilseed radish, peas, grey mustard, and their mixtures.</p> <p>Key parameters measured were plant height (75.8–312.2 cm), density (108.4–468.7 plants/m²), biomass (26.4–34.3 t/ha), and seed yield: rapeseed (20.2–23.5 c/ha), grey mustard (15.6–18.4 c/ha), oilseed radish (19.3–21.7 c/ha), and peas (23.8–25.4 c/ha). Use of green manure crops improved soil bulk density (1.24–1.30 g/cm³), water permeability (70.3–122.8 m³/ha), and fertility indicators: humus (1.16–1.20%), nitrate nitrogen (11.58–31.48 mg/kg), phosphorus (29.72–41.3 mg/kg), and potassium (301.5–312.0 mg/kg).</p> <p>Weed infestation decreased by 7.2–13.8%, while earthworm burrows increased 3.2–5.9 times. Late-season potato varieties showed longer vegetation (3–10 days), taller plants (65.3–73.4 cm), more branches (3.7–4.6), and larger leaf area (56.7–70.9 thousand cm²/m²). Tubers yield ranged 31.2–37.9 t/ha, commercial yield 30.1–36.5 t/ha, with a multiplication coefficient of 6.2–8.4.</p>

Keywords: Green manure crops, planting period, growth and development, growing season, biomass, late harvest potato varieties, leaf area, commercial and seed yield, growth coefficient, seed quality.

INTRODUCTION In 2023-2025, global potato production reached 383.1 million tons, reflecting a 2.6% increase compared to the previous year. This growth was achieved through a 1.7% increase in yield and a 0.9% expansion in cultivated area. In 2023-2025, the global area under potato cultivation was approximately 16.8 million hectares, which represents a 7.2% decrease compared to 18.1 million hectares in 2023. At the same time, due to the rise in global yields, total potato production increased from 376 million tons in 2023 to 383 million tons in 2023, with an average yield of 22.8 tons per hectare. The leading potato producers include China (97.239 million tons), India (55.137 million tons), Ukraine (20.888 million tons), Russia (19.495 million tons), the USA (19.375 million tons), Bangladesh (10.743 million tons), Germany (9.959 million tons), France (8.902 million tons), Poland (8.2 million tons), and the Netherlands (7.3 million tons). Eleven countries worldwide – Kuwait, the Netherlands, Belgium, New Zealand, the UK, Denmark, the USA, Germany, Ireland, and Switzerland – had potato yields of 40.9 to 51.4 tons per hectare or higher. The lowest potato yields (tons per hectare) were recorded in Eritrea (0.66 t/ha), Cameroon (3.0 t/ha), Nigeria (3.77 t/ha), Botswana (3.89 t/ha), the Congo (4.6 t/ha), and Bolivia (5.59 t/ha) ¹.

The rapid growth of the global population, the increasing demand for food products, and the drastic changes in climate have made it crucial to ensure food security, improve and preserve soil fertility, fight against weeds and pests, and enhance the productivity and quality of agricultural crops. The use of biological methods in crop rotation systems, such as green manure crops (main crops, cover crops, secondary, intercropping, and fodder crops), is receiving significant attention for achieving these goals. Moreover, identifying suitable green manure crops for different soil-climate conditions, achieving high biomass and seed yields, developing and improving agro-technologies for their use as green fertilizers, and regularly enhancing these practices have become a necessity.

In our country, the effects of green manure crops on the fertility of cotton, cereal, and other crop soils, as well as on plant growth, development, disease resistance, and yield, have been studied [1, 2, 3, 4], while in potato cultivation, [5, 6, 7, 8, 11, 12, 13, 14.] research has been conducted.

Currently, in our country, including in the potato-growing region of Kashkadarya, the amount of potatoes produced does not meet the needs of the population. Taking this into account, the government has tasked scientists with developing research and organizing seed production to create high-yielding, disease-resistant, high-tasting, and long-

¹ https://potatoes.news/record-global-potato-crop-analysis-and-trends/?utm_source=chatgpt.com

shelf-life potato varieties suited to modern technology and local conditions. Along with traditional selection methods, an accelerated technological approach has been implemented to produce virus-free seed potatoes, ensuring full supply to the population and the possibility of export. In the field of agricultural crops such as cotton, winter wheat, vegetable crops, and potatoes, green manure crops play a critical role in maintaining, improving, and preserving natural soil fertility through short crop rotation systems [1,2,3,4,15,16,17,18.].

In the development of potato cultivation, the cultivation of autumn green manure crops provides, first, a way to enrich the soil with nutrients, thereby maintaining and enhancing its natural fertility; second, green manure crops possess allelopathic properties that positively affect the soil's mechanical, water-physical, agro-physical, agro-chemical, and microbiological properties. Therefore, conducting scientific research on the use of autumn green manure crop biomass as green fertilizer for the cultivation of late-season (late harvest) potato varieties in typical irrigated saline soils is highly relevant today.

RESEARCH OBJECTIVE: The aim of the research is to study the biomass yield of autumn green manure crops, the planting periods and seed yield of green manure crops, the effect of green manure crop mass on the growth, development, yield formation, productivity, seed quality, and soil fertility of late-season (late harvest) potato varieties (planted in typical irrigated saline soils of Kashkadarya region), and to identify prospective green manure crops and potato varieties that ensure stable, high-quality, healthy, and pure yields. The objective also includes improving the cultivation technology based on these findings.

The research object includes typical irrigated saline soils of Kashkadarya region, autumn rapeseed variety "Yugur 1", oilseed radish variety "Raduga", grey mustard variety "Yubileynaya", pea (green pea) variety "Osiyo 2001", as well as potato varieties Bahro-30, Bardoshli-3, Sante, Saviola, Arizona and Red Scarlet.

RESEARCH LOCATION, CONDITIONS, AND METHOD

The field experiment was conducted from 2023 to 2025 in the typical irrigated saline soils of Kashkadarya region, specifically in the "Hisor" farmers' union of the Yakkabag district. The soils in this area are traditionally irrigated, with groundwater located at a depth of 8-10 meters. The mechanical composition of the soil is sandy loam. In the experimental field, the humus content in the plow layer (0-30 cm) ranged from 1.8% to 0.98%, soil bulk density was 1.27-1.30 g/cm³, and relative density was 2.58-2.65 g/cm³. The total nitrogen content was 0.095-0.094%, total phosphorus 0.144-0.163%, potassium 2.6-2.9%, nitrate nitrogen content 5.14-6.51 mg/kg, mobile phosphorus 15-25 mg/kg, and exchangeable potassium 287-307 mg/kg. The data indicated that the content of these nutrients was slightly lower in the soil's plow layer.

The area of the experimental plots was 372 m² for green manure crops, 14 m² for each variety, and there were 3 replications. The green manure crops were planted between October 10-12. The planting rates were as follows:

- Rapeseed – 8.0 kg/ha
- Peas (green peas) – 30 kg/ha
- Grey mustard (*Sinapis alba*) – 6.0 kg/ha
- Oilseed radish – 16.0 kg/ha

For the mixed treatments, the planting rates were halved. Prior to planting, fertilizers were applied at a rate of N₃₀P₁₀₀K₆₀ kg/ha. The green manure crops were irrigated three times at a rate of 450-500 m³/ha, with the first irrigation taking place early in the spring. In the second ten-day period of April, the biomass of the green manure crops was assessed, and then the crops were harvested with a KIR-1.5M type combine harvester, threshed, disked, and plowed to a depth of 28-30 cm.

After the green manure crops, 30-50 gram seed tubers of potato varieties were planted on November 25-30 in a 70x20 cm planting scheme at a depth of 20 cm.

The field and production experiments, including planting, crop care, yield harvesting, calculation, and analysis, were conducted following the general methods and recommendations of the Ministry of Agriculture, the All-Russian Institute of Plant Science, the All-Russian Potato Research Institute, the Uzbekistan Research Institute of Vegetables, Melon Crops, and Potato Cultivation, and the State Commission for the Testing of New Agricultural Varieties. Yield data were statistically analyzed using the methods of B.A. Dospekhov and Microsoft Excel software for mathematical statistical analysis [9-10].

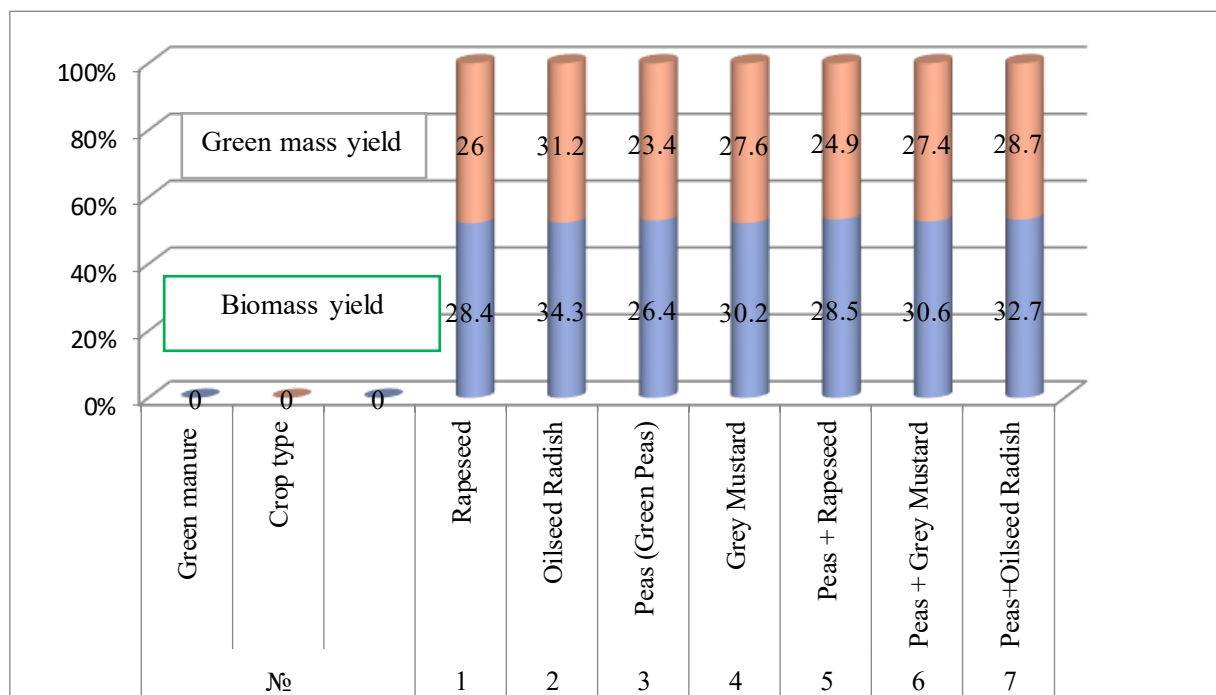
Table 1: Biometric Indicators of Green Manure Crops during the Growing Period

No.	Green Manure Crop Name and Variety	33-35 Days After Germination					Plant Growth Period												
		26-29.11					28.02-4.03			20-25.03				28.03-03.04.					
		Plant Height, cm	Number of plants per 1 m ² , pieces	Number of stems, units	Number of side branches, units	Root length, cm	Plant Height, cm	Number of plants per m ² , units	Root length, cm	Plant Height, cm	Number of plants per m ² , units	Number of stems, units	Number of side branches, units	Plant Height, cm	Number of plants per m ² , units	Number of stems, units	Number of side branches, units	Number of plants per 1 m ² , pieces	
Year 2024																			
1.	Rapeseed	26,5	476,2	1	3,8	23,7	35,2	470,0	63,5	91,6	1	6,3	102,3	112,4	1	8,4	139,3	470,0	
2.	Oilseed Radish	30,5	481,5	1	6,1	27,0	35,3	475,6	67,3	88,2	1	14,4	98,0	111,5	1	20,9	120,3	475,6	
3.	Peas (Green Peas)	28,4	200,1	4	4	24,8	33,1	195,8	50,2	101,5	4	4,4	95,3	193,8	4	6,7	109,2	195,8	
4.	Grey Mustard	29,7	472,5	2	7,4	30,9	35,2	467,4	68,6	112,3	2	8,8	115,8	210,3	2	14,4	140,3	467,4	
5.	Peas + Rapeseed	25,7	376,1	2,6/1	3,1	24,5	32,2	372,6	65,6	84,6	2,6/1	6,3	96,1	97,9	2,6/1	6,5	111,4	372,6	
6.	Peas + Grey Mustard	29,7	479,5	2,4/1	7,4	30,9	35,2	377,4	67,5	112,3	2,4/1	8,8	115,8	210,3	2,4/1	14,4	140,3	377,4	
7.	Peas+ Oilseed Radish	26,7	492,4	2,7/1	4,3	23,8	30,3	488,8	45,9	96,6	2,7/1	5,8	103,3	204,9	2,7/1	12,3	119,1	488,8	
Year 2025																			
1.	Rapeseed	27,1	478,1	1	3,3	29,8	32,8	475,0	66,4	98,3	1	8,0	104,0	117,0	1	11,9	140,3	475,0	
2.	Oilseed Radish	31,4	488,1	1	5,2	33,1	35,7	485,0	64,8	103,1	1	16,6	101,3	135,0	1	25,7	128	485,0	
3.	Peas (Green Peas)	28,6	198,0	3,3	3,3	30,8	31,0	201,8	45,8	102,9	3,3	5,0	96,1	217,0	3,3	7,0	110,5	201,8	
4.	Grey Mustard	31,6	489,1	2	6,7	33,7	34,3	486,0	65,8	117,9	2	10,5	117,2	226,8	2	16,5	139,3	486,0	
5.	Peas + Rapeseed	28,4	378,6	3,0/1	3,1	29,6	30,6	375,3	66,7	96,5	3,0/1	6,7	96,3	99,3	3,0/1	6,8	116,4	375,3	
6.	Peas	31,6	484	2,8/1	6,7	33,	34,	376	66,4	117,	2,8/1	10,5	117,	226,	2,8	16,	139,	376	

.	+ Grey Mustard		,4			7	3	,0		9			2	8	/1	5	3	,0
7	Peas+ Oilseed Raphan	28,5	481, 4	1,7/1	4	30, 8	30, 4	479, 3	44, 6	101, 5	1,7/1	8,5	104, 0	222, 5	1,7/1	13, 4	118, 6	479, 3

RESEARCH RESULTS

The biomass yield of various cover crops planted in the autumn period ranged from 26.4 to 34.3 tons per hectare. Among the studied cover crops, the highest biomass yield was observed when oilseed radish was planted, with a yield of 34.3 tons per hectare. Relatively high biomass yields (30.6-32.7 tons/ha) were recorded when a mixture of peas (blue chickpeas) + oilseed radish and blue mustard was planted.



Biomass Yield of Autumn Cover Crops

In the conditions of typical saline soils of the Kashkadarya region, which have been irrigated for a long time, autumn crops were planted for seed production on 20-24 October (autumn rapeseed, blue vetch, oil radish, peas) and in spring, on 7-10 February (spring rapeseed and blue vetch). Seven variants were tested with three replications and three repetitions for seed and grain yield, planting at a depth of 1.5-2 cm for rapeseed, 3-4 cm for oil radish, and 6-7 cm for peas.

During the years 2023-2025, the growth period of autumn cover crops was observed, and the formation of vegetative organs was noted. For each cover crop type, the plant height ranged from 31.6 to 42.3 cm, and the density of plants per m² was as follows: rapeseed – 470.0-475.0, oil radish – 475.0-485.0, peas – 195.8-201.8, blue vetch – 467.4-486.0, peas + rapeseed – 372.6-377.2, peas + blue vetch – 376.0-379.6, peas + oil radish – 479.3-496.7 plants. Root length was as follows: rapeseed – 63.5-69.6 cm, oil radish – 64.8-70.2 cm, peas – 45.8-54.6 cm, blue vetch – 65.8-70.4 cm, peas + rapeseed – 65.6-67.4 cm, peas + blue vetch – 66.4-69.3 cm, peas + oil radish – 44.6-47.8 cm. These indicators gradually increased in accordance with the law and allowed for biomass to be turned under the soil. At the flowering phase, the plant height of cover crops ranged from 97.9 to 245.6 cm, with lateral branches numbering from 6.5 to 24.2, and root length ranged from 109.2 to 140.3 cm (Table 1, Figures 1, 2, 3, 4).

In the experiment, each siderate crop plot has an area of 46 m² (length 10 m, width 4.6 m), and the cultivable area is 23 m². The total area of the siderate crop plot is 336 m². When growing siderate crops for seed, mineral fertilizers of N₃₀P₆₀K₆₀ kg/ha were applied to the soil before autumn plowing, considering soil fertility. During the growing period, nitrogen fertilizer of N₃₀ kg/ha was applied. The crops were irrigated twice in autumn and once in spring at a rate of 450-500 m³/ha. Phenological observations and biometric measurements were carried out during the growth and development stages of the siderate crops.

In autumn, for the rapeseed grown for seed, during the flowering and ripening phases, the plant height per stem was 116.1–120.7 cm, the stem thickness per m² was 57.6–63 stems, the number of stems was 1, the number of side branches was 7.0–9.3, the average length of one pod was 7.0–8.0 cm, the number of seeds per pod was 8.2–9.6, and the weight of 1000 seeds was 4.7–6.0 grams. The seed yield of autumn rapeseed was 22.7–24.3 centners/ha, and for spring rapeseed, it was 15.5–16.7 centners/ha.

In autumn, the blue sweet clover plant during flowering and ripening had a plant height of 199.5–284.8 cm, the stem thickness per m² was 54.0–55.6, the number of stems was 1, and the number of side branches was 7.6–10. The average length of one pod was 10.2–10.6 cm, the number of seeds per pod was 10.6–11, and the weight of 1000 seeds was

3.9–4.1 grams. The seed yield of autumn blue sweet clover was 17.8–19.6 centners/ha, and for spring blue sweet clover, it was 13.5–14.5 centners/ha.

The oilseed turnip plant, after sowing the seeds, germinated in 3–6 days with field germination rates of 87.1–93.6%, the budding phase lasted 10–13 days, flowering lasted 17–20 days, pod formation and seed maturation took 35–37 days, and the ripening and full ripening phase lasted 8–16 days. In the flowering and ripening phases of the oilseed turnip, the plant height was 141.1–145.2 cm, the stem thickness per m² was 58.0–58.3, the number of stems was 1, the number of side branches was 8–10, the pod length was 8.2–9.0 cm, the number of seeds per pod was 7.0–8.0, and the weight of 1000 seeds was 9.7–12.3 grams. The seed yield was 22.0–23.5 centners/ha.



1-rasm. Peas (Green Peas).



2nd image. Pea + Rape.



3nd image. Peas + Grey Mustard.



4nd image. Oilseed Radish; Grey Mustard; Rapeseed.

2nd Table. Phenological Observation Results of Siderate Crops Grown for Seed in Autumn

No.	Green Manure Crop Name	Sowing Period, Day, Month	Sowing rate, kg/ha	Sowing depth, cm	Field germination of seeds, %	Plants' growth and development stages reporting							
						Emergence		Spiking (bud formation, ear formation, and heading)		Flowering		Full ripening	
						10 %	75 %	10 %	75 %	10 %	75 %	10 %	75 %
Years 2022-2023													
1.	Rapeseed	10.10.22	7	1,5-2	91,5	22.10	24.10	11.03	20.03	23.03	8.04	17.05	3.06
2.	Oilseed Radish	10.10.22	15	3-4	93,6	23.10	26.10	11.03	21.03	24.03	9.04	17.05	26.05
3.	Peas (Green Peas)	10.10.22	30	6-7	94,0	23.10	27.10	12.03	20.03	24.03	9.04	19.05	3.06
4.	Grey Mustard	10.10.22	6	1,5-2	91,1	22.10	24.10	12.03	20.03	24.03	14.04	17.05	4.06
Years 2023-2024													
1.	Rapeseed	12.10.23	7	1,5-2	92,5	24.10	27.10	13.03	23.03	25.03	11.04	20.05	5.06
2.	Oilseed Radish	12.10.23	15	3-4	91,1	25.10	29.10	14.03	24.03	25.03	11.04	19.05	28.05
3.	Peas (Green Peas)	12.10.23	30	6-7	90,4	25.10	29.10	13.03	23.03	26.03	12.04	22.05	5.06
4.	Grey Mustard	12.10.23	6	1,5-2	90,7	24.10	27.10	13.03	23.03	26.03	17.04	19.05	7.06
Years 2024-2025													
1.	Rapeseed	10.10.24	7	1,5-2	87,7	26.10	28.10	15.03	25.03	27.03	13.04	20.05	6.06
2.	Oilseed Radish	10.10.24	15	3-4	87,1	28.10	30.10	14.03	26.03	28.03	14.04	19.05	27.05
3.	Peas (Green Peas)	10.10.24	30	6-7	89,2	29.10	01.11	14.03	24.03	27.03	13.04	22.05	5.06
4.	Grey Mustard	10.10.24	6	1,5-2	86,5	26.10	28.10	14.03	24.03	28.03	18.04	19.05	7.06
Green manure crops sown in the spring period													
Year 2023													
1.	Rapeseed	7.02.23	7	1,5-2	85,3	9.02	11.02	21.03	5.04	8.04	24.04	13.06	26.06
2.	Grey Mustard	7.02.23	6	1,5-2	84,1	9.02	11.02	21.03	5.04	8.04	26.04	12.06	26.06
Year 2024													
1.	Rapeseed	9.02.24	7	1,5-2	84,4	11.02	14.02	21.03	4.04	7.04	23.04	12.06	26.06
2.	Grey Mustard	9.02.24	6	1,5-2	83,3	11.02	14.02	21.03	5.04	8.04	26.04	12.06	26.06
Year 2025													
1.	Rapeseed	10.02.25	7	1,5-2	83,4	12.02	14.02	22.03	6.04	9.04	25.04	13.06	28.06
2.	Grey Mustard	10.02.25	6	1,5-2	84,6	12.02	14.02	22.03	6.04	9.04	27.04	13.06	28.06

Table 3. Biometrics indicators for growing green manure crops for seed production in the autumn period

No	Green Manure Crop Name	Yield indicators of a single plant					
		Plant height, cm	Seed density per 1 m ² , seeds	Number of stems and side branches, pieces	Average length of one pod (bean, ear), cm	Number of seeds (grains) in one pod (bean, ear), pieces	Weight of 1000 seeds (grains), grams
Year 2023							
1.	Rapeseed	116,1	57,6	1/7	8,0	8,2	4,7
2.	Oilseed Radish	141,1	58	1/8	8,2	7,0	9,7
3.	Peas (Green Peas)	240,0	95	4,1/6,4	9,3	6,3	66,3
4.	Grey Mustard	199,5	54	1/7,6	10,2	10,6	3,9
Year 2024							
1.	Rapeseed	118,2	63	1/9,3	7,6	9,6	6,0
2.	Oilseed Radish	145,2	58,3	1/10	9,0	8,0	12,3
3.	Peas (Green Peas)	276,6	96,6	4,7/9	12,3	7,0	64,7
4.	Grey Mustard	281,2	55,6	1/10	10,6	10,6	4,1
Year 2025							
1.	Rapeseed	120,7	62	1/9	7,7	8,6	5,1
2.	Oilseed Radish	143,7	58	1/9	9,0	7,6	11,7
3.	Peas (Green Peas)	281,1	94,3	4,6/9	12,0	5,0	64,1
4.	Grey Mustard	284,8	54	1/9	10,6	11,0	4,0
Growing green manure crops for seed production in the spring period							
Year 2023							
1.	Rapeseed	110,5	61,3	1/7	7,0	5,3	3,4
2.	Grey Mustard	201,1	53,3	1/7,6	8,0	7,0	3,7
Year 2024							
1.	Rapeseed	110,6	63	1/7,6	7,6	5,6	3,5
2.	Grey Mustard	203,8	54	1/8,6	8,6	7,3	3,6
Year 2025							
1.	Rapeseed	104,6	61,6	1/7	6,5	5,3	3,5
2.	Grey Mustard	197,1	54,6	1/8,3	8,0	6,3	3,5

Table 4. Seed and grain yield of autumn green manure crops, c/ha

No.	Type of green manure crops	By years			Average yield
		2023	2024	2025	
1	Oilseed Radish	22,0	23,4	23,5	23,0
2	Peas (Green Peas)	26,7	28,6	28,5	28,0
$S_x^- = (\%)$		3,17	2,06	2,32	
LSD_{0,5}=(tons/ha)		1,39	0,94	1,06	
Seed yield of cruciferous green manure crops in autumn and spring periods					
1	Autumn rapeseed	22,7	24,2	24,3	23,7
2	Autumn Grey Mustard	17,8	19,5	19,6	19,0
3	Spring rapeseed	15,5	16,5	16,7	16,2
4	Sprin Grey Mustard	13,5	14,3	14,5	14,1
$S_x^- = (\%)$		4,64	3,48	4,15	
LSD_{0,5}=(tons/ha)		0,81	0,65	0,85	

After sowing peas (green beans) in autumn, they germinated in 7 days, and the field germination rate was 89.2–94.0%. The budding phase lasted 10–12 days, the flowering phase lasted 16–18 days, and the pod and seed formation lasted 33–36 days. The maturation and full ripening of the seeds in the pods lasted 14–16 days.

In autumn, the seeds of the Vostok-55 variety of peas (green beans) had a plant height of 240.0–281.1 cm in the flowering and ripening phases, the stem thickness per m² was 94.3–96.6, the number of stems was 4.1–4.7, the number of side branches was 6.4–9, the average length of one pod was 9.3–12.3 cm, the number of seeds per pod was 6.3–9.3, and the weight of 1000 seeds was 64.1–66.3 grams. The peas (green beans) ripened between June 3rd and 5th. The seed yield of the Vostok-55 variety of peas was 26.7–28.5 centners/ha on average (see tables 2, 3, and 4).

According to the results of our research, when rapeseed is sown in the autumn for seed production, the seed yield in the spring was 7.2-7.6 centners higher per hectare. We recommend sowing rapeseed for seed production in the autumn from October 10 to 20. In autumn green manure crops, the growth period of the varieties of late-ripening potato such as Bahro-30, Bardoshli-3, Sante, Saviola, Arizona, and Red Scarlet was found to be 40-70 days, during which the plants developed a wide leaf surface on each stem. When used as green manure, the biomass of autumn green manure crops, based on varieties, reached 56.7-70.9 thousand m² per hectare, which was 10.4-22.2 thousand m² more compared to the control (autumn plowing) (Table 5).

Table 5. Biometrics indicators of potato varieties sown after autumn green manure crops (2023-2025 years)

No.	Green Manure Crop Name	Plant height, cm	Weight of one plant stem, g	From this		Leaf area of one plant, m ²	Leaf area of plants per hectare, thousand m ²
				Stem, g	Leaf, g		
Sante variety							
1	Control (autumn plowing)	59,1	227,9	138,2	89,7	0,621	46,3
2	Rapeseed	66,7	384,1	238,7	145,4	0,778	58,5
3	Oilseed Radish	65,8	369,4	226,3	143,1	0,764	56,7
4	Peas (Green Peas)	71,3	402,2	244,6	157,6	0,883	68,6
5	Grey Mustard	67,2	391,6	239,1	152,5	0,781	59,1
6	Peas + Rapeseed	68,4	395,1	239,6	155,5	0,867	65,4
7	Peas + Grey Mustard	69,6	397,0	240,7	156,3	0,869	66,7
8	Peas+Oilseed Radish	70,4	399,2	242,4	156,8	0,875	67,2
Bahro-30 variety							
1	Control (autumn plowing)	60,5	247,3	154,7	92,6	0,627	48,2
2	Rapeseed	69,4	398,7	245,3	153,4	0,781	58,8
3	Oilseed Radish	67,9	394,4	243,6	150,8	0,766	57,5
4	Peas (Green Peas)	73,4	425,4	258,7	166,7	0,890	70,1
5	Grey Mustard	69,8	402,2	247,3	154,9	0,783	59,4
6	Peas + Rapeseed	70,6	411,8	250,6	161,2	0,872	66,1
7	Peas + Grey Mustard	71,4	417,1	254,1	163,0	0,875	67,3
8	Peas+Oilseed Radish	71,9	418,2	254,6	163,6	0,876	67,7
Saviola variety							
1	Control (autumn plowing)	58,7	226,9	137,6	89,3	0,616	45,6
2	Rapeseed	69,6	405,4	247,0	158,4	0,785	59,4
3	Oilseed Radish	68,2	398,7	245,1	153,6	0,771	58,5
4	Peas (Green Peas)	72,6	422,1	256,8	165,3	0,893	70,7
5	Grey Mustard	69,7	406,0	247,2	158,8	0,787	59,7
6	Peas + Rapeseed	70,7	412,6	251,0	161,6	0,875	67,2
7	Peas + Grey Mustard	71,8	418,4	254,6	163,8	0,880	68,5
8	Peas+Oilseed Radish	71,6	416,6	253,7	162,9	0,879	67,9
Arizona variety							
1	Control (autumn plowing)	58,6	227,6	137,8	89,8	0,619	45,8
2	Rapeseed	64,4	404,6	246,7	157,9	0,779	58,6
3	Oilseed Radish	63,0	398,2	244,8	153,4	0,768	58,3
4	Peas (Green Peas)	68,5	420,3	255,7	164,6	0,891	70,2
5	Grey Mustard	65,3	405,5	246,9	158,6	0,786	59,3
6	Peas + Rapeseed	65,8	411,4	250,6	160,8	0,874	66,9

7	Peas + Grey Mustard	67,1	417,2	254,3	162,9	0,879	68,0
8	Peas+Oilseed Radish	67,6	414,9	252,8	162,1	0,878	67,6
Bardoshli-3 variety							
1	Control (autumn plowing)	60,0	246,0	154,1	91,9	0,625	48,1
2	Rapeseed	68,4	397,6	244,7	152,9	0,778	58,5
3	Oilseed Radish	67,3	393,0	242,8	150,2	0,765	57,3
4	Peas (Green Peas)	71,2	425,2	258,6	166,6	0,889	70,0
5	Grey Mustard	68,7	401,2	246,5	154,7	0,782	59,2
6	Peas + Rapeseed	70,0	411,2	250,3	160,9	0,871	66,0
7	Peas + Grey Mustard	70,8	417,9	254,5	163,4	0,876	67,4
8	Peas+Oilseed Radish	70,9	419,5	255,1	164,4	0,877	67,8
Red skarlet variety							
1	Control (autumn plowing)	60,6	248,3	155,3	93,0	0,631	48,7
2	Rapeseed	68,8	402,6	246,5	156,1	0,782	59,0
3	Oilseed Radish	68,0	398,2	244,8	153,4	0,767	57,8
4	Peas (Green Peas)	70,6	431,4	262,2	169,2	0,893	70,9
5	Grey Mustard	68,9	404,1	248,7	155,4	0,784	60,1
6	Peas + Rapeseed	69,6	417,4	253,8	163,6	0,873	68,1
7	Peas + Grey Mustard	69,9	422,2	256,4	165,8	0,877	69,7
8	Peas+Oilseed Radish	70,0	421,4	256,1	165,3	0,877	69,3

Table 6. The effect of autumn green manure crops on the morphological and productivity indicators of late-ripening potato varieties (2023-2025 years)

No	Green Manure Crop Name	Plant height, cm	On one plant						
			Stem, piece	lateral branch, piece	Leaf, piece	haulm weight, grams	tuber yield, grams	number of tubers, piece	Average weight of 1 tuber, grams
Sante variety									
1	Control (autumn plowing)	59,1	3,4	5,5	171,3	227,9	677,5	7,7	87,9
2	Rapeseed	66,7	3,6	7,2	204,7	384,1	841,5	9,0	93,5
3	Oilseed Radish	65,8	3,6	7,0	200,1	369,4	834,1	8,8	94,7
4	Peas (Green Peas)	71,3	4,2	8,9	242,7	402,2	998,6	10,2	97,9
5	Grey Mustard	67,2	4,0	7,6	206,8	391,6	886,2	9,6	92,3
6	Peas + Rapeseed	68,4	4,0	8,4	232,6	395,1	940,0	9,7	96,9
7	Peas + Grey Mustard	69,6	4,0	8,6	237,7	397,0	959,3	9,7	98,8
8	Peas+Oilseed Radish	70,4	4,0	8,7	238,8	399,2	964,5	10,0	96,4
Bahro-30 variety									
1	Control (autumn plowing)	60,5	3,4	4,8	172,6	247,3	682,8	8,3	82,2
2	Rapeseed	69,4	3,6	5,4	206,3	398,7	846,3	9,0	94,0
3	Oilseed Radish	67,9	3,6	5,2	205,7	394,4	839,6	9,0	93,2
4	Peas (Green Peas)	73,4	4,6	6,6	243,4	425,4	994,7	10,7	92,9

5	Grey Mustard	69,8	4,0	5,6	219,7	402,2	878,2	9,6	91,4
6	Peas + Rapeseed	70,6	4,2	6,2	234,8	411,8	925,6	10,2	90,7
7	Peas + Grey Mustard	71,4	4,2	6,3	239,5	417,1	948,6	10,4	91,2
8	Peas+Oilseed Radish	71,9	4,3	6,4	240,6	418,2	970,4	10,6	91,5
Saviola variety									
1	Control (autumn plowing)	58,7	3,2	4,7	166,8	226,9	684,5	9,7	70,5
2	Rapeseed	69,6	3,5	5,3	205,4	405,4	839,3	10,2	82,2
3	Oilseed Radish	68,2	3,5	5,2	203,8	398,7	834,2	10,2	81,7
4	Peas (Green Peas)	72,6	4,4	6,6	239,4	422,1	982,1	11,4	86,1
5	Grey Mustard	69,7	3,7	5,4	212,1	406,0	848,6	10,3	82,3
6	Peas + Rapeseed	70,7	4,2	6,4	233,7	412,6	952,3	11,2	85,0
7	Peas + Grey Mustard	71,8	4,3	6,5	236,9	418,4	967,2	11,3	85,5
8	Peas+Oilseed Radish	71,6	4,4	6,6	237,2	416,6	971,5	11,4	85,2
Arizona variety									
1	Control (autumn plowing)	58,6	3,3	4,7	166,3	227,6	679,1	9,6	70,7
2	Rapeseed	64,4	3,6	5,3	203,7	398,2	832,2	10,2	81,5
3	Oilseed Radish	63,0	3,5	5,2	202,8	398,2	826,4	10,2	81,0
4	Peas (Green Peas)	68,5	4,3	6,6	238,2	420,3	983,4	11,4	86,2
5	Grey Mustard	65,3	3,7	5,4	209,5	405,5	841,6	10,3	81,7
6	Peas + Rapeseed	65,8	4,1	6,4	232,3	411,4	946,8	11,2	84,5
7	Peas + Grey Mustard	67,1	4,1	6,5	236,2	417,2	969,2	11,3	85,7
8	Peas+Oilseed Radish	67,6	4,2	6,6	236,7	414,9	970,5	11,3	85,8
Bardoshli-3 variety									
1	Control (autumn plowing)	60,0	3,2	4,7	170,8	246,0	658,4	8,0	82,3
2	Rapeseed	68,4	3,6	5,3	201,6	393,0	767,3	8,7	88,1
3	Oilseed Radish	67,3	3,4	5,2	196,7	393,0	733,0	8,5	86,2
4	Peas (Green Peas)	71,2	4,2	6,7	237,6	425,2	887,4	9,6	92,4
5	Grey Mustard	68,7	3,8	5,5	206,9	401,2	773,7	8,8	87,9
6	Peas + Rapeseed	70,0	4,1	6,3	233,3	411,2	848,1	9,3	91,1
7	Peas + Grey Mustard	70,8	4,1	6,4	235,5	417,9	854,3	9,6	88,9

8	Peas+Oilseed Radish	70,9	4,4	6,5	236,9	419,5	858,7	9,6	89,4
Red skarlet variety									
1	Control (autumn plowing)	60,6	3,4	4,8	177,4	248,3	692,7	9,8	70,6
2	Rapeseed	68,8	3,6	5,6	207,6	402,6	841,3	10,4	80,8
3	Oilseed Radish	68,0	3,5	5,4	206,4	398,2	837,6	10,3	81,3
4	Peas (Green Peas)	70,6	4,4	6,8	251,7	431,4	993,5	12,1	82,1
5	Grey Mustard	68,9	3,7	6,0	223,1	404,1	857,6	10,7	80,1
6	Peas + Rapeseed	69,6	4,0	6,3	240,6	417,4	970,3	11,3	85,8
7	Peas + Grey Mustard	69,9	4,2	6,4	246,6	422,2	984,5	11,4	86,3
8	Peas+Oilseed Radish	70,0	4,2	6,6	245,7	421,4	986,8	11,5	85,8

After sowing green manure crops in the autumn, such as peas (blue vetch) alone or in mixtures with rapeseed, blue vetch, and oil radish, and using their biomass as green manure, the highest leaf area per hectare (65.4–70.9 thousand m²) was recorded for the potato varieties grown, compared to the control (autumn plowing), with an increase of 19.1–22.2 thousand m² per hectare.

The highest increase in the weight of one plant stem was observed in the late-ripening potato varieties Bahro-30, Bardoshli-3, Sante, Saviola, Arizona, and Red Scarlet grown after autumn green manure crops. Compared to the control (autumn plowing), the weight of the plant stem per plant increased by 369.4–431.4 g or 142.5–183.1 g, and the tuber yield per plant increased by 733.0–998.6 g or 74.6–305.9 g (Table 6).

After sowing green manure crops in the autumn and applying their biomass as green manure in the spring, the effect of green manure on the growth, development, productivity, and soil fertility of the late-ripening potato varieties Bahro-30, Bardoshli-3, Sante, Saviola, Arizona, and Red Scarlet was evaluated under typical degraded soil conditions. The seed yield of these varieties was highest when peas (blue vetch) were used as green manure in the autumn. This led to an increase of 31.8–37.9 tons or 8.0–9.5 tons per hectare compared to the control (autumn plowing).

When green manure crops such as peas + rapeseed, peas + blue vetch, peas + oil radish, and blue vetch alone were sown in the autumn and their biomass was used as green manure, the yield of potatoes per hectare ranged from 28.9 to 36.5 tons, which was 5.1–7.6 tons higher than the control (autumn plowing). After growing potatoes following autumn green manure crops, the additional yield per hectare was 2.8–9.0 t/ha higher, ensuring an additional yield of 109.8–131.1% (Table 7).

Table 7. Yield of potato varieties studied after the application of autumn siderate crop biomass (after ninety days)

No	Green Manure Crop Name	Yield by years, t/ha		Average yield, t/ha	Compared to the control	
		2023	2024		t/ha	%
Sante variety						
1	Control (autumn plowing)	24,6	23,5	24,0	-	100
2	Rapeseed	29,4	28,5	28,9	4,9	120,4
3	Oilseed Radish	28,2	27,4	27,8	3,8	115,8
4	Peas (Green Peas)	33,2	30,8	32,0	8,0	133,3
5	Grey Mustard	30,6	28,3	29,4	5,4	122,5
6	Peas + Rapeseed	31,2	29,8	30,5	6,5	127,0
7	Peas + Grey Mustard	32,5	30,3	31,4	7,4	130,8
8	Peas+Oilseed Radish	32,6	31,1	31,8	7,8	132,5
	$S_x^- = (\%)$	4,47	4,18			
	LSD_{0,5} = (t/ha)	1,21	1,63			
Bahro-30 variety						
1	Control (autumn plowing)	24,2	23,5	23,8	-	100,0

2	Rapeseed	28,7	27,6	28,1	4,3	118,0
3	Oilseed Radish	28,0	26,3	27,1	3,3	113,8
4	Peas (Green Peas)	32,6	31,1	31,8	8,0	133,6
5	Grey Mustard	29,6	28,3	28,9	5,1	121,4
6	Peas + Rapeseed	31,6	28,8	30,2	6,4	126,8
7	Peas + Grey Mustard	32,0	29,5	30,7	6,9	128,9
8	Peas+Oilseed Radish	32,3	29,9	31,1	7,3	130,6
	$S_x^- = (\%)$	4,14	4,68			
	LSD_{0,5} = (τ/га)	1,20	1,37			
Saviola variety						
1	Control (autumn plowing)	29,6	27,3	28,4	-	100,0
2	Rapeseed	32,6	31,8	32,2	3,8	113,3
3	Oilseed Radish	32,1	30,4	31,2	2,8	109,8
4	Peas (Green Peas)	38,0	36,2	37,1	8,7	130,6
5	Grey Mustard	33,0	32,2	32,6	4,2	114,7
6	Peas + Rapeseed	36,2	34,3	35,2	6,8	123,9
7	Peas + Grey Mustard	36,6	35,2	35,9	7,5	126,4
8	Peas+Oilseed Radish	36,8	35,5	36,1	7,7	127,1
	$S_x^- = (\%)$	2,85	2,60			
	LSD_{0,5} = (τ/га)	0,98	0,87			
Arizona variety						
1	Control (autumn plowing)	29,6	28,1	28,8	-	100,0
2	Rapeseed	33,2	31,7	32,4	3,6	112,5
3	Oilseed Radish	33,1	31,3	32,2	3,4	111,8
4	Peas (Green Peas)	39,0	36,2	37,6	8,8	130,5
5	Grey Mustard	33,6	32,1	32,8	4,0	113,8
6	Peas + Rapeseed	36,1	34,7	35,4	6,6	122,9
7	Peas + Grey Mustard	36,5	35,0	35,7	6,9	123,9
8	Peas+Oilseed Radish	37,0	35,6	36,3	7,5	126,0
	$S_x^- = (\%)$	2,88	2,59			
	LSD_{0,5} = (τ/га)	0,98	0,88			
Bardoshli-3 variety						
1	Control (autumn plowing)	28,4	27,1	27,7	-	100,0
2	Rapeseed	32,7	31,3	32,0	4,3	115,5
3	Oilseed Radish	31,0	30,4	30,7	3,0	110,8
4	Peas (Green Peas)	36,3	34,7	35,5	7,8	128,1
5	Grey Mustard	33,0	31,4	32,2	4,5	116,2
6	Peas + Rapeseed	33,6	31,8	32,7	5,0	118,0
7	Peas + Grey Mustard	35,1	32,7	33,9	6,2	122,3
8	Peas+Oilseed Radish	35,5	33,2	34,3	6,6	123,8
	$S_x^- = (\%)$	4,37	3,46			
	LSD_{0,5} = (τ/га)	1,41	1,09			
Red skarlet variety						
1	Control (autumn plowing)	29,3	28,6	28,9	-	100,0
2	Rapeseed	33,3	32,0	32,6	3,7	112,8
3	Oilseed Radish	33,4	31,6	32,5	3,6	112,4
4	Peas (Green Peas)	39,3	36,6	37,9	9,0	131,1
5	Grey Mustard	33,8	32,4	33,1	4,2	114,5
6	Peas + Rapeseed	36,6	34,8	35,7	6,8	123,5
7	Peas + Grey Mustard	36,8	35,2	36,0	7,1	124,5
8	Peas+Oilseed Radish	37,4	35,7	36,5	7,6	126,2
	$S_x^- = (\%)$	4,40	3,49			
	LSD_{0,5} = (τ/га)	1,42	1,11			

In potato cultivation, after using green manure crops like peas, rapeseed, blue vetch, peas + rapeseed, peas + blue vetch, and peas + oil radish, the field productivity reached 95.8–98.6% with emergence occurring 3–6 days earlier, the growth period extended by 6–8 days, plant height increased by 9.8–15.6 cm, and the number of stems per plant increased by 1.4–2.0. The incidence of viral diseases decreased significantly (open: 7.6–8.8%, hidden: 23.3–26.7%) with improved seed quality. Notably, in the autumn, when rapeseed, peas, blue vetch, oil radish alone, and peas + rapeseed, peas + blue vetch, peas + oil radish were used as green manure, a sharp decrease in plant and tuber infection with viral diseases was observed.

By increasing the yield per hectare by 21.5–31.0 tons, high-quality (with low infected tuber weight of 3.3–4.1%) and healthy (non-infected) crops were produced.

The lowest viral disease incidence was recorded when rapeseed, blue vetch, oil radish, and mixtures of peas + rapeseed, peas + blue vetch, and peas + oil radish were used as green manure, resulting in a reduction of 11.4–11.0% for visible symptoms and 27.6–27.0% for hidden symptoms (including virus X: 7.8–7.1%; S: 12.2–11.8%; Y: 7.0–6.7%; M: 1.0–0.9%) compared to the control (autumn plowing).

SUMMARIES:

1. In the typical irrigated chernozem soil conditions of Kashkadarya region, during the autumn period, when crops like rapeseed, oilseed turnip, barley, peas, peas + rapeseed, peas + green vetch, and peas + oilseed turnip were used as siderates, the biomass yield ranged from 26.4 to 34.3 tons per hectare.
2. During the autumn period, when rapeseed, oilseed turnip, barley, peas, and green vetch were used as siderates and sown for seed production, seed yield per hectare was as follows: Autumn rapeseed – 22.7–24.3 c/ha, autumn green vetch – 17.8–19.6 c/ha, oilseed turnip – 22.0–23.5 c/ha, peas – 26.7–28.5 c/ha, spring rapeseed – 15.5–16.7 c/ha, and spring green vetch – 13.5–14.5 c/ha. The autumn sowing of rapeseed and green vetch compared to the spring period provided an additional 7.2–7.6 and 4.3–5.1 centners of seed yield, respectively.
3. After the application of autumn siderates, the field productivity, emergence rate, growth, and development of potato seed tubers were found to be high across all varieties. Particularly, when peas, green vetch pure crops and peas + rapeseed, peas + green vetch, and peas + oilseed turnip mixed crops were used as siderates, the field productivity of potato varieties like Bakhro-30, Bardoshli-3, Sante, Saviola, Arizona, and Red Scarlet increased by 2.7–3.5%, emergence was 3–5 days earlier, and the growing period extended by 3–10 days.
4. When siderate crops were applied, the growth and development of intermediate-ripening potato varieties were faster compared to early-ripening varieties. The tall (65.3–73.4 cm or 6.7–12.8 cm) varieties with more stems (3.7–4.6 or 0.4–1.2 more stems), broader leaf surfaces (59.1–70.9 or 13.5–22.2 thousand m² more), and stronger haulms (391.6–431.4 grams) and root systems were formed. As a result, productivity indicators for these varieties showed that tuber yield per plant ranged from 773.7 to 994.7 grams, the number of tubers ranged from 8.8 to 12.1, and the average weight of a tuber ranged from 80.1 to 97.9 grams.
5. During the autumn period, when peas + rapeseed, peas + green vetch, peas + oilseed turnip mixed crops and pure green vetch were used as siderates, the biomass application resulted in potato yields ranging from 31.2 to 37.9 tons per hectare. Compared to the control (autumn plowing), the potato yields increased by 2.8–9.0 tons per hectare, resulting in an additional yield of 109.8–131.1%.
6. The least damage from viral diseases was observed when rapeseed, green vetch, oilseed turnip pure crops and peas + rapeseed, peas + green vetch, peas + oilseed turnip mixed crops were used as siderates. The seed tubers planted under these conditions showed a reduction in viral infection compared to the control (autumn plowing). The visible infection decreased by 11.4–11.0%, while the hidden infection decreased by 27.6–27.0%, including viral X-7.8–7.1%, S-12.2–11.8%, U-7.0–6.7%, and M-1.0–0.9%.

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